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REPRODUCTION OF THREE SPECIES OF POCKET MICE (*PEROGNATHUS*) IN THE BONNEVILLE BASIN, UTAH

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ABSTRACT.—Data on reproduction of three species of pocket mice (*Perognathus*) occurring in northern Utah are summarized. *Perognathus parvus* and *P. formosus* bred in spring but not the remainder of the year. This occurred despite mild fall and winter temperatures and shallow snowcover. Litter sizes for *P. parvus* and *P. formosus* were similar to those reported by previous investigators. A small sample of *P. longimembris* indicated they may have much larger litters (averaging 5.78 young) than previously reported for laboratory populations. Adult body mass was positively correlated with testis mass in all species, and with litter size in *P. parvus*.

Pocket mice (genus *Perognathus*) are widespread and ubiquitous components of rodent communities in western North America. Despite a growing body of knowledge concerning their ecology, such as competitive interactions (e.g., Brown and Lieberman 1973), seed-caching (e.g., Kenagy 1973, Reichman 1975), and physiological adaptations to arid environments (MacMillen 1972), studies of pocket mouse reproduction are primarily anecdotal or based on laboratory colonies (Jones 1985).

Here we report on reproduction in field populations of the long-tailed pocket mouse (*Perognathus formosus*), Great Basin pocket mouse (*P. parvus*), and little pocket mouse (*P. longimembris*) in the Bonneville Basin of northwestern Utah. Specifically, we examine seasonal variation in reproductive activity, litter size, and allometric relationships between body mass and reproductive variables.

STUDY AREAS

Most *P. formosus* were trapped on the north end of the Newfoundland Mountains ($N = 161$), with a few specimens from the Grassy Mountains ($N = 24$) and Floating Island ($N = 12$). *P. parvus* were collected primarily from the Grassy Mountains ($N = 21$), Hogup Mountains ($N = 36$), and Stansbury Island ($N = 32$). *P. longimembris* in this study were sampled from Floating Island ($N = 16$), located 30 miles NE of Wendover

(Tooele County), Utah, in the Bonneville Salt Flats. Collection sites are between 1300 and 1420 m in elevation on the Floating Island, Newfoundland Mountain, and Stansbury Island sites; and 1650 m in the Hogup Mountain and Grassy Mountain sites (Fig. 1).

All collection sites are dominated by northern cold-desert vegetation, including sagebrush (*Artemisia* spp.), saltbush (*Atriplex* spp.), rabbitbrush (*Chrysothamnus* spp.), horsebrush (*Tetradymia* spp.), greasewood (*Sarcobatus* spp.), and juniper (*Juniperus osteosperma*). The dominant shrubs vary according to elevational, moisture, and soil salinity gradients. All sites show a high degree of similarity in plant genera (39–52% overlap, using Jaccard's index of similarity) with the exception of Stansbury Island, which ranges between 22% and 29% similarity when paired with other sites. This is probably due to the increased diversity found in dunes sampled on the north shore of this island.

METHODS

Specimens were live-trapped or snap-trapped on a monthly basis in 1986 on the Newfoundland and Grassy mountains for approximately 500 trap nights per month. Pocket mice from Stansbury Island and Floating Island were sampled between April and September.

Mice were euthanized and frozen on dry ice in the field. In the laboratory, mice were

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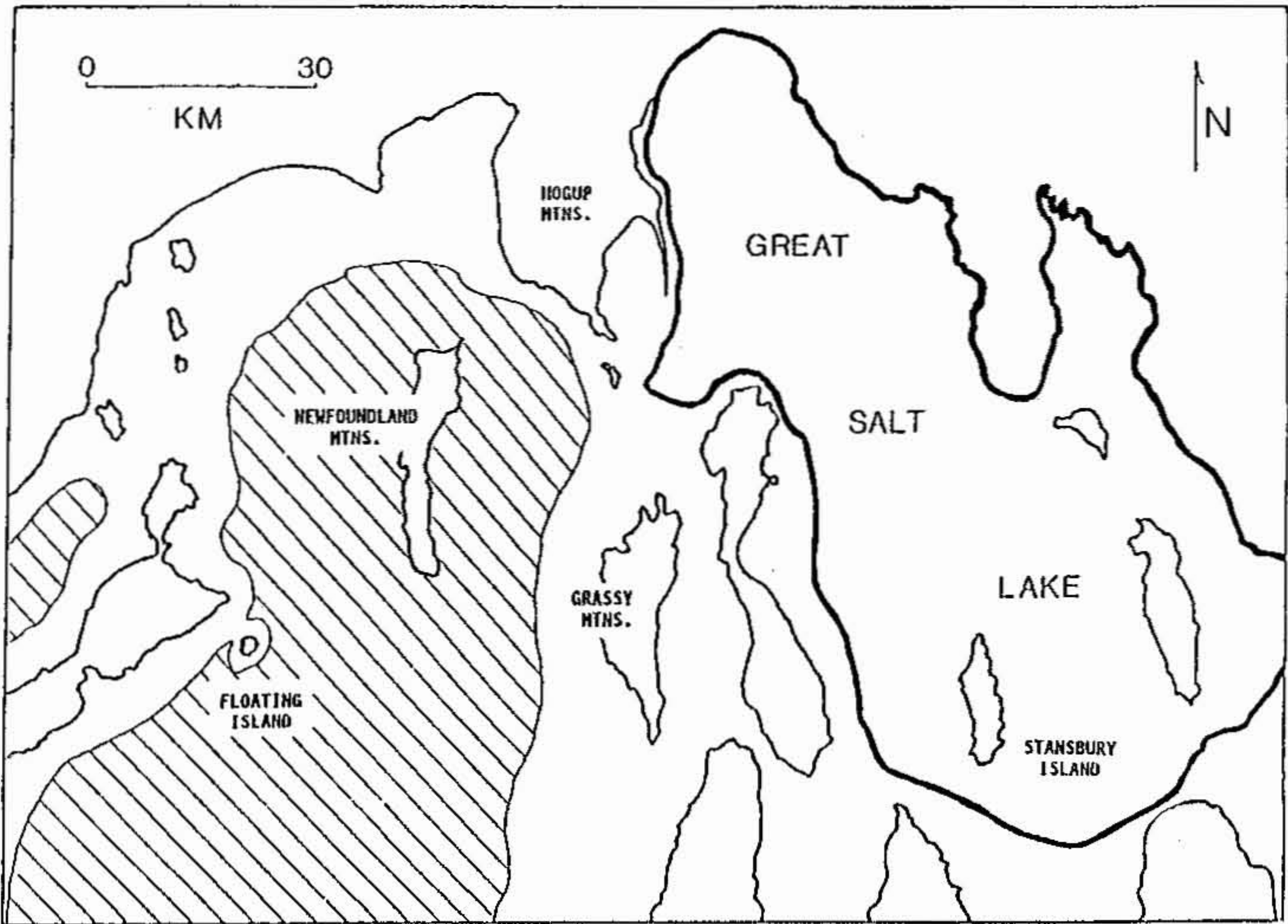


Fig. 1. Study areas in northwestern Utah sampled for three species of *Perognathus*. Area in hatchmarks indicates the extent of barren salt flats. Contour lines are drawn at approximately 1300 m.

weighed to the nearest 0.5 g and measured (total length, tail, hind foot, ear) to the nearest millimeter. Reproductive tracts were removed and placed in alcohol/formalin/acetic acid (AFA) mixture (90 parts 70% ethanol, 5 parts each formalin and glacial acetic acid). Histological procedures followed those of Brown (1964) and Duke (1957).

Testes were stripped of the epididymides and measured lengthwise to the nearest 0.1 mm using an ocular micrometer. Testes were then dried at 80 C for 48 h and weighed to the nearest 0.1 mg on a Mettler AE160 electronic analytical balance.

Uteri and ovaries were cleared through an alcohol-xylene series using Hemo-De, a xylene substitute. Placental scars were counted at this stage and ovaries infiltrated and embedded in paraffin for sectioning. Serial sections 10 microns thick of the entire ovary were stained in Gill's hematoxylin and mounted with Permunt mounting medium. Corpora lutea were counted on a dissecting

microscope at 25X magnification. Embryos present were counted and measured to the nearest 1 mm.

RESULTS

Results are based on data from 104 female and 93 male *P. formosus*, 25 female and 64 male *P. parvus*, and 9 female and 7 male *P. longimembris*. All data were taken from individuals in adult pelage. The 1986 field season was divided into three seasons as follows: emergence to late June, July through mid-September, and mid-September through early December. This was done to divide the aboveground activity of the heteromyids into three time lengths of equal sampling intensity.

LONG-TAILED POCKET MICE.—Males were first captured in early March, females in mid-April, and neither showed evidence of breeding at that time. Twenty-nine percent of the females sampled ($N = 17$) through the end of

TABLE 1. Seasonal variation of testis mass (dry weight, mg) and seminal vesicle length (mm) of *Perognathus formosus*.

Season	April-June	July-mid-Sept.	Sept.-Dec.
Testis	158.68 (± 5.73) N = 22	25.25 (± 2.41) N = 57	27.28 (± 1.81) N = 11
Seminal vesicle	8.80 (± 0.40) N = 20	4.76 (± 0.20) N = 17	No data*

*No animals with seminal vesicles developed.

TABLE 2. Correlations of body mass with male reproductive variables in three species of *Perognathus*.

Species		<i>formosus</i>	<i>parvus</i>	<i>longimembris</i>
Testis mass	rho (N)	.502 (90)	.702 (64)	.618 (7)
	P	<.001	<.001	.139
Seminal vesicle length	rho (N)	-.167 (37)	.672 (49)	.314 (6)
	P	.324	<.001	.545

June had corpora lutea. This dropped to only 6.3% ($N = 63$) for July-September (Fisher's Exact test, $X^2 = 7.04$, $P = .018$), and none captured after mid-September showed any signs of reproductive activity. Ten percent of the females ($N = 19$) carried embryos early in the season through June, whereas only 1.3% ($N = 79$) carried embryos in the summer (Fisher's Exact test, $X^2 = 4.38$, $P = .095$).

Male reproductive activity paralleled the observations for females. Testis mass and seminal vesicle lengths were smaller as the season progressed (Table 1), reflecting a spring (April-June) breeding peak followed by breeding inactivity the remainder of the year. Mean testis mass was more than five times greater in the spring than in either summer or fall (Kruskal-Wallis, $X^2 = 50.9$, $P < .001$). Seminal vesicles were nearly twice as long in spring (8.8 mm) as in fall (4.8 mm), reflecting a similar pattern (Mann-Whitney $U = 2.5$, $P < .001$). Adult male body mass was significantly correlated with testis mass (Spearman's rho = 0.502, $P < .001$, $N = 90$, Table 2).

The mean litter size estimated from 35 females with one set of placental scars was 5.89 (± 0.30). Nine sets of corpora lutea from separate individuals revealed a smaller estimate of 4.78 (± 0.74). Our small sample sizes for these data may reflect the fact that corpora lutea in *Perognathus* regress rapidly (Duke 1957) compared with other species where they may persist for months (Brown and Conaway 1964). Three females with embryos had litters of six, six, and five. Thirty-four

percent of the females with placental scars had given birth to more than one litter. No evidence of resorbing embryos or polyovuly was observed.

GREAT BASIN POCKET MICE.—This species also apparently has only one peak breeding effort in the spring, although sample sizes are too small to permit meaningful statistical tests. Males were first captured in mid-April, females about two weeks later. Females were reproductively active (corpora lutea or embryos present) when first captured. Forty-five percent (9 of 20) of females captured had corpora lutea, and 28% (7 of 25) were carrying embryos.

Males caught between April and June had significantly larger testes and seminal vesicles (Table 3) than individuals from the remainder of the season (Mann-Whitney $U = 28.0$, $P < .001$ for testes mass; $U = 46.5$, $P < .001$ for seminal vesicle lengths). Adult male body mass was significantly correlated with testis mass (Spearman's rho = 0.702, $P < .001$, $N = 64$) and seminal vesicle length (Spearman's rho = 0.672, $P < .001$, $N = 49$) (Table 2).

Litter size in this species was approximately five, although this was from a sample of only nine females. One set of placental scars numbered five, seven pregnant females averaged 5.17 (± 0.46) embryos, and nine sets of corpora lutea averaged 5.33 (± 0.37). No evidence of polyovuly or resorption of embryos was observed. Size of the mother was correlated with the number of corpora lutea (Spearman's rho = 0.738, $P = .023$, $N = 9$) and

TABLE 3. Seasonal variation of testis mass (dry weight, mg) and seminal vesicle length (mm) of *Perognathus parvus*.

Season	April-June	July-Dec.
Testis	153.09 (± 6.54) N = 22	61.33 (± 5.63) N = 42
Seminal vesicle	10.50 (± 0.36) N = 22	6.77 (± 0.39) N = 27

embryos (Spearman's $\rho = 0.611$, $P = .145$, $N = 7$). Although based on an extremely small sample, this agrees with correlations found in *Peromyscus maniculatus* (Myers and Master 1983, Cramer 1988).

LITTLE POCKET MICE.—Litter size averaged 5.78 (± 0.22) embryos per litter ($N = 9$). The modal size was six, but most of these were in very early stages of development where uterine swellings were less than 3 mm. One female captured later in pregnancy (crown-rump length of embryos 10 mm) had resorbed one embryo, leaving a potential litter of five. Some preimplantation loss was also noted. Two of the litters of six resulted from seven ova as inferred from corpora lutea counts.

DISCUSSION

LONG-TAILED POCKET MICE.—Previous published reports on reproduction in *P. formosus* are few but generally support our findings. For a population in southeastern Washington, French et al. (1974) reported an average litter size of 5.6 (77 litters) and a mean corpora lutea count of 6.0 ($N = 51$), both comparable to the present results. The high proportion of long-tailed pocket mice with placental scars from multiple litters may simply reflect the longevity of this species, which has been estimated as up to four years in mark-recapture studies (French et al. 1974).

The only information on the length of the breeding season for this species was offered by Hall (1946), who found embryos in only 2 of 91 females captured in July in Nevada. Our data on male and female reproductive activity indicating a spring peak and cessation of breeding activity by early July support those observations. Even given a combination of apparently favorable weather conditions in fall and winter, no breeding occurred during this period in long-tailed pocket mice. September and

October had above average rainfall (196% and 155% above normal, respectively) but cooler than average temperatures (2.6 and 1.1 C below normal). November and December had below average precipitation (snowcover) (39% and 15% of normal, respectively), and November was 0.9 C warmer than normal (NOAA Climatological Data Annual Summary, Utah 1986). *Peromyscus maniculatus* in the same area continued to breed into December (Cramer 1988). These data suggest that reproductive activity in the fall in these species of pocket mice may be more closely tied to photoperiod than to climatic factors. Reichman and Van De Graaff (1975) showed the onset of reproduction in *Dipodomys merriami* to be dependent on winter rainfall and subsequent spring production of annual seeds and green vegetation. Kenagy and Bartholomew (1981) reported a similar effect of green vegetation on male reproductive development in *Perognathus formosus*. It is possible, then, that habitat productivity cues are important for the onset of breeding in the spring, but cessation of breeding in the fall is dependent on photoperiod.

GREAT BASIN POCKET MICE.—In a Washington population of Great Basin pocket mice, Scheffer (1938) found an average litter size of 5.16 ($N = 77$) from embryo counts and estimated that few individuals produced more than one litter per year. Iverson (1967) reported a mean litter size of 4.85 ($N = 39$) for a population of *P. parvus* in south central British Columbia. He also found that females bred from April to August and that males were reproductively inactive by mid-August. O'Farrell et al. (1975) also suggested that an average of 1.1 litters per year was produced by this species in south central Washington. Our data support previous estimates of litter size in this species and confirm indirectly the supposition that only one litter per year is produced on average, since we found only a short spring breeding peak. Reproductive activity in both males and females supports the hypothesis of a single spring breeding peak with young-of-the-year deferring reproduction until the following spring.

LITTLE POCKET MICE.—This species produced an average of four young ($N = 52$) in the laboratory, with a range of one to six (Hayden et al. 1966). Other than Hayden's study, data for this species are scarce. Duke's (1957) study

does not specify litter sizes for the three species he studied (same three as in this study), but he cited an average litter size for all three species of 5.38. In our samples, the modal litter size for *P. longimembris* is six, much higher than the average of four reported in the laboratory (Hayden et al. 1966).

Our results suggest that pocket mice in northern Utah generally breed only in the spring although they may produce more than one litter per year. Long-tailed pocket mice and little pocket mice usually have six young per litter, while Great Basin pocket mice usually produce about five young per litter. These data are consistent with previous literature with the exception of our litter estimates for little pocket mice. Even given our relatively small sample sizes, the large discrepancy (two young per litter) between our field data and previous lab estimates (Hayden et al. 1966) suggests that caution be exercised in extrapolating from the lab to the field. This could be particularly misleading when drawing inferences from large literature reviews of diverse data sets (e.g., Jones 1985).

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