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NOTES

RANGE EXTENSION OF THE VIRGINIA OPOSSUM (*DIDELPHIS VIRGINIANA*) IN NORTH DAKOTA—

The Virginia opossum (*Didelphis virginiana*) is broadly distributed across North America from Costa Rica in the south to southern Ontario in the north and from the southern Great Plains in the west to the eastern United States. The Virginia opossum also was introduced multiple times to the Pacific Coast beginning in the late 1800s and has established populations in that region (Gardner and Sunquist 2003). This species is a habitat generalist known to frequent wetland and hardwood habitats but also can be found in grasslands, along forest edges, and in agricultural and suburban settings throughout its range (Gardner and Sunquist 2003, Beatty et al. 2014). However, the Virginia opossum is adapted poorly to winter, limiting its northern distribution to more tolerable warmer climates. It does not hibernate or exhibit torpor, and it will remain in its den rather than forage on nights when temperatures are below freezing or when there is deep snow, risking starvation if more than 54 days of winter are too harsh to forage (Brocke 1970).

Despite these limitations, the Virginia opossum has expanded north in recent decades (Myers et al. 2009) and has been documented in novel areas of the Upper Midwest and New England (e.g., Dice 1927, Goodwin 1935, Jackson 1961). Both climate change and human land use alteration have been identified as contributing factors to their current range expansion. A recent study conducted across Michigan and Wisconsin identified reduced days of snow on the ground and increased agricultural land as two key factors facilitating the opossum's expansion in the Midwest (Walsh and Tucker 2017). As generalist omnivores, opossums benefit from increased road kill and resources provided by agricultural practices (Beatty et al. 2014). Humans are further ameliorating winter conditions by providing shelter and easily accessible food, as evidenced by opossums in urban areas weighing more than individuals in adjacent natural habitats (Kanda 2005, Wright et al. 2012).

The Virginia opossum has long been established in the southern Great Plains, with fossil records in Texas dating back approximately 800,000 years (Graham and Lundelius 2010). Within the past two centuries, the Virginia opossum began spreading into the northern Great Plains and was documented in Nebraska by the early 1900s (Swenk 1908). The earliest museum record from South Dakota was collected in 1933 near the Nebraska border (USNM 251112), and the species has since become noticeably more common along the eastern side of the state (Choate and Jones 1980). The Virginia opossum also has become well established in the southern half of Minnesota over the past century (Hazard

1982, MN DNR 2017).

The first reported sightings of Virginia opossum in North Dakota came from the southeastern corner of the state along the Red River Valley between the 1930s and 1950s (Bailey 1926, Adams 1961), although the species was not confirmed in the state until 1990 (Seabloom 2011). Over the past twenty years, anecdotal sightings have been reported to the North Dakota Game and Fish Department (NDGF), including one from Ward County, in the northwestern corner of the state. This record, though, has no verifiable voucher and the location reported is approximately 270 km from previous observations. Verifiable observations that included either photo or carcass evidence have been restricted to seven counties south of Grand Forks (S. Tucker, NDGF, personal communication; Table 1). Only one Virginia opossum from North Dakota has been deposited in a museum collection as a voucher specimen (UND 2583, skin and skull). This female opossum was collected in Bismarck during the early fall and had the following measurements: total length 726 mm; tail length, 282 mm; hind foot length, 62 mm; ear length, 44 mm; and weight, 1.60 kg. Her weight suggests she was a young adult. Sightings of the Virginia opossum have been reported to NDGF in all four seasons, with most reports falling in summer and early autumn (Table 1). The Virginia opossum records in North Dakota are noticeably associated with major rivers and streams, including waterways in the Red River Basin and the Missouri River. These waterways include riparian zones with green ash (*Fraxinus pennsylvanica*) and elm trees (*Ulmus pumila*), potentially serving as corridors for dispersing populations of Virginia opossum from Minnesota and South Dakota; these records are summarized as a map in Figure 1 and detailed in Table 1.

Herein, we report a 220 km range extension of the Virginia opossum north from the closest established populations in Minnesota and South Dakota and the second museum voucher for the species in North Dakota. The individual was first spotted in a suburban Grand Forks neighborhood adjacent to a marsh during the early morning of 20 January 2017. Grand Forks residents reported to the first author (LLW) that they observed the opossum eating at the base of a bird feeder and attempting to enter a dog's outdoor shelter. Grand Forks is located within the Red River Valley, which is predominated by tallgrass prairie. The city of Grand Forks, with a population over 52,000, is largely developed and surrounded by various agriculture including soybeans, barley, sugar beets, potatoes, and alfalfa (US Census Bureau 2010). Approximately 89% of land in Grand Forks County is farmland (USDA 2012). Undeveloped prairie is more predominant on the western side of the county (ND GIS Hub 2015).

Table 1. Locality information for all available records of Virginia opossum (*Didelphis virginiana*) in North Dakota. Visual observation and carcass data provided by North Dakota Game and Fish Department (NDGF).

Map No.	Catalog No. ^a	Sex	County	Specific Locality	Date	Source
1	UMMZ 178776	Male	Grand Forks	Grand Forks	22 Jan 2017	Voucher skin, skull, and skeleton
1	No voucher	Male	Grand Forks	Grand Forks	5 June 2017	Photo, NWRC ^a
2	UND 2583	Female	Burleigh	Bismarck	13 Sep 1990	Voucher skin and skull
3	No voucher	N/A	Ward	T161, R088, sec. 03	10 Sep 1991	Visual observation, NDGF
4	No voucher	N/A	Stutsman	T141, R069, sec. 28	28 Jun 1996	Visual observation, NDGF
5	No voucher	N/A	Traill	T144, R053, sec. 34	13 June 2011	Carcass, NDGF
6	No voucher	N/A	Cass	T137, R052, sec. 19	2 Jan 2005	Photo, NDGF
7	No voucher	N/A	Burleigh	T141, R077, sec. 06	22 Jul 2008	Carcass, NDGF
8	No voucher	N/A	Ransom	T133, R053	7 Sep 2008	Carcass, NDGF
9	No voucher	N/A	Dickey	T131, R062, sec. 10	13 Sep 2008	Carcass, NDGF
10	No voucher	N/A	Richland	T132, R052, sec. 29	1 Nov 2009	Carcass, NDGF
11	No voucher	N/A	Burleigh	T141, R081, sec. 25	20 June 2012	Visual observation, NDGF
12	No voucher	N/A	Barnes	T138, R056, sec. 13	15 Dec 2014	Photo, NDGF
13	MZ 11627	Male	Ransom	Isley Twp, sec. 05	19 June 2017	Voucher in prep

^aUMMZ = University of Michigan Museum of Zoology, UND = University of North Dakota, NWRC = National Wildlife Research

Center, MZ = UMMZ Mammal Division's field number series

In the same area the opossum was observed originally, an individual was killed by bow and arrow by a Grand Forks resident on 22 January 2017 and subsequently deposited in the collections of the University of Michigan Museum of Zoology (UMMZ), with permission from NDGF. The specimen was prepared as a standard voucher (skin, skull, and skeleton) and cataloged as UMMZ 178776 (Table 1). The UMMZ archived tissue samples of heart, kidney, liver, lung, spleen, muscle, and testes and took a blood sample for future virus screening. The specimen was male with testes descended (largest testis, 29 × 18 mm). Standard external measurements were as follows: total length, 875 mm; tail length, 373 mm; hind foot length, 73 mm; ear length, 50 mm; and weight, 2.39 kg.

The individual's abdominal skin thickness was 7.52 mm (measured with a digital caliper [Fowler, Boston]). There were no ectoparasites found on the haunches, nape, snout, or behind ears, all of which are areas most likely to harbor ectoparasites, especially mites (Whitaker et al. 1976). No endoparasitic worms were observed in the intestines under a dissecting microscope (WILD, Heerbrugg, Switzerland). The content of the stomach and intestines also was evaluated under a dissecting microscope. The stomach was full, indicating that the opossum successfully foraged prior to death, and we identified sunflower seeds, muscle tissue, hair,

and unidentified bone fragments from small mammals in the stomach. We found grass, leaf matter, and a sunflower seed in the lower intestine, along with guard hair distributed throughout the lower intestine in a density of at least ten hairs per inch, suggesting it had groomed recently.

Frostbite is known to affect the ears, tail, footpads, limbs, face, and male genitals in domesticated mammals. Clinical signs in areas affected include blisters, ulcers, and discoloration of skin, with the skin turning black as it becomes necrotic (Scott 2008). In opossums, the typical frostbite symptoms reported are missing or blistered ears and tail (Gardner and Sunquist 2003). Other than slight red coloration of the left ear, this individual did not display the common signs of frostbite for opossums. However, the hind feet were blackened and crusty, while the nose was inflamed with blisters. This likely indicates that, similar to domestic animals, the footpads and face, along with ears and tail, are also susceptible to frostbite in opossums.

Opossums remain in their den rather than forage on days when temperatures do not reach above freezing (Brocke 1970). Between 1 December 2016 and 22 January 2017, when the opossum died, there were 41 days in which the temperature did not reach above freezing (NOAA 2017), and the individual was thin enough to readily feel ribs and sacral vertebrae. The winter temperatures and the individual's condition suggest

that this opossum spent much of the winter in a den rather than foraging. Its weight was less than opossums trapped in January in Massachusetts that were known to have survived through the winter (Kanda 2005). By remaining in its den, this opossum may have reduced exposure to wind and snow that would typically cause frostbite in the ears and tail, with the nose and hind feet bearing the brunt of the cold den floor. Given its full stomach, the individual likely was persisting via opportunistic foraging around Grand Forks residents' homes whenever temperatures reached above freezing. Between 20 and 22 January 2017, the time frame in which the opossum was observed foraging, the minimum temperature in Grand Forks was at or above freezing (NOAA 2017).

Because of their relatively slow metabolic rate, Virginia opossum only need to forage 35 days in the winter to avoid starvation, provided these foraging sessions are successful (Brocke 1970). Therefore, increased access to resources, such as those in an urban area like Grand Forks, might increase successful foraging events and allow the Virginia opossum to expand into more northerly areas that would otherwise be intolerable. Juvenile and adult male opossums tend to disperse more than their female counterparts (reviewed by Gardner and Sunquist 2003), a trait that often makes males the earliest colonizers in a range extension. However, it is important to note that the first vouchered specimen in North Dakota was female.

Since the collection of UMMZ 178776, two additional adult male opossums have been reported in North Dakota (see Table 1, Fig. 1). Researchers found the first opossum in a skunk trap in Grand Forks on 5 June 2017 near the same marsh habitat and neighborhood as the individual described above (Dokken 2017); it was released at the trap site with no measurements taken. The second individual was killed in a trap baited with cat food during a predator survey in Ransom County on 19 June 2017. This specimen was obtained by the UMMZ and will be archived in the mammal collection. These additional sightings provide further support that opossums likely have established themselves in North Dakota. However, additional survey work, especially in more northern localities, such as Grand Forks and the Red River Valley, is needed to determine whether or not a breeding population exists in the state.

This research was funded by a departmental grant from the University of Michigan's Ecology and Evolutionary Biology Department. We thank C. Kuster for reporting her observation of the specimen and S. Easter for helping us locate the specimen. We also thank E. H. Boucher for collecting the specimen and T. Heitkamp and A. Boucher for temporarily storing the specimen. We acknowledge B. O'Connor for expertise in parasites and S. Tucker for providing data on previous opossums in North Dakota. P. Myers, P. K. Tucker, M. C. Chitwood, E. J. Finck, and one anonymous reviewer provided comments on earlier drafts of this manuscript.—Lisa L. Walsh^{1,3}, Robert Seabloom²,

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Submitted 1 May 2017. Accepted 10 October 2017. Associate Editor was M. Colter Chitwood.