December 2014

A First Survey of the Centipedes of Great Smoky Mountains National Park

Joseph DeSisto
JOSEPH.DESISTO@UCONN.EDU

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Abstract

I summarize the results of a survey of the centipedes of Great Smoky Mountains National Park that took place between June 1 and August 10, 2014 in collaboration with Discover Life in America. Thirty-eight species are reported, including 22 new records for the park, elevating the known centipede diversity in the park from 37 to 59. Some faunal elements are discussed, as well as previous records for the park that may be misidentifications, or that warrant suspicion due to taxonomic problems. Among the new records is the third known locality for *Strigamia hoffmani* Pereira, a species described only in 2009 from two locations in western Virginia.

Introduction

Centipedes (class Chilopoda) attract little attention in part because, although a few species are brightly colored, most are uncharismatic animals, even compared with other arthropods. While the house centipede *Scutigera coleoptrata* L. is a common nuisance pest, and an 8-inch-long *Scolopendra heros* Girard can be formidable (terrifying to some), the vast majority of centipedes are small, inconspicuous creatures, spending their lives underground and largely out of sight (Lewis, 1981).

As a result, the centipede fauna of North America is very poorly known (Mercurio, 2010; Crabill 1952). Nonetheless, centipedes are important to humans in many capacities. All species are venomous, and their venom may prove to be of medical or research value. Centipedes exhibit a variety of developmental patterns, from anamorphy to epimorphy, and many soil centipedes (order Geophilomorpha) exhibit intraspecific variation in segment number. These may be of value as developmental biology models, particularly in investigations of segmentation and tagmosis. Several of the larger species are found in the exotic pet trade. They are also of ecological importance as generalist predators of soil-dwelling invertebrates (Lewis, 1981).

Centipedes are myriapods myriapods with 15 or more pairs of legs (always an odd number) and a single pair of legs per tergite, in contrast to millipedes (class Diplopoda), which have two pairs per tergite. The major synapomorphy connecting all centipedes, however, is the presence of venom-injecting forcipules. The forcipules resemble fangs and are located beneath the head capsule, but they are actually derived from the first pair of legs (Lewis, 1981). There are five orders of centipedes, four of which can be found in North America (all excepting Craterostigmomorpha). They are related accordingly: Scutigeromorpha + (Lithobiomorpha + (Craterostigmomorpha + (Scolopendromorpha + Geophilomorpha))); this phylogeny is supported by a wealth of molecular and morphological data (Giribet and Edgecombe, 2007)

The goal of this study was to document the diversity and distribution of centipedes in Great Smoky Mountains National Park (GSMNP). The park was an ideal location for such a survey as it is biologically and geologically diverse, and of cultural significance as the most visited national park in the United States. The project was also designed to help meet the goals of the All-Taxa Biodiversity Inventory (ATBI), a long-term survey of all the species in the park conducted by the non-profit Discover Life in America (DLIA).

The initial aim of this project was to survey the entire class Chilopoda in GSMNP. However, it quickly became clear that there were simply too many species in the park to complete a useful survey of the entire class in a single summer. Feeling it would be more useful instead to gather more data for a smaller number of species, I chose to focus efforts on the soil centipedes, order Geophilomorpha. I chose this order because its members are more likely to be of value as indicators of soil quality and community health, since they are largely subterranean in habits (Lewis, 1981). In addition, the Lithobiomorpha, easily the most diverse order in GSMNP, is rife with taxonomic problems (virtually all North American genera are in desperate need of revision) (Eason, 1990). In "Results," I include all species of centipede documented, but readers should keep in mind that 257 of the 595 centipedes examined were soil centipedes, even though this order accounts for only about 15% of the known diversity in GSMNP.

Many taxonomic problems need to be resolved before a survey of the centipedes of GSMNP, or anywhere else in North America, can be considered complete. This will likely take a lifetime or several lifetimes of work, as the North American centipede fauna is poorly known and many species remain to be described, synonymized, revised, etc. As such, this survey should not be considered a resolution of the centipede fauna of GSMNP, but a stepping stone to the plethora of questions that remain to be answered about these fascinating and important animals.

Methods and Material Examined

I examined 595 centipede specimens, which can be divided into several categories based on how they were obtained: a) 136 specimens I collected myself between June 1 and August 10, 2014, b) 150 specimens that had been deposited in the park's natural history collection from previous biological surveys and bioblitzes as early as 2010, and c) 309 specimens collected as "bycatch" during a 2010-12 survey of the park's earthworms, in association with DLIA.

Location data for specimens I collected were determined with a handheld GPS. Although geographic distribution of species within the park was an important part of this survey, most geographic data are still under analysis and so not included in this report, which should be considered as preliminary until such data are available. Subsequent versions will contain location data (latitude and longitude) for individual specimens.

Specimens were collected by hand and via pitfall traps and Berlese funnels, and preserved in 70% ethanol. Hand-collecting methods included peeling the bark from dead logs and stumps, sifting through soil, flipping logs and other woody debris, and removing (then returning) moss mats from large stones. In the lab, specimens were examined under a dissecting microscope. Extremely small specimens (e.g., the dwarf Strigamia hoffmani, scarcely more than 10 mm long) were mounted on temporary slides and examined under a compound microscope.

Determinations were made using a variety of taxonomic papers and keys, all in "References." Although no specimens in the genus *Escaryus* Cook & Collins were found, I would like to stress the value of Pereira and Hoffman's summary of the genus' American representatives (Pereira and Hoffman, 1993), as two new species were described therein, both from southern Appalachia. Either or both may be found to inhabit GSMNP.

All specimens are deposited in the GSMNP natural history collection at the Twin Creeks Science and Education Center.

Results

Fig. I includes a list of all 38 centipede species I recorded from Great Smoky Mountains National Park. Species that are recorded here for the first time are in bold.

Including 22 new records from this study, 59 species of centipede are now documented in GSMNP. Species that were previously recorded from GSMNP are listed in Fig. II: those not recorded in this study are in bold. Finally, a "taxa tally," broken down by order, is presented in Fig. III, which includes numbers of previously known species and new records for the park.

A few interesting faunal elements can be elicited from the data. For example, of 25 specimens of *Geophilus rupestris* (Crabill) for which elevation data is available, all were found at 5,000 feet or higher. I collected 4 individuals of this species at a single site, Clingman's Dome, at 6296 feet. The site is dominated by spruce-fir forest.

Relatively few of the species found in GSMNP are introduced. Whereas in Connecticut, nearly 30% (8 of 27) of centipede species are considered introduced (DeSisto, unpublished data), in GSMNP, this applies to only 3 of 59 or 5% of centipede species. I propose two factors influencing this phenomenon:

a) the native centipede diversity is far greater in GSMNP than in Connecticut, and
b) the climate in temperate Europe, where these introductions originate, is more similar to that of Connecticut than GSMNP.

(It is worth noting here that Crabill (1952) felt that the presumed native *Paobius vagrans* Chamberlin is a likely junior synonym of *Lithobius crassipes* Koch, which is an introduced species. This is, however, unconfirmed.)

Hemiscolopendra marginata (Say), commonly known as the Florida blue centipede, is certainly the largest centipede in the park, reaching up to three inches in length. In much of the southeast it is a common and frequently encountered species, especially so because it's propensity for climbing often leads it to invade houses, where it may inflict a painful bite (Hoffmani, 1994). Curiously, however, only a single specimen was found in GSMNP, under the bark of a fallen tree, about 1.5 meters from the ground. Perhaps this species is less frequently collected because a) it is more arboreal than expected for a centipede, and/or b) relatively few collectors are willing to pick up a 3-inch-long centipede. Shelley (2002) notes that this species is absent from the higher-elevation regions of the southern Appalachians, which would exclude it from much of GSMNP.

The discovery of the recently described *Strigamia hoffmani* is probably the greatest contribution of this study, as it was previously only known from two localities in western Virginia: Burkes Garden and Bent Mountain (Pereira, 2009). Specimens in GSMNP were extracted from litter along Gregory Ridge Trail, in old growth forest. Thus far, it would appear *S. hoffmani* is a southern Appalacchian endemic, although this is far from certain. With a body length that does not exceed 16 mm, this species is a dwarf among centipedes, and one of North America's most amazing, albeit inconspicuous centipedes.

Discussion

There are records of a few species, none found in this study, whose status in GSMNP must be questioned. The first of these is *Geophilus mordax* Meinert. When Crabill described *Geophilus ampyx*, he stressed that, until his description, *G. ampyx* had previously been misidentified as *G. mordax* (Crabill, 1954). Even today, the two species are easily confused (*G. mordax* is distinguished only by the presence of a sacculus or pit on each sternite). In addition, while no specimens of *G. mordax* were observed during this study, *G. ampyx* was found to be

abundant (33 specimens were taken at 11 sites). With the bright red color of a Maraschino cherry, *G. ampyx* is also one of the most beautiful centipedes in the area.

The situation is further complicated by the fact that the species currently accepted as *Geophilus mordax* is polymorphic, and probably comprises two separate species, one with lateral coxopleural pores on the ultimate legs and the other without. Although Crabill (1954) felt there wasn't enough evidence to erect either of these forms to species status, Hoffman later referred to the *virginiensis* form (the one with lateral coxopleural pores) as *Geophilus virginiensis* Bollman, and considered it to be a separate species (Hoffman, 1995). However, no description of *G. virginiensis* has ever been published, and neither Hoffman nor Crabill examined the type specimen of *G. mordax*, so for the time being, *G. mordax* is a valid name and *G. virginiensis* is not. I strongly suspect that the previous record of *Geophilus mordax* was actually a misidentified *G. ampyx*, but as the specimen was nowhere to be found in the park collection, *G. mordax* provisionally retains its status as a GSMNP native.

The species currently known as *Geophilus orites* (Chamberlin) is probably a junior synonym of *Geophilus rupestris*. According to Crabill, Chamberlin's description of *Dysmesus orites* is based on a damaged specimen, and although the type specimen was in too poor condition to identify as *G. rupestris*, Crabill felt justified in assigning it to the genus *Brachygeophilus* Brölemann (Crabill, 1981), which at the time also contained *Brachygeophilus rupestris.* Later, the entire genus was synonymized with *Geophilus* Leach (Foddai et al, 1995).

Taxonomy is complicated. The result of this mess is that *G. orites* is probably invalid and *G. rupestris* is a possible senior synonym. Supporting this claim is the fact that during this study, *G. rupestris* was found to be common at high elevations in the park (19 specimens from 6 sites), while *G. orites* was not recorded at all. Contrary to this evidence, however, the type specimen of *G. orites* was collected by Chamberlin in the Greenbrier Cove area (Crabill, 1981), which is elevated around 2,000 feet, outside the expected habitat for *G. rupestris*.

Finally, there is a previous record of *Escaryus liber* Cook & Collins, a cold-loving soil centipede that, in the southern part of its range, is not commonly found during the hottest months of the year. (During these times, it presumably burrows deeper into the soil where temperatures are more constant.) The presence of *E. liber* is not unlikely, but it should be noted that in 1993 described two new species of *Escaryus* were described from Virginia (Pereira and Hoffman). As such, the true identity of the *E. liber* record must be regarded as suspect.

Despite their reputation, centipedes are important members of the soil macro-invertebrate community, a community which is itself both understudied and critical to the health of forest ecosystems. Centipedes are generalist predators, preying on soil-dwelling animals such as insects and earthworms. Experiments with spiders (predators) and springtails (prey) have shown that soil-dwelling arthropod predators, by feeding on detritivores, can indirectly affect the rate of decomposition of leaf litter (Lawrence and Wise, 1999).

In several cases, densities of detritivorous arthropods such as springtails have been shown to be directly and positively related to the health of trees (Moldenke et al, 2000), as they help bacteria and fungi recycle the nutrients plants need to survive. Conversely, several invasive species of European earthworms have had profound negative effects on plant and animal diversity in those North American forests not previously inhabited by earthworms, in part by making such nutrients inaccessible to plants (Frelich et al, 2006).

The soil invertebrate fauna, though seldom fully appreciated, has a very real and palpable impact on the health of the forests on which we depend both for our economy and our survival. Although a few groups are well-known (like earthworms), the complexity and diversity of many

more (like centipedes) all but overwhelm the poverty of our knowledge. We would do well to, at a bare minimum, know what species exist, where they occur, and what environmental needs and challenges they face.

Acknowledgements

I would like to thank Mr. Robert Holster, the Holster Scholarship program and its coordinator Dr. Jill Deans, and the Office of Undergraduate Research at the University of Connecticut, for providing financial support for this project, as well as Discover Life in America for providing housing, technical support, and lab facilities in the park. Rebecca Nichols, entomologist at GSMNP, provided me with access to the park's natural history collection and a list of taxa already known from the park. Dr. Jane O'Donnell, my research advisor at the University of Connecticut, provided counsel, support, and the encouragement needed to make this project work, as well as reference specimens from the University of Connecticut Biological Collection.

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Figures

Fig. I: A list of centipede species documented during the course of this study. Species that are newly recorded for Great Smoky Mountains National Park are in bold.

order	**family**	**genus**	**species**	**author**
Scutigeromorpha	Scutigeridae	*Scutigera*	*coleoptrata*	(Linnaeus)
Lithobiomorpha	Henicopidae	***Lamyctes***	***emarginatus***	**(Newport)**
Lithobiomorpha	Henicopidae	*Zygethobius*	*pontis*	Chamberlin
Lithobiomorpha	Lithobiidae	*Arenobius*	*manegitis*	(Chamberlin)
Lithobiomorpha	Lithobiidae	*Bothropolys*	*multidentatus*	(Newport)
Lithobiomorpha	Lithobiidae	***Garibius***	***catawbae***	**Chamberlin**
Lithobiomorpha	Lithobiidae	***Garibius***	***georgiae***	**Chamberlin**
Lithobiomorpha	Lithobiidae	*Garibius*	*pagoketes*	Chamberlin
Lithobiomorpha	Lithobiidae	*Gonibius*	*rex*	(Bollman)
Lithobiomorpha	Lithobiidae	***Lithobius***	***atkinsoni***	**Bollman**
Lithobiomorpha	Lithobiidae	***Lithobius***	***forficatus***	**(Linnaeus)**
Lithobiomorpha	Lithobiidae	***Lithobius***	***melanops***	**Newport**
Lithobiomorpha	Lithobiidae	*Nampabius*	*fungiferopes*	(Chamberlin)

Lithobiomorpha	Lithobiidae	***Nampabius***	***inimicus***	**Chamberlin**
Lithobiomorpha	Lithobiidae	***Nampabius***	***mycophor***	**Chamberlin**
Lithobiomorpha	Lithobiidae	***Nampabius***	***parienus***	**Chamberlin**
Lithobiomorpha	Lithobiidae	***Nampabius***	***tennesseensis***	**Chamberlin**
Lithobiomorpha	Lithobiidae	***Nampabius***	***turbator***	**Crabill**
Lithobiomorpha	Lithobiidae	*Nampabius*	*virginiensis*	Chamberlin
Lithobiomorpha	Lithobiidae	***Paobius***	***vagrans***	**Chamberlin**
Lithobiomorpha	Lithobiidae	***Sozibius***	***pennsylvanicus***	**Chamberlin**
Scolopendromorpha	Cryptopidae	*Cryptops*	*leucopodus*	(Rafinesque)
Scolopendromorpha	Plutoniumidae	***Theatops***	***posticus***	**(Say)**
Scolopendromorpha	Plutoniumidae	*Theatops*	*spinicaudus*	(Wood)
Scolopendromorpha	Scolopendridae	*Hemiscolopendra*	*marginata*	(Say)
Scolopendromorpha	Scolopocryptopidae	*Scolopocryptops*	*nigridius*	McNeill
Scolopendromorpha	Scolopocryptopidae	*Scolopocryptops*	*sexspinosus*	(Say)
Geophilomorpha	Dignathodontidae	***Strigamia***	***bidens***	**Wood**
Geophilomorpha	Dignathodontidae	*Strigamia*	*bothriopus*	Wood
Geophilomorpha	Dignathodontidae	*Strigamia*	*chionophila*	Wood
Geophilomorpha	Dignathodontidae	***Strigamia***	***hoffmani***	**Pereira**
Geophilomorpha	Geophilidae	*Arctogeophilus*	*umbraticus*	(McNeill)
Geophilomorpha	Geophilidae	***Arenophilus***	***bipuncticeps***	**(Wood)**
Geophilomorpha	Geophilidae	***Arenophilus***	***watsingus***	**Chamberlin**
Geophilomorpha	Geophilidae	***Geophilus***	***ampyx***	**Crabill**
Geophilomorpha	Geophilidae	***Geophilus***	***cayugae***	**Chamberlin**
Geophilomorpha	Geophilidae	***Geophilus***	***rupestris***	**(Crabill)**
Geophilomorpha	Geophilidae	*Geophilus*	*varians*	McNeill
Geophilomorpha	Himantariidae	***Chomatobius***	***euphorion***	**(Crabill)**

Fig. II: A list of centipede species previously recorded in GSMNP, provided by Discover Life in America.

order	**family**	**genus**	**species**	**author**
Scutigeromorpha	Scutigeridae	*Scutigera*	*coleoptrata*	(Linnaeus)
Lithobiomorpha	Henicopidae	*Zygethobius*	*sp.*	
Lithobiomorpha	Lithobiidae	*Arenobius*	*manegitis*	(Chamberlin)
Lithobiomorpha	Lithobiidae	*Bothropolys*	*multidentatus*	(Newport
Lithobiomorpha	Lithobiidae	***Enarthrobius***	***covenus***	**Chamberlin**
Lithobiomorpha	Lithobiidae	***Enarthrobius***	***dybasi***	**Chamberlin**
Lithobiomorpha	Lithobiidae	***Enarthrobius***	***fumans***	**Chamberlin**
Lithobiomorpha	Lithobiidae	***Enarthrobius***	***litus***	**Chamberlin**
Lithobiomorpha	Lithobiidae	*Garibius*	*pagoketes*	Chamberlin
Lithobiomorpha	Lithobiidae	*Gonibius*	*rex*	(Bollman)

Lithobiomorpha	Lithobiidae	***Helembius***	***nannus***	**Chamberlin**
Lithobiomorpha	Lithobiidae	***Nadabius***	***aristeus***	**Chamberlin**
Lithobiomorpha	Lithobiidae	***Nadabius***	***eremites***	**Chamberlin**
Lithobiomorpha	Lithobiidae	***Nadabius***	***pullus***	**(Bollman)**
Lithobiomorpha	Lithobiidae	*Nampabius*	*fungiferopes*	(Chamberlin)
Lithobiomorpha	Lithobiidae	***Nampabius***	***lundii***	**Chamberlin**
Lithobiomorpha	Lithobiidae	*Nampabius*	*virginiensis*	Chamberlin
Lithobiomorpha	Lithobiidae	***Paitobius***	***arienus***	**(Chamberlin)**
Lithobiomorpha	Lithobiidae	***Paitobius***	***carolinae***	**(Chamberlin)**
Lithobiomorpha	Lithobiidae	***Paitobius***	***juventus***	**(Bollman)**
Lithobiomorpha	Lithobiidae	***Sonibius***	***bius***	**(Chamberlin)**
Lithobiomorpha	Lithobiidae	***Sonibius***	***scepticus***	**Chamberlin & Wang**
Lithobiomorpha	Lithobiidae	***Sozibius***	***proridens***	**(Bollman)**
Scolopendromorpha	Cryptopidae	*Cryptops*	*leucopodus*	(Rafinesque)
Scolopendromorpha	Plutoniumidae	*Theatops*	*spinicaudus*	(Wood)
Scolopendromorpha	Scolopendridae	*Hemiscolopendra*	*marginata*	(Say)
Scolopendromorpha	Scolopocryptopidae	*Scolopocryptops*	*nigridius*	McNeill
Scolopendromorpha	Scolopocryptopidae	*Scolopocryptops*	*sexspinosus*	(Say)
Geophilomorpa	Dignathodontidae	*Strigamia*	*bothriopus*	Wood
Geophilomorpa	Dignathodontidae	***Strigamia***	***branneri***	**(Bollman C.H.)**
Geophilomorpa	Dignathodontidae	*Strigamia*	*chionophila*	Wood
Geophilomorpa	Geophilidae	***Arctogeophilus***	***fulvus***	**(Wood)**
Geophilomorpa	Geophilidae	*Arctogeophilus*	*umbraticus*	(McNeill)
Geophilomorpa	Geophilidae	***Geophilus***	***mordax***	**Meinert**
Geophilomorpa	Geophilidae	***Geophilus***	***orites***	**(Chamberlin)**
Geophilomorpa	Geophilidae	*Geophilus*	*varians*	McNeill
Geophilomorpa	Schendylidae	*Escaryus*	*liber*	Cook & Collins

Fig. III: New and previous centipede species records in GSMNP, broken down by order.

order	**previous records**	**new to GSMNP**	**total**
Geophilomorpha	9	8	17
Scolopendromorpha	5	1	6
Lithobiomorpha	22	13	35
Scutigeromorpha	1	0	1
total	37	22	59