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2012

This shrew is a jumping mouse (Mammalia, Dipodidae): *Sorex dichrurus* Rafinesque, 1833 is a synonym of *Zapus hudsonius* (Zimmermann, 1780)

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PROCEEDINGS OF THE
BIOLOGICAL SOCIETY
OF WASHINGTON

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Abstract.—Constantine S. Rafinesque described *Sorex dichrurus* as a shrew in 1833, based on a specimen he found in a proprietary museum near Niagara Falls on the New York/Ontario border. The name subsequently has been ignored by the scientific community. By describing this specimen as a shrew and ascribing it to the genus *Sorex*, Rafinesque clearly indicated that his species should be considered a member of the taxonomic family now recognized as the Soricidae (Mammalia, Eulipotyphla). Yet, the description of the animal, and its comparison to “*Gerbillus*,” clearly identify it as a dipodid rodent, specifically *Zapus hudsonius* (Zimmermann, 1780); *S. dichrurus* should be treated as a junior subjective synonym of that taxon. Based on its type locality of Goat Island, New York, this name is also a junior synonym of the subspecies *Z. hudsonius canadensis* (Davies, 1798).

Keywords: *americanus*, *canadensis*, *dichrurus*, nomenclature, Rodentia, Soricidae, Soricomorpha, taxonomy

The early nineteenth-century naturalist Constantine Samuel Rafinesque (1783–1840; a.k.a. Constantine Smaltz Rafinesque, Constantine Samuel Rafinesque Schmaltz) was a prolific, if not particularly careful, describer of the diversity of the natural world, particularly in the nascent United States. Among his accomplishments in documenting the botanical, zoological, geological, and paleontological resources of the Old and New Worlds, Rafinesque is credited with naming approximately 2700 genera and 6700 species of plants (Merrill 1949). Although plants, molluscs, and freshwater fishes appear to have attracted Rafinesque’s closest attentions (e.g., Rafinesque 1820a, Binney & Tryon 1864, Merrill 1949), other groups of organisms were not neglected, and he contributed more modest numbers of new names for mammals, birds, amphibians, reptiles, and a broad array of terrestrial, aquatic, and marine invertebrates, including insects (e.g., Rafinesque 1820b).

Among the mammals Rafinesque proposed is *Sorex dichrurus* Rafinesque, 1833, a species that he referred to as a shrew (Mammalia, Soricidae). Apart from the original description, however, there is only one subsequent mention of this species by Rafinesque (1840). The name, and the animal it represents, was ignored by Rafinesque’s contemporaries, and it does not appear in any subsequent synonymies of North American mammals. As part of my on-going studies of North American Soricidae, I identified the modern species for which this name was proposed, and I investigated the history of the name to determine its taxonomic validity and status.

Materials and Methods

Researching taxa described by C. S. Rafinesque is challenging. A large number of his publications occur in obscure, local periodicals and books, many of which

were self-published and had short histories, small publication runs, and limited circulation. *Sorex dichrurus*, for example, was described in Rafinesque's journal, *Atlantic Journal and Friend of Knowledge*, that lasted through eight numbers spanning the spring of 1832 through the winter of 1833.

I first identified the small mammal described and named by Rafinesque (1833) based on his original description, comparing it to the known modern mammalian faunas of New York and Ontario. External measurements of comparative specimens are those recorded by the original collectors on skin tags of specimens in the U.S. National Museum of Natural History (USNM), Smithsonian Institution, Washington, D.C. Head-and-body length was calculated by subtracting length of tail from total length. Percentage length of tail was calculated by dividing length of tail by head-and-body length and multiplying by 100. Specimens examined are listed in the Appendix.

To determine the taxonomic status of the name, I searched relevant synonymies in a number of taxonomic reviews and compendia, focusing on North American Soricidae (shrews) and Dipodidae (jumping mice; Bachman 1837, Baird 1857, Coues 1876, Merriam 1895a, 1895b; Miller 1895, Preble 1899, Krutzsch 1954, Hall 1981, Holden & Musser 2005, Hutterer 2005). No names proposed by Rafinesque appear among the synonymies for North American soricids, but several of his names, not including *S. dichrurus*, are addressed in the literature pertaining to dipodids, beginning with Coues (1876). For information regarding Rafinesque's activities in 1826, I studied his published autobiography (Rafinesque 1836) and his field notes for that year, preserved in the "Constantine Samuel Rafinesque papers 1815–1834 and undated" (RU 7250, Box 1: book 17), Smithsonian Institution Archives (SIA), Washington, D.C.

Rafinesque's Discovery of *Sorex dichrurus*

Rafinesque (1833:175) stated that he encountered the specimen that became the type of his *Sorex dichrurus* in the "Museum of the Falls." This discovery took place during a long journey he undertook after leaving his position at Transylvania University in Lexington, Kentucky, a post he had held for the previous seven years. In his autobiographical sketch, *A Life of Travels and Researches*, Rafinesque (1836) outlined his travels north from Kentucky to Sandusky, Ohio; by boat along Lake Erie to New York and southern Ontario; and eventually south through New York to his new home in Philadelphia, Pennsylvania. Although he wrote of his visit to Niagara Falls (Rafinesque 1833:81: "This phenomenon of nature excited my admiration instead of horror caused by [Mount] Etna."), he did not mention visiting any museums or studying any specimens of mammals. Fortunately, some of his hand-written field notes survive and are preserved in the Smithsonian Institution Archives. According to his outline-like notes for 1826, he visited Niagara Falls from 23rd to 26th May. He crossed the bridge to see Goat Island on 25 May, the same day he visited the museum. He wrote (SIA: RU 7250, Box 1, Folder 4):

25th May Th[ursday] — In stage to Manchester at Niagara Falls — Ridge road Devils rock on Niagara — Village of Manchester Judge [Augustus Seymour] Porter now amile [sic] Square Mills — fine place, Bath I[sland]. — bridge \$500 per annum 25 cents to Is[land] — Goat I[sland]. — 500 acres — fine plants — Shells Minerals — Museum Rock of Niagara geodic Limes[-] tone, at black rock hornstone Limestone, black hornstone Falls is carving away annually — now Indented — fashionable place, 2000 visitors annually at least, lots high — fine fish Osteognotus chloropterus —

Although Rafinesque's notes list the museum, plants, shells, minerals, some points of geology, and a fish (his name for the bowfin, *Amia calva*), there is no mention of a shrew, a mouse, or any specimen that could be the basis for *S. dichrurus*.

The museum in which Rafinesque found the jumping mouse was almost certainly Thomas Barnett's private cabinet of natural history housed in his home near Table Rock in Niagara Falls, Ontario. This collection served as the core of what has been touted as Canada's earliest museum, the Niagara Falls Museum, which Barnett formally opened to the public in 1827 (<http://www.niagaramuseum.com/> [accessed 18 July 2012]; Pine 1994; see Teather 2008 for an alternate early history of this institution). Barnett is described as "an expert taxidermist" by local historians (Czarnota 2011), and, by 1836, his museum displayed "upwards of 800 stuffed animals of various kinds and descriptions" (Parsons 1836:47). Specimens from the Niagara Falls Museum were exchanged with taxonomists throughout the world, with material traded internationally to collections such as those of the Smithsonian Institution (Taney & Henry 1856) and the Australian Museum (Kreff 1864). The Niagara Falls Museum existed in various forms and at different locations around Niagara Falls until 1999, when it was purchased by a private collector and moved to Toronto (Teather 2008). The history and status of the Niagara Falls Museum are relevant because it presents the possibility that the type specimen of *Sorex dichrurus* might still exist, either among the remaining collections of the museum, or among the specimens traded to, or purchased by, another institution.

Description and Identity of *Sorex dichrurus*

Rafinesque described *S. dichrurus* as article 133 in the summer 1833 issue of his *Atlantic Journal*. This article reads in full (Rafinesque 1833:175–176):

133. *Sorex dichrurus*. N. Sp. of Shrew.

I discovered this new small quadruped, in 1826, at the falls of Niagara; it had been caught even on Goat Island, in the middle of the falls, and preserved in the Museum of the Falls. It must dwell both in Canada and New York, but is rare,

not having seen it elsewhere. —The specific name means tail bicolored.

Sorex dichrurus. Raf. Fulvous, back brown, belly white, tail longer than body, nodose [sic], with a pencil of hair at the tip, fulvous above, white beneath.

Small animal, similar to a mouse, and to some sp. of *Gerbillus*. Body 3 inches long, tail slender, 4 or 5 inches, head slanting, and elongated, snout sharp, eyes oblong, ear small oboval.

The title of Rafinesque's article provides the context for understanding his new species as a soricid. He specifically referred to his new species as a "shrew," and he placed it in the genus *Sorex*, the name then applied to all North American soricids (Harlan 1825, Godman 1826). No North American shrew, however, comes close to this description, either in pelage coloration or in having a tail longer than its head and body (Table 1). Moreover, in a seemingly irrelevant comparison for describing a shrew, Rafinesque notes the similarity of *S. dichrurus* to *Gerbillus*, a genus that at the time included North American jumping mice (*Zapus* Coues, 1876 and *Napaeozapus* Preble, 1899: Dipodidae, Zapodinae), as well as Old World gerbils (Muridae, Gerbillinae). That he understood the distinction between shrews and gerbil-like rodents is clear from his earlier classification of mammals (Rafinesque 1815:58, 59) in which he placed *Sorex* as a genus of his Family Sorexia, Order Ferea ("Les Carnassiers") and classified *Gerbillus* as a genus of his Family Dipodea, Order Gliria ("Les Gliriens"). Moreover, he claimed at one time to be preparing a monograph on *Gerbillus* in which he would name ten Old and New World species (Rafinesque 1814). Rafinesque's ability to distinguish these mammals in practice, however, is less apparent. Three species of North American *Gerbillus* previously described by Rafinesque (1814, 1818) were questioned by Coues (1876:262), who described them as "undoubtedly figments of the author's fertile imagination" (although, in fact, at least two of these species more likely derived from the imagination

Table 1.—External measurements (mm) of *Sorex dichrurus* and *Zapus hudsonius*. Measurements for *S. dichrurus* are based on Rafinesque's (1833) estimate of the animal's body proportions and were converted from inches.

| | Head and body length | Tail length | Tail as percentage of head and body |
|-------------------------------------|----------------------|-------------|-------------------------------------|
| <i>S. dichrurus</i> | 76 | 102–127 | 134–167 |
| Dipodidae: | | | |
| <i>Z. h. canadensis</i> | 80 ± 5 | 126 ± 7 | 159 ± 12 |
| (n = 7) | 70–84 | 117–134 | 140–176 |
| <i>Z. h. americanus</i> | 85 ± 4 | 125 ± 7 | 147 ± 9 |
| (n = 23) | 79–94 | 113–140 | 133–165 |
| Soricidae: | | | |
| <i>Sorex cinereus cinereus</i> | 47 ± 5 | 40 ± 2 | 86 ± 9 |
| (n = 34) | 36–61 | 34–47 | 62–104 |
| <i>Sorex fumeus fumeus</i> | 68 ± 6 | 45 ± 2 | 67 ± 6 |
| (n = 22) | 59–79 | 40–49 | 57–81 |
| <i>Blarina brevicauda talpoides</i> | 94 ± 5 | 27 ± 3 | 29 ± 3 |
| (n = 25) | 85–101 | 22–35 | 24–38 |
| <i>Cryptotis parvus parvus</i> | 58 ± 7 | 16 ± 3 | 29 ± 5 |
| (n = 26) | 46–72 | 12–21 | 20–36 |

of J. J. Audubon, who provided the credulous Rafinesque with descriptions and illustrations of a number of fantastic animals—Markle 1997). Rafinesque's applied understanding of shrews is similarly questionable. A species he named *Sorex melanotis* (the “Black-eared shrew”; Rafinesque 1818:446) is listed in his field notes as “*Musculus melanotis – au Sorex*,” where it is compared to the opossum, *Didelphis* (SIA: RU 7250, Box 1, Folder 4: Book 17).

Despite the clear differences between *Sorex* and *Gerbillus* as understood by North American naturalists by 1833 (Harlan 1825, Godman 1826), Rafinesque's description of *S. dichrurus* closely matches a jumping mouse in size (Table 1), in the “pencil of hairs” at the tip of the tail (Coues 1876), and in the tri-colored pelage (dark-colored dorsum; paler, but distinctly colored laterum; and white ventrum—Figs. 1, 2). By describing the tail as “nodose” (knobby or knotty), Rafinesque suggested that the tail vertebrae were present, and his notation regarding the “pencil of hairs” at its tip indicates that it was unbroken, thus rendering the tail measurement more accurate (Table 1). Of the two similarly sized species of dipodids

in New York and adjacent Ontario, Rafinesque's description of the pelage more closely matches the fulvous *Zapus hudsonius* (Zimmermann, 1780) than the more brightly rufous *Napaeozapus insignis* (Miller, 1891). Also, the tip of the tail of *N. insignis* is white, whereas the description of *S. dichrurus* (and its Latin name) matches the completely bicolored tail characteristic of *Z. hudsonius*. The type locality of *S. dichrurus* is Goat Island, New York, which is within the distribution of the subspecies *Z. hudsonius canadensis* (Davies, 1798) according to Hall (1981). Therefore, *Sorex dichrurus* should be treated as a junior subjective synonym of both *Z. hudsonius* and *Z. hudsonius canadensis*.

Obscurity of *Sorex dichrurus*

The only subsequent mention of *S. dichrurus* in print is in an article entitled, “The new Quadrupeds of North America, described in my Atlantic Journal of 1832,” that Rafinesque (1840:68) published in his journal *The Good Book and Amenities of Nature*. This article was a proactive attempt by Rafinesque to bring *S. dichrurus*, and a number of other species he named, to the attention of contemporary



Fig. 1. Illustrations based on the two syntypes of *Dipus canadensis* Davies 1798 (= *Zapus hudsonius canadensis*) from "the neighbourhood of Quebec," Canada (Davies 1798:155). Image courtesy of the Joseph F. Cullman 3rd Library of Natural History, Smithsonian Institution Libraries, Washington, D.C.

taxonomists. Unfortunately, he forgot, or ignored as trivial, the fact that *S. dichrurus* was described in 1833 (rather than 1832), and he misspelled *S. dichrurus* as "*S. dicrurus*." Although Rafinesque was notorious for proposing "improved" names for already named species (including some of his own: Merrill 1949, Boewe 2003), in this instance, it seems likely to have been a misprint. Despite his efforts, there is no record of the scientific community recognizing *S. dichrurus*, either as a shrew or as a jumping mouse. Rafinesque's tendency to publish in obscure, difficult-to-obtain journals may have left many of his fellow naturalists unaware of his discovery. The continued confusion of "*Gerbillus*" and "*Sorex*" would also have made it difficult for taxonomists to understand what kind of animal was described. Many of Rafinesque's contemporaries simply chose to

ignore his work. Richard Harlan's antipathy, summarized in the Introduction of his *Fauna Americana* (1825:vii), is representative of many of Rafinesque's fellow natural historians:

Mr. Rafinesque, professor in the Transylvania University, in the State of Kentucky, has described, or rather indicated, a great variety of animals; but his insulated situation, and almost utter ignorance of the labours of other naturalists, have seduced him into grievous errors, and occasioned much confusion in natural history. It is possible, that some of his animals may be new species, but from the looseness of his imperfect descriptions, we have been obliged to reject them in almost every instance.

The aversion of this earlier generation of natural historians, combined with Rafinesque's own "grievous errors" and his practice of publishing in obscure journals, has resulted in ignorance of much of his work among later generations of biolo-

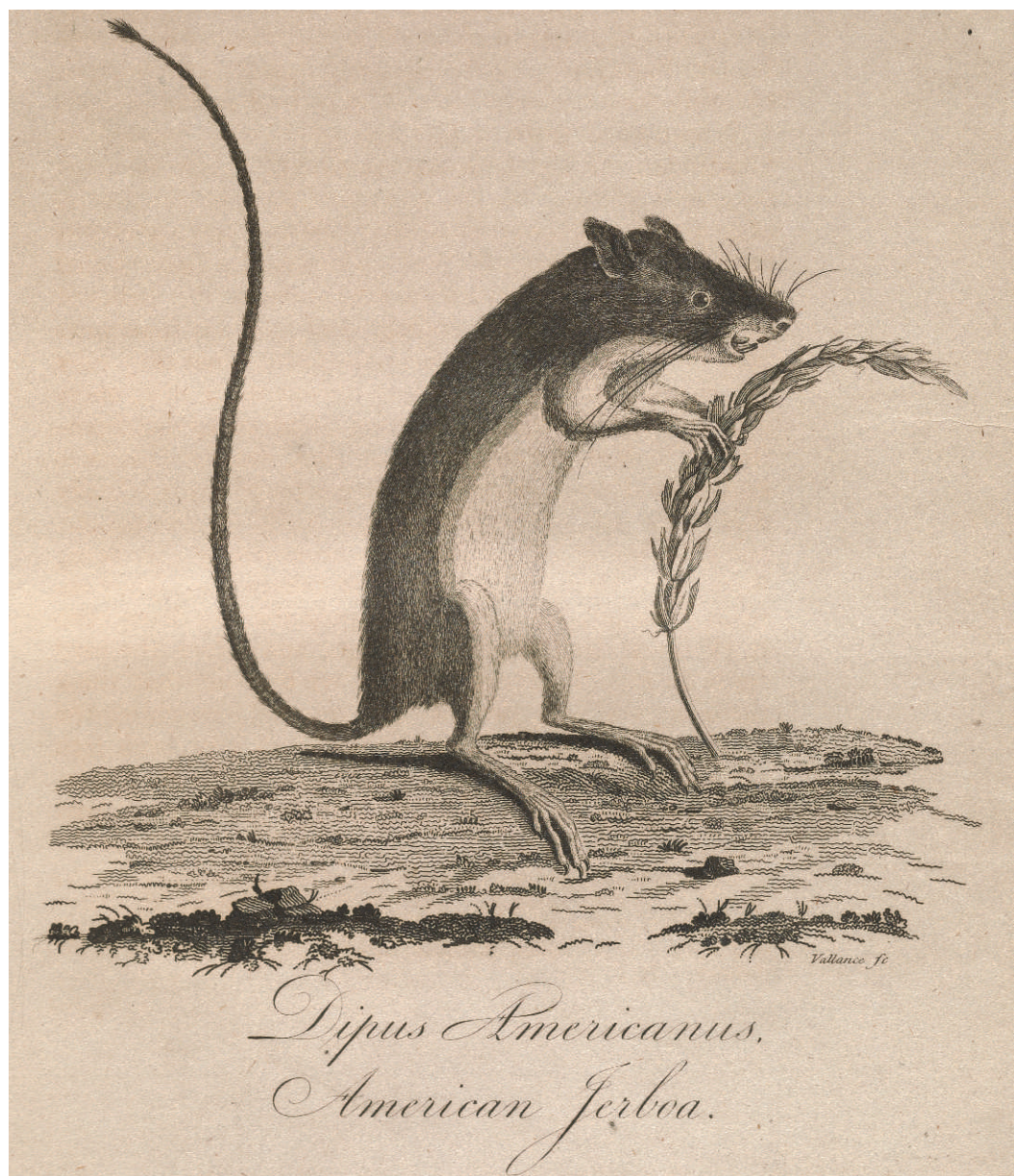


Fig. 2. Illustration of one of the two syntypes of *Dipus americanus* Barton 1799 (= *Zapus hudsonius americanus*), from "near the river Schuylkill, a few miles from Philadelphia," Pennsylvania (Barton 1799:114). Image courtesy of the Dibner Library of the History of Science and Technology, Smithsonian Institution Libraries, Washington, D.C.

gists. In the first comprehensive systematic reviews of the jumping mice, for example, Coues (1876) and Preble (1899) appear to have been unaware of Rafinesque's description of *S. dichrurus*, which is under-

standable considering that it was described as a shrew. Preble (1899:11) correctly discounted two other species described by Rafinesque (1818), *Gerbillus megalops* and *G. leonurus*, as "plainly not referable to

Zapus.” Regarding a third, *G. soricinus* Rafinesque, 1814, Preble (1899:12) only stated, “I have not seen the original reference.” None of these species has been listed subsequently by mammalian taxonomists (e.g., Krutzsch 1954, Hall 1981, Holden & Musser 2005).

Despite his tendency toward hastiness and brevity in his taxonomic work and publications (Pennell 1942, Merrill 1949, Boewe 2003), Rafinesque has been described as “beyond question the best field-botanist of his time” (Pennell 1942:59), and the names of taxa proposed by him, even those outside the plant kingdom, require a fair evaluation. Recognition of his contributions is relevant to understanding the early development of knowledge about the native biota of North America as well as the philosophies that guided that knowledge.

Amended Synonymy

Zapus hudsonius canadensis

Dipus hudsonius Zimmermann, 1780:358.

Type locality: Hudson Bay, Canada.

Dipus canadensis Davies, 1798:157. Type locality: near city of Quebec, Canada.

Sorex dichrurus Rafinesque, 1833:175.

Type locality: Goat Island, New York.

Sorex dicrurus: Rafinesque, 1840:68 (incorrect subsequent spelling of *S. dichrurus* Rafinesque, 1833).

Zapus hudsonius: Coues, 1876, 1:253 (name combination).

Zapus hudsonius canadensis: Batchelder, 1899:4 (name combination).

Zapus hudsonius ontarioensis Anderson, 1943:59. Type locality: Pancake Bay (Batchawana Bay), Lake Superior, about 40 mi NE Sault Ste. Marie, Ontario, Canada.

Acknowledgments

My sincere thanks to Tad Bennicoff (SIA); Daria Wingreen-Mason and Leslie

Overstreet (Smithsonian Institution’s (SI) Joseph F. Culman 3rd Library of Natural History); Kirsten Van der Veen (SI’s Dibner Library of the History of Science and Technology); Erin Rushing (SI Libraries Digital Imaging Division). Sandy Feinstein, Robert Fisher, Alfred L. Gardner, and an anonymous reviewer provided valuable comments on previous versions of this manuscript.

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Associate Editor: Michael D. Carleton.

Appendix

Specimens Examined

All specimens listed are in the United States National Museum of Natural History (USNM), Smithsonian Institution, Washington, D.C.

Blarina brevicauda.—NEW YORK: 22839, 22840, 22915, 35462, 35463, 35465–35470, 35472–35476, 35506–35513, 36280.

Cryptotis parvus.—MARYLAND: 283659, 283660, 567524–567526, 570487. NEW JERSEY: 302727–302729. VIRGINIA: 331041, 332319, 364538, 395306,

522984, 528371, 528375, 528376, 568146–568151, 569083, 569087, 569088.

Sorex cinereus.—NEW JERSEY: 34747–34751, 76663–76671, 302709–302711, 305138. NEW YORK: 56582, 56584–56586, 56588–56590, 82821, 83165, 111042. ONTARIO: 319520, 319521, 320002–320005.

Sorex fumeus.—NEW HAMPSHIRE: 76391, 76392, 289525, 289526. NEW YORK: 34561, 55945, 55946,

83163, 83164, 110811, 111043, 111044, 254056–254065.

Zapus hudsonius americanus.—NEW YORK: 56575, 56576, 56578–56580, 86251, 110986, 110988, 110992, 110993, 110995–110997, 110999, 111001–111003, 111006, 111010, 171929, 246001, 282741, 282742.

Zapus hudsonius canadensis.—ONTARIO: 264534, 320049–320051. QUEBEC: 303363, 303366, 320052.