Notes

High Spring Mortality of Adult Richardson's Ground Squirrels, *Urocitellus richardsonii*, Associated with a Severe Rainstorm in Southwestern Saskatchewan

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Heavy rains with strong winds in southwestern Saskatchewan from 20 to 29 May 2010 flooded fields where adult Richardson's Ground Squirrels (*Urocitellus richardsonii*) had recently been live–trapped. Natural mortality rates in six marked populations (n = 11 to 29 animals) ranged from 9.1 to 42.9%. The mean mortality rate of populations (28.9%) was significantly greater than that estimated for four populations (8.5%) studied in April and May 2007 and 2008 during drought periods. This finding is in agreement with past studies on other ground squirrel species which showed that spring snowstorms and heavy rains caused an increase in natural mortality rates.

Key Words: Richardson's Ground Squirrel, *Urocitellus richardsonii*, *Spermophillus richardsonii,* natural mortality, spring rainstorm, weather, Saskatchewan.

From 2000 to 2009, the western and central Canadian prairies experienced severe drought conditions, which created ideal environmental conditions for Richardson's Ground Squirrels (*Urocitellus richardsonii*, formerly *Spermophillus richardsonii*; Helgen et al. 2009 revised the genus *Spermophilus* on the basis of craniometric comparisons) (Proulx 2010). In 2010, however, the southwestern region of Saskatchewan received abnormally high amounts of rain which flooded agricultural fields. The scarcity of sunshine and cooler than normal temperatures meant that the fields did not dry out (Environment Canada 2011*). In the past, late snowstorms and heavy rains have been associated with increased mortality and decreased reproductive success in Belding's Ground Squirrels (*Urocitellus beldingi*, formerly *Spermophilus beldingi*) (Morton and Sherman 1978) and Columbian Ground Squirrels (*Urocitellus columbianus,* formerly *Spermophilus columbianus*) (Neuhaus et al. 1999). Quanstrom (1966) suggested flood tolerance in hibernating Richardson's Ground Squirrels, and Michener (1992) reported two animals drowning when exiting the hibernaculum. However, the effect of seasonally bad weather, including heavy rainfalls, strong winds, cold temperatures, and short–term floods, on the survival of adult Richardson's Ground Squirrels that have emerged from hibernation in spring is poorly known (Yensen and Sherman 2003).

During an assessment of pesticides in southwestern Saskatchewan from 2007 to 2010, I conducted a capture–recapture program of Richardson's Ground Squirrels to estimate natural mortality rates (e.g., Proulx et al. 2011). In spring 2010, heavy rains with strong winds lasted 10 days, and fields where Richardson's Ground Squirrels had recently been live–trapped were flooded. The recapture of animals immediately after the rainstorm was a unique opportunity to assess the effect of severe weather on the survival of adult Richardson's Ground Squirrels that had emerged from hibernation several days or weeks before. I predicted that natural mortality rates of adult Richardson's Ground Squirrel populations would be higher during spring 2010 with heavy rainfalls and short–term flooding than in previous years with dry environmental conditions.

Methods

The study was carried out near the town of Hazenmore (Figure 1), where a pesticide assessment program for Richardson's Ground Squirrels was being planned. The original protocol involved capturing and marking ≥20 adult Richardson's Ground Squirrels, independently of their sex, in study plots of 1.3 ha each approximately 150 m apart. The study plots were located in mixed grasslands of Crested Wheatgrass (*Agropyron cristatum*), brome (*Bromus* spp.), Slender Wheatgrass (*Elymus trachycaulus*), and alfalfa (*Medicago* spp.).

The effect of the severe rainstorm on marked Richardson's Ground Squirrel populations was determined by comparing the 2010 natural mortality rates estimated with live–trapping to those of adult populations studied in spring 2007 and 2008 in study plots approximately 250 m apart in other similar mixed grasslands in Hazenmore and Mankota (Figure 1). The exact size of study plots, determined on the basis of capture–recapture locations (Proulx et al. 2011), ranged from 0.5 to 1.6 ha (Table 1).

Environmental conditions differed from year to year. Precipitation and maximum wind gusts were greater during the May 2010 rainstorm than during other periods (Table 1). Also, because there was little sunshine and temperatures were cool, water was not evaporating; grasslands were saturated with water and short–term floods were present in low–lying areas. The 2007 and 2008 studies were conducted in April, when temperatures were colder than in May 2010 (Table 1). Both adult and juvenile Richardson's Ground Squirrels were active on the surface in 2010; in 2007 and 2008, spring populations were composed only of adults that had recently emerged from hibernation. The 2010 adult populations were captured a month later than those of 2007 and 2008, and there was a difference in the reproductive status of animals among years.

For this study, the six populations in 2010 consisted of adult Richardson's Ground Squirrels that had been ear–tagged during the last two days of the capture program, i.e., 18 and 19 May, just before the bad weather began. That is to say that these animals were most likely alive when the rainstorm started. Two hundred Tomahawk live–traps 15 × 15 × 48 cm (Tomahawk Live Trap, Tomahawk, Wisconsin) baited with peanut butter on bread were set and checked early in the morning and in mid–afternoon. Adult Richardson's Ground Squirrels were tagged (Monel # 1 tag, Newport, Kentucky) in both ears. Recaptures occurred from 31 May to 4 June (i.e., 12 days after the end of the original capture program) and from 11 to 14 June to ensure that all animals that were still alive after the rainstorm had been captured. For the purposes of comparison, only the adult Richardson's Ground Squirrels of two populations ear–tagged during the last two days of the 2007 capture program and those of two populations ear–tagged during the last day of the 2008 trapping program were used. These animals were likely alive before a period of no–trapping activity that lasted 12–15 days in 2007 and 14 days in 2008 (Table 1).

A Student *t*–test was used to compare the mean mortality rate of the 2010 populations to that of the 2007 and 2008 pooled populations. Fisher's exact probability test was used to compare sex ratios of captured and recaptured Richardson's Ground Squirrel populations (Zar 1999) and to determine whether differential mortality resulted in a shift in population structure. A 0.05 level of significance was used for all tests.

Results

One of the two 2007 populations (n = 12 animals) had a female–biased ($P < 0.05$) sex ratio; the other (n = 14 animals) had an even ($P > 0.05$) sex ratio. Together, these populations had a female–biased sex ratio. Both 2008 populations (n = 8 and 10 animals) had a non–significant tendency for more males. Together, these populations had a male–biased ($P < 0.05$) population. Five of the six 2010 populations (n = 11 to 29 animals) had a female–biased ($P < 0.05$) sex ratio; one population (n = 21 animals) had an even ($P > 0.05$) sex ratio. Together, the populations had a female–biased ($P < 0.05$) sex ratio.

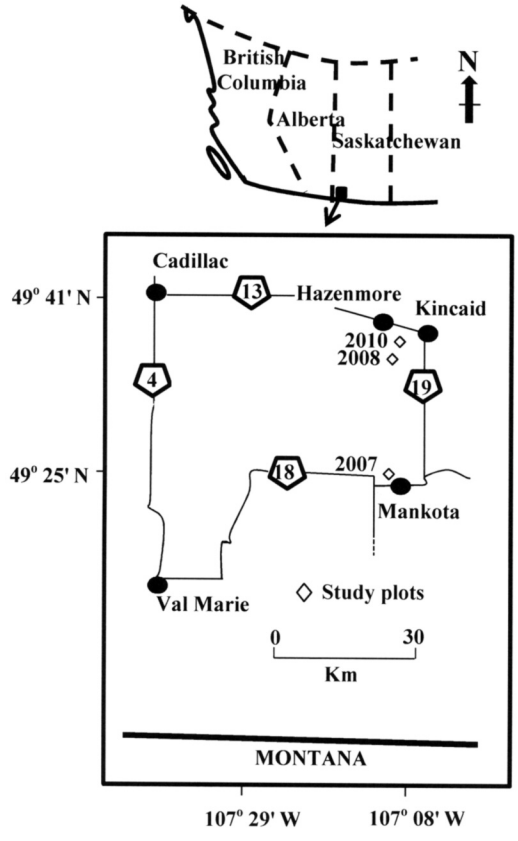

FIGURE 1. Location of study plots (2007 = two plots, 2008 = two plots, and 2010 = six plots) in southwestern Saskatchewan.

In 2007 and 2008, mortality rates following a period of no–trapping activity ranged from 0 to 16.7% and averaged 8.5% (SD 6.9). In 2010, after the period of severe weather, mortality rates ranged from 9.1 to 42.9%. The 2010 grand mean mortality rate of populations ($\bar{X}$ = 28.9%, SD 12) was significantly greater than that of the 2007 and 2008 populations (t = 2.9, $P < 0.01$).

The two 2007 recaptured populations had an even ($P > 0.05$) sex ratio, but there was a tendency for more females, as in the original pooled populations. The sex ratio of the 2008 recaptured populations was identical to that of the captured populations. Two of the 2010 recaptured populations had an even ($P > 0.05$) sex ratio; the others had a female bias ($P < 0.05$). Together, the 2010 recaptured populations had a female–biased ($P < 0.05$) sex ratio.

TABLE 1. Environmental conditions (G. MacKenzie's local weather station in Hazenmore; Environment Canada 2012*) and study plot characteristics in spring 2007, 2008, and 2010, southwestern Saskatchewan.

	2007	2008	2010
		Study plots	
n	2	2	6
Size (ha)	0.5, 1.6	0.2, 0.3	1.3
		Capture program	
Dates	23 and 24 April	23 April	18 and 19 May
Single lowest temperature (°C)	2.2	−12.9	11.9
Single highest temperature (°C)	19.1	2.2	27.5
Precipitation (mm)	2.2	0	0
Wind speed (km/h)	≤28	≤20	≤33
Maximum wind gusts (km/h)	0	37	44–54
		Severe rainstorm	
Dates	–	–	20–29 May
Single lowest temperature (°C)	–	–	0.2
Single highest temperature (°C)	–	–	16.4
Precipitation (mm)	–	–	55
Wind speed (km/h)	–	–	≤59
Maximum wind gusts (km/h)	–	–	<31–85
		Recapture program	
Dates	6–10 May	7 May	31 May–4 June	11–14 June
Single lowest temperature (°C)	−0.9	1.2	1.1	7.5
Singe highest temperature (°C)	25.9	14.6	20.6	24.7
Precipitation (mm)	0	0	3	12.7
Wind speed (km/h)	≤50	≤22	≤54	≤50
Maximum wind gusts (km/h)	–	≤31	50–69	≤31–63

Discussion

On average, nearly 30% of the Richardson's Ground Squirrels which were most likely alive before the severe rainstorm of May 2010 perished. This finding is in agreement with Morton and Sherman (1978), who found that a spring snowstorm resulted in an increase of approximately 30% in the mortality rate of adult female Belding's Ground Squirrels that had emerged from hibernation. Neuhaus et al. (1999) also reported an increase in the mortality rate of adult female and male Columbian Ground Squirrels of 11% and >22%, respectively, following a late spring snowstorm.

It is unlikely that the disappearance rate observed in spring 2010 was due to dispersal because, at this time of year, Richardson's Ground Squirrels do not disperse (Michener and Locklear 1990) and the fields surrounding the study plots were also flooded. It is also unlikely that predators killed many Richardson's Ground Squirrels during the rainstorm. Low temperatures, rain, and wind are known to have a negative impact on predator activity (e.g., Ables 1969; Doncaster 1985). However, on 30 May, one Striped Skunk (*Mephitis mephitis*) was observed feeding on a Richardson's Ground Squirrel. Although the Striped Skunk was likely scavenging, Richardson's Ground Squirrels suffering from hypothermia move slowly and erratically on the surface (Proulx, unpublished observations) and could easily be killed by small carnivores.

Since the sex ratio of most of the recaptured Richardson's Ground Squirrel populations was similar to that of their respective captured populations, there was apparently no significant differential mortality of males or females, and population structures remained the same. Reproduction in Richardson's Ground Squirrels imposes high energy demands on both males and females (Michener 1983, 1984, 1989), so adverse conditions caused by the rainstorm and cold temperatures would have led to greater energetic costs and increased mortality rates (e.g., Neuhaus et al. 1999). Independent of the fact that the 2010 populations were in a more advanced reproductive condition than that of the 2007 and 2008 populations, Richardson's Ground Squirrels inhabiting cold, water–saturated burrow systems may die from drowning, hypothermia, and climatic stress (Sauer 1985; Michener 1992; Popovic 2006). On the other hand, some populations lost more animals than others, e.g., the mortality rate of a population inhabiting a study plot that was slightly more elevated than other study plots was 9.1% compared to 19.2–42.9% in other populations. Although study plots were not assessed for variation in the extent of flooding, water did accumulate more in some study plots than in others, and

the impact of the rainstorm certainly varied among sites according to the amount of relief and soil type.

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