A NORTHWARD RANGE EXTENSION OF THE HISPID COTTON RAT (*SIGMODON HISPIDUS*) IN MISSOURI—The hispid cotton rat (*Sigmodon hispidus*) is a widely distributed rodent with a geographic range extending from north-central Mexico to southern Nebraska and central Virginia and from southeastern Arizona east to Florida (Carleton et al. 1999, Peppers and Bradley 2000, Wilson and Reeder 2005) with isolated populations in Arizona (Bradley et al. 2012) and California (Clark 1972). Range expansions for the species have been well documented (Clark 1972, Farney 1975, Benedict et al. 2000, Wright et al. 2010, Wills et al. 2011). The majority of these range expansions have occurred across the Central Plains during the 20th century and have been attributed to climate change (e.g., Benedict et al. 2000, Hoffman 2008).

Bailey (1902) was the first to document movement of *S. hispidus* into the Central Plains by documenting individuals for the first time in Kansas that most likely moved northward from Oklahoma. By 1947, the species had reached the Kansas/Nebraska border (Cockrum 1948). Just over 10 years later, Jones (1960) reported 12 individuals near the Nemaha River in southeastern Nebraska, and by the late 1960s (Choate and Genoways 1967, Genoways and Schlitter 1967) and mid-1970s (Farney 1975), the species had been documented in several parts of the state.

Recent studies have not documented *S. hipsidus* north of the Platte River in Nebraska (Benedict et al. 2000, Wright et al. 2010, Wills et al. 2011), which may have acted as a dispersal barrier. However, in the adjacent state of Missouri, Genoways and Schlitter (1967) reported the first record of the species just north of the Missouri River in Platte County, suggesting the permeability of such a barrier (Puth and Wilson 2001). Genoways and Schlitter (1967) hypothesized that periodic floods may have resulted in the displacement of individuals on the northern side of the river. In addition, they posited that dispersal might have been possible when the river was covered with ice during the cold periods of the year. Additional collecting efforts within Platte County confirmed the establishment of the species north of the Missouri River (Easterla 1968). Prior to these studies (Genoways and Schlitter 1967, Easterla 1968), *S. hispidus* only had been reported from areas exclusively south of the Missouri River (Schwartz and Schwartz 2001). Although *S. hispidus* first was documented in Missouri in 1945, Schwartz and Schwartz (2001) suggested that the species likely had been established in the state for some time, but they were unable to rule out a recent range expansion similar to that documented in areas west of the state. The discovery of remnants of three *S. hispidus* in owl pellets found within Fremont County in southwestern Iowa (Bowles 1975, 1977) would suggest the latter; however, the vouchered presence of *S. hispidus* populations in areas further north of the Missouri River has yet to be recorded.

In 2005 and 2006, during collecting efforts for another study (Thompson et al. 2011), we collected 14 *S. hispidus* (5 females, 9 males) from six localities in northwestern Missouri (Table 1, Fig. 1). We trapped individuals with Sherman

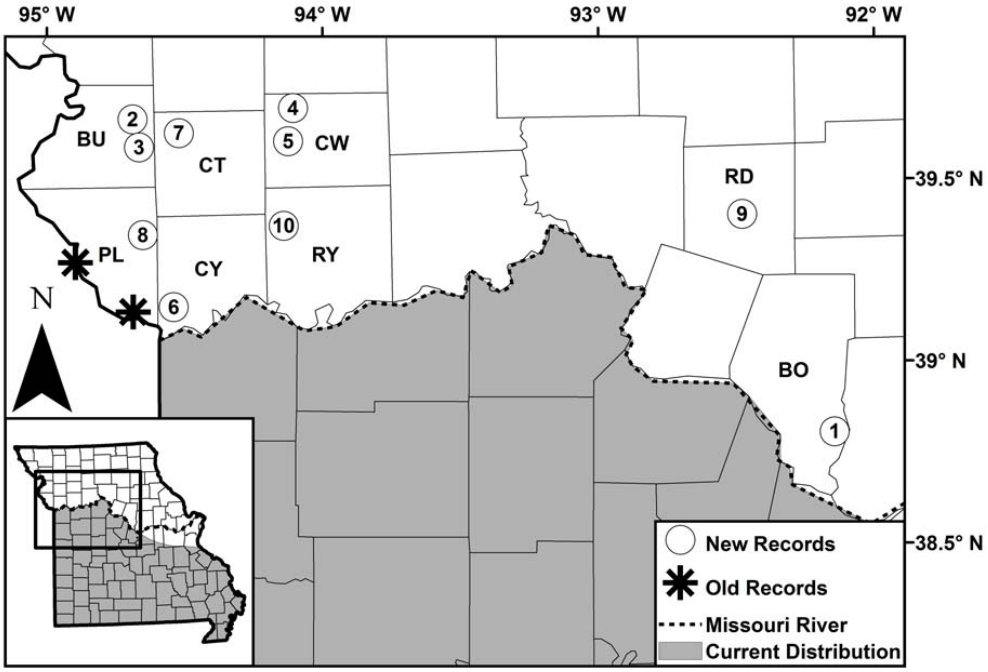

Figure 1. Map of old and new locality records for Sigmodon hispidus north of the Missouri River in the state of Missouri, USA. Current distribution of S. hispidus was redrawn from Schwartz and Schwartz (2001). Old records were reported previously by Genoways and Schlitter (1967) and Easterla (1968). Numbers within circles correspond to the localities of new records documented herein and detailed in Table 1. BO = Boone County, BU = Buchanan County, CW = Caldwell County, CT = Clinton County, CY = Clay County, PL = Platte County, RD = Randolph County, and RY = Ray County.

Table 1. Localities of new records for *Sigmodon hispidus* north of the Missouri River in the state of Missouri. Locality # corresponds to localities represented in Figure 1. Specimens collected for this study were deposited and cataloged at the Natural Science Research Laboratory, Texas Tech University. Additional unpublished records also were included and are indicated in bold.

Loc. #[a]	County	Specific Locality	Date	*N*[b]	Catalog #(s)[c]
1	**Boone**	**1.61 km W of Columbia Airport**	**17 Oct 1966**	**1**	**MUMZ 3286**
2	Buchanan	4.43 km W Easton (T57N, R34W, SE 1/4 sec. 27)	6 Jul 2006	1	TTU 115921
3	**Buchanan**	**Between Gower and Agency**	**5 Dec 1969**	**1**	**MUMZ 3423**
4	Caldwell	3.22 km S, 1.21 km W Kidder (T57N, R29W, SW 1/4 sec. 14)	25 May 2006	1	TTU 115920
5	Caldwell	1.21 km N, 8.05 km W Kingston (T56N, R29W, NE 1/4 sec. 22)	6 Nov 2005	1	TTU 115922
6	**Clay**	**Gladstone**	**4 Feb 1972**		**CMSU 1071**
7	Clinton	7.64 km N, 6.44 km E Gower (T56N, R32W, W 1/2 sec. 8)	8 Jul 2006	4	TTU 115909–115912
8	Platte	5.63 km S, 2.41 km W Ridgely (T53N, R34W, SE 1/4 sec. 13)	8 Jul 2006	6	TTU 115913–115918
9	**Randolph**	**N/A**	**3 Nov 1989**	**1**	**CMSU 1708**
10	Ray	2.01 km S, 4.83 km E Lawson (T52N, R29W, NE 1/4 sec. 9)	9 Jun 2006	1	TTU 116511

[a] Loc. # = locality number; [b] *N* = sample size; [c] MUMZ = University of Missouri, Museum of Zoology; TTU = Natural Science Research Laboratory, Texas Tech University; and CMSU = Central Missouri State University. N/A = not available.

live traps (H. B. Sherman Traps, Tallahassee, Florida, USA) baited with dried oats. We placed traps in roadside ditches dominated primarily by smooth brome (*Bromus inermis*). We prepared individuals as voucher specimens with standard tissues taken (heart, kidney, liver, muscle, lung, and spleen) and deposited in the Natural Science Research Laboratory, Museum of Texas Tech University, Lubbock, USA. We obtained additional specimen records from museum research collections and the Missouri Department of Conservation (MDC) to provide a thorough examination of the species' distribution in the state and to potentially document unpublished records.

Our records represent a range extension for the species with the farthest locality north (~85 km) of specimens previously reported north of the Missouri River (Genoways and Schlitter 1967, Easterla 1968). These specimens expanded the known distribution of this species into three new counties (i.e., Caldwell, Clinton, Ray) in Missouri. Additional vouchered county records north of the Missouri River were discovered in Boone, Buchanan, Clay, and Randolph counties through our query of museum research collections and the MDC (Table 1, Fig. 1). The records in Boone and Randolph counties indicate that populations of *S. hispidus* have established themselves north of the Missouri River in central Missouri. The MDC also reported records from Holt and Howard counties; however, these records have no verifiable vouchers and were not considered further.

Although rivers do not appear to be a prohibitive barrier to the expansion of the geographic range of *S. hispidus*, the species' range has not expanded as far north in Missouri as it has in Nebraska. Several hypotheses have been postulated to explain the slowing northward expansion in Nebraska, including *S. hispidus* encountering a new predator, (i.e., the least weasel [*Mustela nivalis*]; Hoofer and Choate 1997) and reaching the limitation of its climatic tolerance (Benedict et al. 2000). However, efforts to collect *S. hispidus* in Missouri have not been documented as intensely in the literature as states to the west, minimizing the possibility for recognizing range expansion (Frey 2009). Therefore, the most parsimonious explanation currently is that the specimens of *S. hispidus* reported herein were from populations north of the Missouri River not documented previously and merely represent a range extension (Frey 2009).

Nonetheless, given the potential for existing populations in Holt and Howard counties in Missouri, it is possible that this species has expanded into northwestern Missouri and reached southwestern portions of Iowa (Bowles 1975, 1977). Individuals of *S. hispidus* are highly successful at reproduction (Cameron and Spencer 1981), and a single, pregnant female dispersing into virgin territory would have the potential to establish a population. Further expansion of such a population would be relatively easy. Males and females have been reported reproductively active as early as one month in age (Chipman 1965). In addition, members of this species are known to have several litters a year (Bancroft 1969) with litter sizes ranging from 1 to 15 pups (Kilgore 1970). Furthermore, *S. hispidus* is active year around (Calhoun 1945), increasing the likelihood of the species expanding its range into previously unoccupied regions. Though it is likely that *S. hispidus* has been trekking northward in Missouri as a response to climate change (Hoffman 2008), additional collecting efforts will be needed to determine whether the species is undergoing an ongoing range expansion or whether it has

been established north of the Missouri River for some time.

Portions of this research were supported by the Central Plains Society of Mammalogists and the Kansas Academy of Sciences. Additional funding was provided by the Department of Biological Sciences and Graduate School at Fort Hays State University. We thank A. L. Sandquist, Iowa Department of Natural Resources, and Squaw Creek National Wildlife Refuge for providing housing during fieldwork. Additional thanks to Central Missouri State University (V. Jackson), Missouri State University (L. Robbins), Truman State University (J. Luscier), Missouri Department of Conservation (D. Fantz), and U.S. Fish and Wildlife Service (F. Durbian) for providing data on specimens. We also thank H. H. Genoways, J. D. Hoffman, and two anonymous reviewers for comments on an earlier version of this manuscript.—*Cody W. Thompson[1,3] and Elmer J. Finck[2]. [1]Department of Biological Sciences, Texas Tech University, Lubbock, Texas 79409-3131, USA; [2]Department of Biological Sciences, Fort Hays State University, Hays, Kansas 67601-4099, USA; [3]Corresponding author email address: cwthomp@umich.edu.*

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Submitted 12 February 2013. Accepted 18 September 2013. Associate Editor was Sue Fairbanks.