Agricultural Disturbances and Small Mammal Communities: *Peromyscus maniculatus* versus *Sigmodon hispidus*

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Abstract

Sigmodon hispidus affected *Peromyscus maniculatus* negatively when the former invaded an area already occupied by *P. maniculatus* after an adjacent field was plowed. Older methods and a new index were used to examine interactions. Previously used methods were inconclusive. The index compares the sum of the reciprocal squares of the initial distances moving animals were from a stationary animal against the sum of the reciprocal squares of the distances after the animals had moved for every moving animals/stationary animal case. Comparison to a random walk model indicated *P. maniculatus* avoided *S. hispidus* while the latter's movements ignored the former. The results underscore the need to understand community dynamics precipitated by agricultural disturbances.

Key Words: *Peromyscus maniculatus*, *Sigmodon hispidus*, Rodentia, competition, interaction, movement, agriculture, tillage.

Introduction

The impact of agriculture on small mammal communities is often ignored (Fleharty and Navo, 1983), yet these areas are important refuges for small mammals (Kaufman and Kaufman, 1989). Some literature documents the differences between rodent populations living in agrarian settings versus nonagrarian areas (Kaufman and Kaufman, 1990; Albers *et al.*, 1990; Wegner and Merriam, 1990), but no studies describe interactions precipitated by agrarian disturbances.

The purpose of this study was to detect effects invading cotton rats, *Sigmodon hispidus*, had on a resident population of the deer mouse, *Peromyscus maniculatus.* After a nearby wheat field was plowed, *S. hispidus* entered an adjacent relict prairie where the mice were located. The interaction between these species is previously undocumented, but I expected the rats to impact the mice negatively because *S. hispidus* is aggressive intraspecifically (Summerlin and Wolfe, 1973) and interspecifically (Glass and Slade, 1980a; Terman, 1973, 1974) and because larger animals spatially exclude *Peromyscus* in enclosures (Grant, 1969) and natural systems (Hallett *et al.*, 1983).

Materials and Methods

I established a 100-station grid (25x4 stations) four km northeast of McPherson, Kansas in an area seperated from the surrounding crop fields by two railraod tracks. 24x8x7 cm Sherman live traps, spaced every 10 m, were baited with sunflower seeds and chicken scratch three evenings about every two weeks. Captures were weighed, sexed, aged, marked, and released. *S. hispidus* was aged by weight: juveniles < = 60 g, adults > 60 g (Glass and Slade, 1980b).

Several methods were used to detect rat-mouse interactions. Except where noted, the significance between pre-*Sigmodon* invasion and post-invasion samples was found by Student T-tests.

The first two methods involved movement and home range. Mean nightly distance moved was calculated. The principle components method (Jennrich and Turner, 1969) was used to determine home range for animals caught three or more times.

Actual spatial distribution was compared to a Poisson distribution (Sokal and Rohlf, 1981) by dividing the mean number of captures per trap into the variance of captures per trap. Values significantly greater than one implied clumped dispersion, less than one hyperdispersion, and statistically indifferent from one random dispersion.

Population center of activity was defined as the mean capture coordinate for every capture in a three day period, and distances centers moved every two weeks were calculated (Terman, 1973).

A mathematical index (1 and 2) determined deer mouse movement patterns in relation to rats:
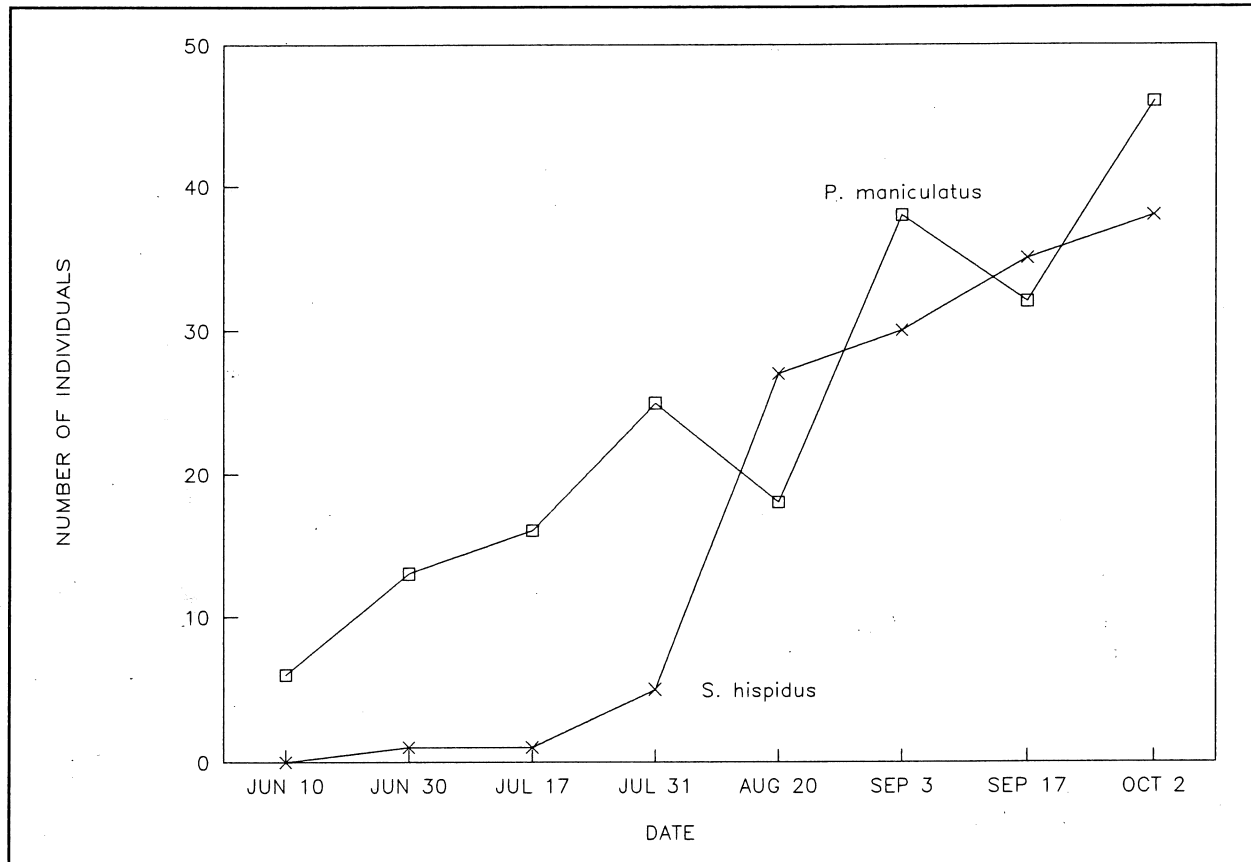
$$D1' = R \cos(T') \tag{1}$$

$$D2' = R \sin(T') \tag{2}$$

in which

$$R = (D1^2 + D2^2)^{(1/2)} \tag{3}$$

and

Figure 1. Number of Individuals caught on the grid. *S. hispidus* invaded in mid-August after plowing in an adjacent field occured.

$$T' = Arctan\ (\frac{D2}{D1}) - (\frac{\pi}{x}) \qquad (4)$$

for which

$$D1 = \sum_{n=1}^{n} \frac{1}{(d_{n,i})^2} \qquad (5)$$

and

$$D2 = \sum_{n=1}^{n} \frac{1}{(d_{n,i+1})^2} \qquad (6)$$

D1 is the sum of the square of each value $d_{n,i}$ divided into one, and $d_{n,i}$ is the distance between one cotton

rat and each mouse n within one mean nightly movement of a rat (42.29 m). D2 is the sum of the reciprical square distances, $d_{n,i+1}$, mice are from the same rat's initial location. This calculation is performed because the influence of an object in two dimensional space declines with the reciprocal square of the distance. Thus rats are considered stationary, and only moving mice are used in this procedure. Distances equalling zero are set equal to the square root of 10 (the distance between traps) so division by zero is avoided.

D1 can be plotted versus D2 (Figure 2). Equations (1) through (4) rotate the axes D1 and D2 so that a regression line through the origin for the null model has a zero slope and data points are unbiased in their effect on the regression equation. The null model data is rotated pi/x radians so that the regression slope for the rotated data is zero (Figure 3), and the actual data is then rotated the same angle. The random walk null model depicts random interaction (Figure 3) and was built on actual data parameters (4x25-station grid, 10 m intertrap distance, 3 to 13 mice caught per night moving 0 to 31.5 m (mean+/-standard deviation), a mean 19.4 rats caught per night) and spanned 700
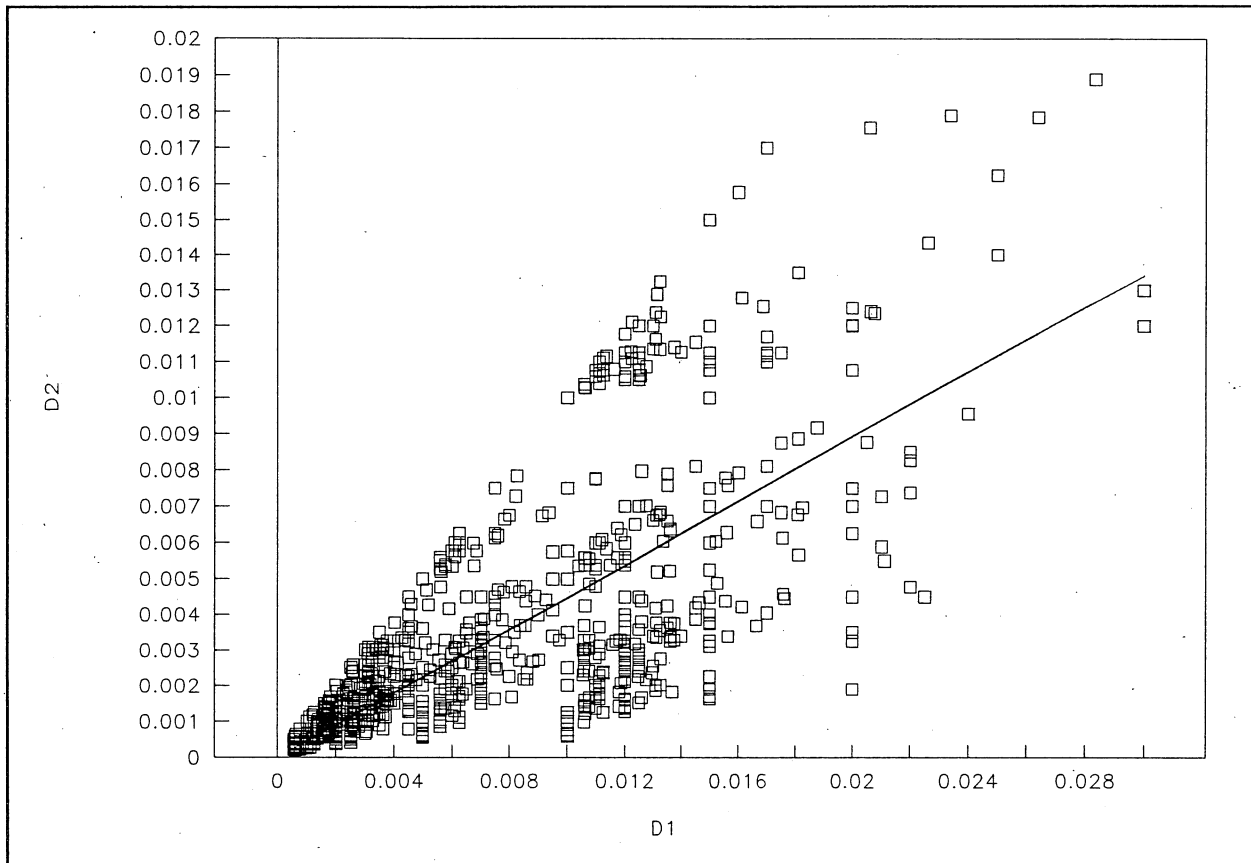
Figure 2. "Unrotated" null model. A regression line forced through the origin is biased toward a more gradual slope.

nights. Points below the model's regression line indicate deer mice overall moved away from *S. hispidus* and points above symbolize no interaction. The significance of the difference between the slopes of the data and null model was determined (Snedecor, 1956, p. 135).

Results

86 *S. hispidus* and 82 *P. maniculatus* individuals were caught in 2200 trap-nights (Figure 1). Other species constitued only 11% of total captures. In early August the wheat field adjacent the area was plowed, and 27 cotton rats (24 adults) were caught August 20-22 in contrast to the 5 (all adults) in the previous session.

The first two methods implied no interaction while the latter three did. *P. maniculatus* nightly movements did not differ significantly (P>.80) nor did home ranges (P>.70) between pre- and post-*Sigmodon* invasion samples (Table 1). Sex was not a differentiating factor (results not shown), and so data was pooled. Spatial analysis on deer mouse dispersion (Table 1) was significantly clumped (P<0.05) before cotton rat influx but random afterward (P>.70). Population activity

center movements differed highly significantly (P<0.001) between pre- and post-*Sigmodon* samples (Table 2).

Table 1. Mean nightly movements, mean home ranges, and dispersion pattern for *P. maniculatus* before and after *S. hispidus* invasion. Values in parentheses are standard deviations. Asterisk (*) indicates significance at 0.05 level.

Parameter	Pre-invasion	Post-invasion	P
Movement (m)	22.1(12.9)	19.7(15.4)	>0.70
Home Range (m²)	2806(2975)	2594(2610)	>0.80
Dispersion	Clumped*	Random	-

The movement index indicated *P. maniculatus* avoided *S. hispidus* (regression slopes different, P<0.001). Figure 4 shows the reaction which is in
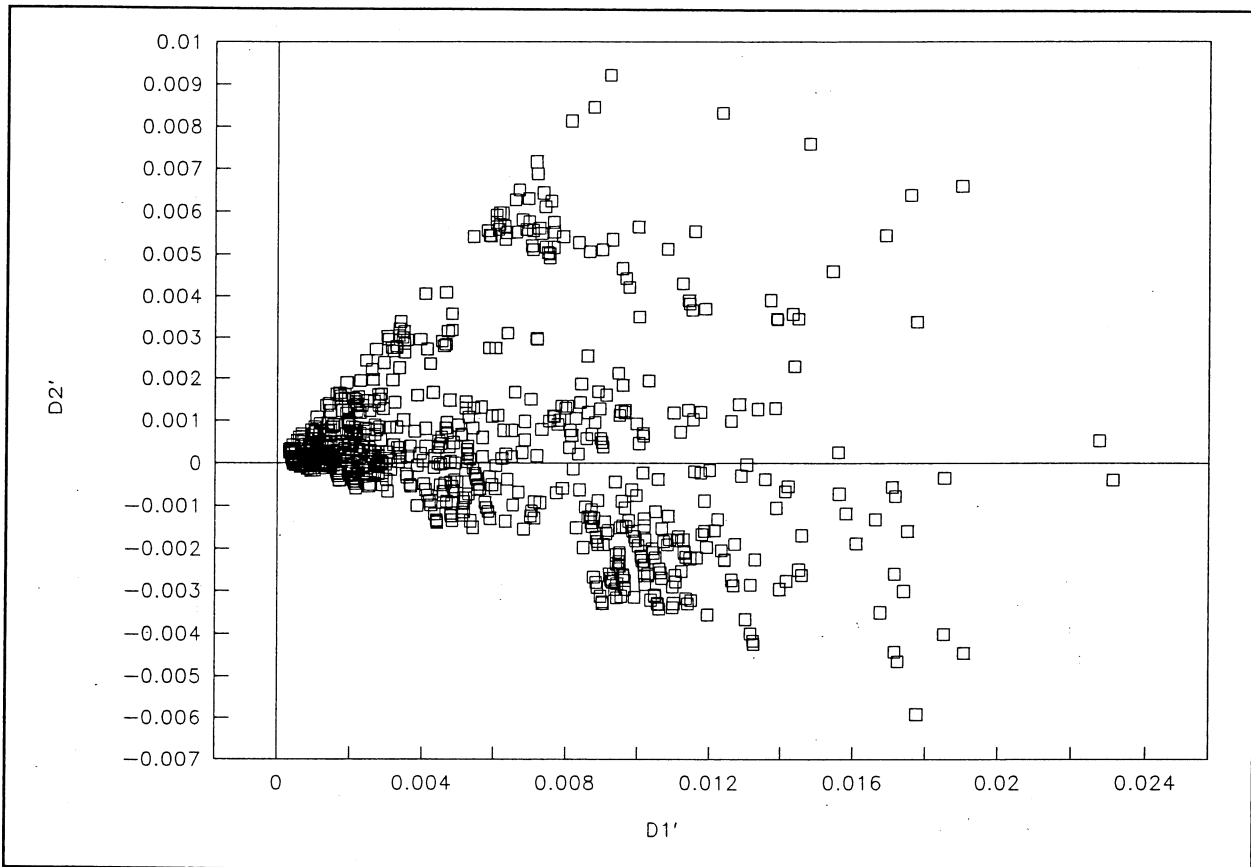
Figure 3. "Rotated" null model. A regression line lies on the x-axis. Points below the line indicate avoidance, and those above no interaction.

contrast to the null model graph, Figure 3. The regression for the real data explains a reasonable amount of the variance ($R^2 = 0.38$).

Table 2. Population center of activity movements for *P. maniculatus* before and after *S. hispidus* invasion in mid-August. Differences between periods were significant at the 0.001 level.

| Movement Period	Movement (m)
June 10 - June 30	49
June 30 - July 17	19
July 17 - July 31	16
July 31 - August 20	24
August 20 - September 3	3
September 3 - September 17	8
September 17 - October 2	12

Discussion

The effects of agricultural activities on wildlife communities next to farmland is undocumented, yet these areas are important habitats for small mammals (Kaufman and Kaufman, 1989) and form the physical mosaic yielding farmland wildlife metacommunities (Merriam *et al.*, 1989; Merriam, 1988), for movement between areas isolated by crop fields is often limited (Yahner, 1983; Wegner and Merriam, 1979).

Previous research depicts the role of farming in the ecology of the two rodents of this study. Agriculture may facilitate the northward migration of *S. hispidus* (Baker, 1971). Cotton rat densities have been found to be higher on a grazed pasture than a relict prairie (data from Fryendall, 1969), and if available, wheat, *Triticum aestivum*, is a large volume of diet (Fleharty and Olson, 1959).

Agricultural also affects *P. maniculatus*. Stickel (1968) cites an example of high turnover after alfalfa harvest, and in Canada no *P. leucopus* were caught in grain fields after plowing, despite previously high densities (Wegner and Merriam, 1990).

This study elucidates an influx of cotton rats into an area already occupied by a deer mouse population. In mid-August after an adjacent wheat field had been plowed, cotton rat density increased five-fold in just 18
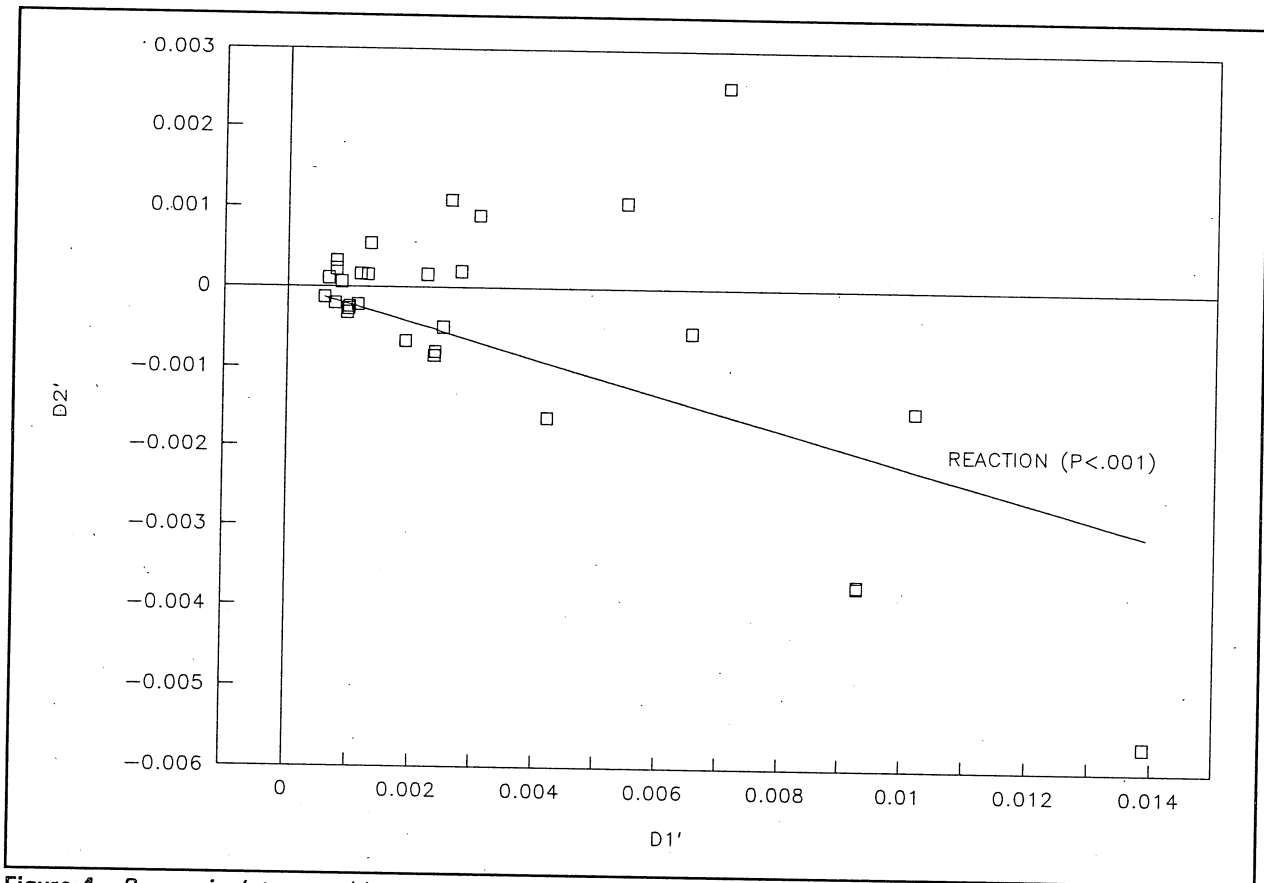
Figure 4. *P. maniculatus* avoidance of *S. hispidus*: 31 stationary *S. hispidus* versus 34 *P. maniculatus* movements. The regression slope differed significantly from the model's (P<0.001).

d (Figure 1). Almost all were adults and probably would have been caught prior mid-August had they been of sympatric origin. I expected *S. hispidus* to affect *P. maniculatus* negatively.

Excluding direct observation, methods used to detect interaction are indirect and thus suceptable to discrepancies when used in conjunction, as they were in this research. Home range and movement restrictions may decline with increased competition (Terman, 1973 and 1979), yet there were no differences in this study, indicating no interaction. In contrast, deer mouse dispersion changed from clumped to random, implying a scattering effect from the rat invasion. The dispersion change may also have been due to intraspecific interactions resulting from higher conspecific densities (Stickel, 1968), and so was nonindicative. Population activity center changes greatly decreased in the post-*Sigmodon* period, probably because *S. hispidus* restricted deer mouse population movements, previously clumped mice became randomly dispersed, or the increased number of mouse captures biased the post-*Sigmodon* samples. Overall, the results were inconclusive.

The interaction index indicated *P. maniculatus*

moved away from nearby *S. hispidus*. The index takes accounts deer mouse movements in relation only to rat positions, and so is not confounded by reactions to non-*Sigmodon* individuals, like conspecifics or the prairie vole, *Microtus ochrogaster*, which was the third most abundant rodent on the grid but nonetheless scarce. Two possible mechanisms underlie the index's biological significance. The retreating movements of *P. maniculatus* may have indicated a move toward spatial exclusion ("micromigration" from a rat-inhabited area) or an avoidance of traps and areas already scented by *S. hispidus*.

If the index is valid in its assumptions, it should be expected to show *S. hispidus* movements did not take *P. maniculatus* locations into account. This was verified (graph not shown), and so the index was demonstrated to indicate a case of interaction and a case of noninteraction, both of which were expected but not directly observable. Observation is the only direct means to detect interaction, and radio-telemetry, although able to indicate interaction (Doncaster, 1990), is expensive and often eschewed for trapping grids in small mammal studies. This index extracts dynamic data from a static data set at a cost lower in money

and time.

Agriculture affects not only animals living within its boundaries but also at its boundaries (Wegner and Merriam, 1979). Disturbances like plowing are annual, change the landscape dramatically (Merriam, 1988), and thus, as demonstrated in this study, alter community dynamics greatly in areas adjacent to crop fields.

Literature Cited

Albers, P., G. Linder and J. Nichols. 1990. Effects of tillage practices and carbofuran exposure on small mammals. Journal of Wildlife Management 54:135-142.

Baker, R.H. 1971. Nutritional strategies of myomorph rodents in North American grasslands. Journal of Mammalogy 52:800-805.

Doncaster, C.P. 1990. Non-parametric estimates of interaction from radio-tracking data. Journal of Theoretical Biology 143:431-443.

Fleharty, E.D. and K. Navo. 1983. Irrigated cornfields as habitat for small mammals in the sandsage prairie region of western Kansas. Journal of Mammalogy 64:367-379.

Fleharty, E.D. & L.E. Olson. 1969. Summer food habits of *Microtus ochrogaster* and *Sigmodon hispidus*. Journal of Mammalogy 50:475-486.

Frydendall, M.J. 1969. Rodent populations on four habitats in central Kansas. Transactions of the Kansas Academy of Science 72:213-222.

Glass, G.E. & N.A. Slade. 1980a. The effect of *Sigmodon hispidus* on spatial and temporal activity of *Microtus ochrogaster*: evidence for competition. Ecology 61:358-370.

Glass, G.E. & N.A. Slade. 1980b. Population structure as a predictor of spatial association between *Sigmodon hispidus* and *Microtus ochrogaster*. Journal of Mammalogy. 61:473-485.

Grant, P.R. 1969. Experimental studies of competitive interaction in a two-species system. III. *Microtus* and *Peromyscus* species in enclosures. Journal of Animal Ecology 40:323-50.

Hallett, J.G., Margaret A. O'Connell and R.L. Honeycut. 1983. Competition and habitat selection: test of a theory using small mammals. Oikos. 40:175-181.

Jennrich, R.I. and F.B. Turner. 1969. Measurement of non-circular home range. Theoretical Biology 22:227-237.

Kaufman, D.W. and Glennis A. Kaufman. 1989. Nongame wildlife management in central Kansas: implications of small mammal use of fencerows. Transactions of the Kansas Academy of Science 92:198-205.

Kaufman, D.W. and Glennis A. Kaufman. 1990. Small mammals of wheat fields and fallow wheat fields in north-central Kansas. Transactions of the Kansas Academy of Science 93:28-37.

Merriam, G. 1988. Landscape dynamics in farmland. Tree 3:16-20.

Merriam, G., M. Kozakeiwicz, Etsuko Tsuchiya and Karen Hawley. 1989. Barriers as boundaries for metapopulations and demes of *Peromyscus leucopus* in farm landscapes. Landscape Ecology 2:227-235.

Snedecor, G.W. 1956. Statistical Methods. Iowa State College Press: Ames, Iowa. 534 pp.

Sokal, R.R. and F.J. Rohlf. 1981. Biometry. W.H. Freeman and Company: New York. 865 pp.

Stickel, Lucille F. 1968. Home ranges and travels. *In* J.A. King (ed.) Biology of *Peromyscus* (Rodentia). American Society of Mammalogists. pp 373-411.

Summerlin, C.T. and J.L. Wolfe. 1973. Social influences on trap response of the cotton rat, *Sigmodon hispidus*. Ecology 54:1156-1159.

Terman, M.R. 1973. Interactions between sympatric *Microtus* and *Sigmodon* (Rodentia: Cricetidae). Ph.D. Diss. Michigan State University. pp. 98.

Terman, M.R. 1974. Behavioral interactions between *Microtus* and *Sigmodon*: a model for competive exclusion. Journal of Mammalogy 55:705-719.

Terman, M.R. 1979. Population dynamics of *Microtus* and *Sigmodon* in central Kansas. Transactions of the Kansas Academy of Sciences 81:337-351.

Wegner, J. and G. Merriam. 1979. Movements by birds and small mammals between a wood and adjoining farmland habitats. Journal of Applied Ecology 16:349-357.

Wenger, John & Gray Merriam. 1990. Use of
    spatial elements in a farmland mosaic by a
    woodland rodent. Biological Conservation.
    54:263-276.

Yahner, R.H. 1983. Small mammals in farmstead
    shelterbelts: habitat correlates of seasonal
    abundance and community structure. Journal of
    Wildlife Management 47:74-84.

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