Extreme color variation in adult prairie voles, *Microtus ochrogaster minor*, of Wadena County, Minnesota. Photograph by Robert Spading.

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NOTES ON THE PRAIRIE VOLE *MICROTUS OCHROGASTER* IN WADENA COUNTY, MINNESOTA

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ABSTRACT

The prairie vole, *Microtus ochrogaster,* as its name suggests, is generally assumed to inhabit relatively undisturbed prairie habitats within its range. The discovery of this species in agricultural croplands in Wadena County that were cleared from presettlement coniferous forests, therefore, seems unique and raises the question to what extent the species requires true upland prairie for its existence in Minnesota. This paper summarizes what is known of the species from Wadena County, corrects published remarks of other authors regarding trapsite habitats in the county and reports one new trapsite location for the county. Additional unreported data for measurements, behavior, reproduction, and color variations are given. Notes on probable predators, known faunal cohorts and plant associates at or surrounding the trap sites are presented and two hypotheses to interpret the presence of *M. ochrogaster* in Wadena County are offered. Changes in land use are identified as factors which possibly explain the disappearance of the species from formerly occupied sites. These have possible management implications for this species now designated as of special concern by the Minnesota Department of Natural Resources.

INTRODUCTION

The prairie vole, *Microtus ochrogaster,* hereafter *ochrogaster* or *ochrogaster minor,* is a widespread inhabitant of the interior grasslands of central North America ranging across the short grass Great Plains in the west to the tall grass prairies in the east (Hall and Kelson, 1959; Stalling, 1990; and Armstrong, et. al, 1986). Within this range, the species can be very local or apparently absent from extensive areas of suitable appearing habitats (Soper, 1964, and Jackson, 1972). In Minnesota, Hazard (1982) and Nordquist and Birney (1988) attribute its scattered distribution and decline to habitat destruction from extensive agricultural activity, or to habitat alteration which favors its congener, the meadow vole, *Microtus pennsylvanicus,* hereafter *pennsylvanicus.* Elsewhere the species has reportedly been displaced by *pennsylvanicus* into habitats with shorter vegetation and less litter (Jackson, 1961; Abramsky and Tracy, 1979; Bowles, 1981; and Miller, 1969). However, still others (Long, 1979; Hamilton and Whitaker, 1979; Allen, 1936; and Taitt and Krebs, 1985) record both species coexisting in the same habitat. Moreover, Getz (1962) found *ochrogaster* dominating *pennsylvanicus* in laboratory conditions, and Findley (1954) concluded that *ochrogaster* forces *pennsylvanicus* to retreat into wetter habitats. Stalling (1990), Reed and Choate (1986) and Huggins and McDaniel (1984) report rather aggressive and rapid range extensions of *ochrogaster* into southern and southeastern United States where *pennsylvanicus* is absent.

In addition to these contradicting reports of interactions with *pennsylvanicus, ochrogaster* displays dramatic annual and multiannual fluctuations in abundance that may also obscure its local distributional status (Crawford, 1971; Rose and Gaines, 1976; Getz et al., 1987; and Jones and Birney, 1988). The vagaries of weather and climate undoubtedly influence such dynamics (Hazard, 1982) but geographical and chronological data for them are inadequate for useful analysis.

In Minnesota, *ochrogaster* occurs almost exclusively in the former prairie region and its extensions into the transition zone (Hazard, 1982). Extreme fragmentation of upland prairie habitats in these regions has presumably isolated extant populations of *ochrogaster* and diminished their genetic diversity as well (Nordquist and Birney, 1988). Consequently, *ochrogaster* is now listed as a species of special concern in the state (Minnesota Department of Natural Resources, 1986, and Coffin and Pfanmuller, 1988). Nordquist and Birney (1988) remark that specimens collected from Minnesota in recent decades "were apparently from small populations persisting in protected relict prairies". The discovery of *ochrogaster minor* at three agricultural sites in an area that was entirely within the coniferous forest zone of Minnesota at the time of European settlement in 1884 (Wendt and Coffin, 1988; Marschner, 1974, and original surveyors' notes, 1884) contradicts that assumption.

KEY WORDS: Prairie vole habitat, *Microtus ochrogaster,* Minnesota.

METHODS AND RESULTS

I discovered *ochrogaster minor* in Wadena County on 2 October, 1965 when I live-trapped a specimen from within a corn shock at site 1 (Table 1, Fig. 1). It was presented to Oscar Kalin, Jr. of the Mammalogy Department at the James Ford Bell Museum of Natural History, University of Minnesota who obtained karyotype material from it and prepared the museum specimen number JFB MNH 7440. I later secured 18 specimens from site 1 on 2, 29 and 30 October, 1966 and two specimens from site 3 (Table 1, Fig. 3) on 16 October, 1967 that were also deposited in the Bell Museum mammalogical collection and subsequently reported by Heany and Birney (1975). All specimens were given field numbers assigned by Oscar Kalin, Jr. Eight additional specimens (Table 2), collected from site 1 (Fig. 1), and one collected at site 2 (Fig. 2), a previously unreported location, are in my temporary possession with the exception of one on temporary exhibit at The Science Museum of Minnesota, St. Paul, Minnesota. Three additional specimens were live-trapped and released on 14 October, 1967 at site 1. Other than as noted all specimens were obtained in standard wooden snap traps baited only with peanut butter. Those collected at site 1 were all taken in 25 traps placed across runways, while the previously unreported specimen at site 2 and two specimens from site 3 were obtained in random transects of 100 traps through habitats showing no sign. Numerous small diggings were observed at site 1 some of which were possibly made by prairie deer mice, *Peromyscus maniculatus bairdii,* or thirteen-lined ground squirrels, *Spermophilus tridecemlineatus.* Plant stem clippings characteristically left by *pennsylvanicus* were not observed at any of the trap sites nor was that species trapped closer than 100 m. to *ochrogaster* and away from the dense cover of fencerows. Conspicuous networks of subsurface runways radiating 35 m. outwards from a central mound perforated with holes were the distinctive signs of *ochrogaster minor* activities. Their pattern suggested a miniature colony of Richardson's ground squirrels, *Spermophilus richardsonii,* and agreed entirely with classical descriptions of Jackson (1972), Stalling (1990), Schmidt (1931), Soper (1964), and Nordquist and Birney (1988).

The central mound was probably formed by a pocket gopher, *Geomys bursarius,* but possibly by red fox, *Vulpes vulpes,* badger, *Taxidea taxus,* or less likely by ants or the voles themselves. The mound measured .75 m in diameter and was partially overgrown with stunted grasses and weeds. Entrance holes measuring 19 mm. in width opened outwards on all sides of the mound at scattered intervals along the runways which measured 25 mm. in width. The runways were clearly visible from above and followed rows of old corn stubble within an area approximately .2 ha. Neither signs nor specimens were encountered elsewhere in the 34 ha. field which was enclosed by lower fields, wetlands, peripheral fencerows on two sides and upland woodlands of jack pine, *Pinus banksiana,* northern pin oak, *Quercus ellipsoidalis,* bur oak, *Q. macrocarpa,* and American hazel, *Corylus americana.*

Some specimens were trapped only moments after placement of traps at entrance holes during daylight hours. None, however, were taken in runways until nightfall, suggesting that nocturnal activity was an avoidance response to diurnal predators induced by the heightened visibility of the voles in the sparse vegetation. Live individuals upon handling revealed a very docile disposition. Upon release, they moved with considerably more agility than *pennsylvanicus,* and with such speed that escape from predators would be enhanced. Table 4 lists potential predators known at site 1. Stalling (1990) remarks that "nearly every predator that is sympatric with *ochrogaster* has been reported to eat this vole." Other mammalian, avian, and reptilian cohorts associated with the colony at site 1 are listed in Fig. 5. Many of these were also recorded at sites 2 and 3. Among them were eight species of birds listed as state endangered, threatened and of special concern and one species of reptile listed as a species of special concern.

All specimens display grizzled pelages that are strikingly distinct from *pennsylvanicus.* Although most appear rather uniform in coloration, two extreme individuals show sharply contrasting light silvery gray and sandy buff toned pelages (see frontispiece). None suggest the dark intense rust-walnut color noted by Long (1976) in populations of *ochrogaster minor* from the transition zone of central Wisconsin. Most of the 27 specimens appeared to be subadults approaching adult dimensions. Only two females were reproductively active. One contained five embryos and another displayed ten placental scars. These data suggest larger than mean litter sizes of 3.4 for the species (Hall and Kelson, 1959) and a potentially rising or high cycle population at the time the specimens were collected. Although the ten scars were believed to represent a single set, the reproductive tract was not saved and the age of the scars is therefore questionable. Furthermore, Corthum (1967) reported that the number of placental scars in *ochrogaster* exceed the number of offspring born to females sacrificed at 28 days or less after producing litters, but are fewer for females sacrificed 42 days after producing litters.

Table 3 gives the results of trapping efforts undertaken in suitable appearing habitats for *ochrogaster minor* at southern and western locations in Wadena County. The last positive signs of the species noted in Wadena County were observed at site 1 on 24 July 1974 .

DISCUSSION

Although the preferred habitat of *ochrogaster* is usually considered to be natural prairie, a wide variety of weedy areas, overgrown fencerows, lightly grazed grassy pasturelands, dry ditches along roadsides, wastelands, and agricultural croplands is used by the species. The known occurrence of *ochrogaster minor* in Wadena County within agricultural lands suggests it adapted to some extent here, as elsewhere, to non-prairie habitats. Getz et al, (1987) indicate that many agricultural plants are nutritionally superior in quality to the original prairie species they have replaced, and offer greater variety and quantity of good food for longer periods each year. Batzli and Cole (1979) indicate also that *ochrogaster* digests rabbit pellets of alfalfa, *Medicago sativa,* and grain significantly better than some other species of voles.

The time of arrival of the species in the area is unclear. However, it could have appeared either early (1) between 7,000 and 6,000 Y.B.P. during the post glacial thermal maximum when prairie reached its most eastward extension and persisted as clearings created and maintained by repeated burning of jack pine forests; as fire control increased in recent decades, and clearings within the pine forests disappeared, scattered populations of *ochrogaster* radiated into cleared areas and agricultural fields after the logging era; or late (2) presumably from the west after the logging and clearing of forests that accompanied white European settlement in the late 1800s created agricultural lands.

TABLE 1. Descriptions of trapsites of *Microtus ochrogaster minor* in Wadena County, Minnesota.

Location	Land Form Features *	Soils *	Recent Vegetation
Site 1: T136N R33W S11 NE 1/4 of NE 1/4	north face of a gently sloping drumlin	well drained dark colored loamy sand over sandy loam, some scattered cobbles and boulders	actively cultivated private field in corn, *Zea maize,* oats, *Avena fatua,* alternated with fallow periods of soil bank set aside or hay crops of alfalfa, *Medicago sativa,* timothy, *Phleum pratense,* red clover, *Trifolium pratense,* white clover, *T. repens,* and alsike, *T. hybridum;* grazed heavily for several weeks in the autumns of 1966 and 1967; cropped of corn in Sept. 1965 and left fallow in 1966 and 1967 with corn stubble, scattered grasses, *Setaria* sp., clovers, *Trifolium* spp., plantain, *Plantago* sp. and mustards, *Brassica* spp. Now in hay crops.
Site 2: T137N R33W S36 NW 1/4 of NE 1/4	north face of a gently sloping drumlin	well drained light colored sand over gravel, some scattered cobbles and boulders	private corn field fallow from cropping of the past year and dominated by horseweed, *Conyza canadensis,* and evening primrose, *Oenothera* sp., on bare sand surface with little or no litter, but some corn stubble. Now in corn.
Site 3: T135N R33W S30 SE 1/4 of SW 1/4	nearly level to gently undulating outwash plain	well drained dark colored sandy loam	private corn field fallow from cropping of the past year dominated by sparse ground cover of weeds including foxtail, *Setaria* sp., plantain, *Plantago* sp., mustard, *Brassica* sp., dandelion, *Taraxacum officiniale,* brome grass, *Bromus* sp., goldenrod, *Solidago* sp., wild rose, *Rosa* sp., horseweed, *Conyza canadensis,* quack grass, *Agropyron repens,* evening primrose, *Oenothera* sp., white sweet clover, *Melilotus alba,* common ragweed, *Ambrosia artemisiifolia,* sow-thistle, *Sonchus* sp., red clover, *Trifolium pratense,* lamb's quarters, *Chenopodium album,* and bladder campion, *Silene vulgaris.* Now in corn with irrigation system.

* Minnesota Soil Atlas, 1969

TABLE 2. Additional *Microtus ochrogaster minor* specimens from Wadena County, Minnesota.

Date of Collection	Location	Age	Sex	Length of: Total Lgth (mm)	Tail (mm)	Hind Foot (mm)	Ear (mm)	Comments
29 Oct. 1966	Site 1	SA	M	120	23	16	10	on temporary exhibit at SMM
29 Oct. 1966	Site 1	AD	F	154	31	15	10	
28 May 1967	Site 1	AD	F	133	25.4	16	11	
29 May 1967	Site 1	AD	F	141	28.7	14	9.7	embryos 5-3R, 2L
14 Oct. 1967	Site 1	SA	F	115	25	15	10	
2 May 1970	Site 2	AD	M	127	33	16.5	9	

TABLE 3. Additional Wadena County sampling locations for *M. ochrogaster.*

Location	Date	Number of Trap Nights	Results
T137N R35W S18 SE 1/4	20-21 June 1968	100	* *Peromyscus maniculatus bairdii, Microtus pennsylvanicus, Blarina brevicauda, Spermophilus tridecemlineatus*
T135N R34W S 29 NW 1/4	22-23 June 1968	100	* *Peromyscus maniculatus bairdii, Microtus pennsylvanicus*
T135N R35W S21 NW 1/4	24-26 June 1968	200	*Microtus pennsylvanicus* (14), *Zapus hudsonius* (2), *Blarina brevicauda* (2), *Sorex cinereus* (1)
T137N R35W S20 NW 1/4	23-24 Aug. 1968	50	*Microtus pennsylvanicus* (3)
T134N R35W S36 SE/SW 1/4	26-27 Apr. 1969	100	*Microtus pennsylvanicus* (18), *Blarina brevicauda* (2), *Peromyscus maniculatus bairdii* (1)
T138N R35W S18	4 - 5 July 1969	100	*Clethrionomys gapperi* (3)
T134N R35W S23	12-13 July 1969	100	*Spermophilus tridecemlineatus* (3), *Microtus pennsylvanicus* (2), *Blarina brevicauda* (2), *Zapus hudsonius* (1)
T134N R33W S17 SE 1/4 of NE 1/4	22-23 May 1976	100	* *Microtus pennsylvanicus, Spermophilus tridecemlineatus, Peromyscus maniculatus bairdii*
T134N R33W S17 SE 1/4 of NE 1/4	3 - 4 June 1989	69	*Microtus pennsylvanicus* (2), *Sorex cinerus* (2), *Spermophilus tridecemlineatus* (1), *Zapus hudsonius* (1), *Peromyscus maniculatus bairdii* (1)
	Total	919	

* Numbers of specimens not available

TABLE 4. Potential predators of *M. ochrogaster* recorded at Site 1.

Mammals	
short-tailed shrew	*Blarina brevicauda*
thirteen-lined ground squirrel	*Spermophilus tridecemlineatus*
Franklin's ground squirrel	*S. franklinii*
coyote	*Canis latrans*
red fox	*Vulpes vulpes*
raccoon	*Procyon lotor*
short-tailed weasel	*Mustela erminea*
badger	*Taxidea taxus*
striped skunk	*Mephitis mephitis*
Birds	
bald eagle*	*Haliaeetus leucocephalus*
northern harrier	*Circus cyaneus*
sharp-shinned hawk**	*Accipiter striatus*
Cooper's hawk**	*A. cooperii*
northern goshawk**	*A. gentilis*
broad-winged hawk**	*Buteo platypterus*
red-tailed hawk	*B. jamaicensis*
rough-legged hawk**	*B. lagopus*
golden eagle**	*Aguila chrysaetos*
American kestrel	*Falco sparverius*
great horned owl	*Bubo virginianus*
snowy owl**	*Nyctea scandica*
barred owl	*Strix varia*
great gray owl**	*S. nebulosa*
long-eared owl	*Asio otus*
short-eared owl*	*A. flammeus*
black-billed magpie**	*Pica pica*
American crow	*Corvus brachyrhyncos*
common raven**	*C. corax*
northern shrike**	*Lanius excubitor*
loggerhead shrike*	*L. ludovicianus*
Reptiles	
common garter snake	*Thamnophis sirtalis*
eastern hog-nosed snake*	*Heterodon platyrhinos*

- Species identified as threatened or special concern on federal and/or state (Minnesota Department of Natural Resources, 1986) lists.

•• Species present only as transients or winter visitants.

TABLE 5. Faunal cohorts of *M. ochrogaster* recorded at Site 1.

Mammals	
masked shrew	*Sorex cinerus*
pigmy shrew	*S. (Microsorex) hoyii*
white-tailed jack rabbit	*Lepus townsendii*
prairie deer mouse	*Peromyscus maniculatus bairdii*
white-tailed deer	*Odocoileus virginianus*
Birds	
ring-necked pheasant	*Phasianus colchicus*
greater prairie-chicken*	*Tympanuchus cupido*
killdeer	*Charadrius vociferus*
upland sandpiper*	*Bartramia longicauda*
northern flicker	*Colaptes auratus*
western kingbird	*Tyrannus verticalis*
eastern kingbird	*T. tyrannus*
horned lark	*Eremophila alpestris*
eastern bluebird***	*Sialia sialis*
American robin***	*Turdus migratorius*
water pipit*	*Anthus spinoletta*
Sprague's pipit*,**	*A. spragueii*
American tree sparrow**	*Spizella arborea*
chipping sparrow	*S. passerina*
clay-colored sparrow	*S. pallida*
vesper sparrow	*Pooecetes gramineus*
savannah sparrow	*Passerculus sandwichensis*
grasshopper sparrow	*Ammodramus savannarum*
Le Conte's sparrow***	*A. leconteii*
song sparrow***	*Melospiza melodia*
Lincoln's sparrow***	*M. lincolnii*
swamp sparrow***	*M. georgiana*
dark-eyed junco**	*Junco hyemalis*
Lapland longspur**	*Calcarius lapponicus*
chestnut-collared longspur*,**	*C. ornatus*
snow bunting**	*Plectrophenax nivalas*
bobolink	*Dolichonyx oryzivorus*
red-winged blackbird***	*Agelaius phoeniceus*
eastern meadowlark	*Sturnella magna*
western meadowlark	*S. neglecta*
yellow-headed blackbird***	*Xanthocephalus xanthocephalus*
Brewer's blackbird	*Euphagus cyanocephalus*
brown-headed cowbird	*Molothrus ater*
common redpoll**	*Carduelis flammea*
hoary redpoll**	*C. hornemanni*
American goldfinch	*C. tristis*

* Species identified on Minnesota check list (DNR, 1986) as special concern.
** Species utilizing the site only as transients or winter visitants.
*** Species breeding in adjoining habitats and utilizing the habitats sporadically, more commonly as migrating transients.

TABLE 6. Common prairie plants of openings in jack pine forests found at or near *M. ochrogaster* trapsites in Wadena County.

oval-leaved milkweed	*Asclepias ovalifolia*
hoary puccoon	*Lithospermum canescens*
hairy puccoon	*L. carolinense*
snowberry	*Symphoricarpos albus*
frostweed	*Helianthemum bicknellii*
white sage	*Artemesia ludvicianus*
azure aster	*Aster oolentangiensis*
horseweed	*Conyza canadensis*
sunflowers	*Helianthes spp.*
blazing star	*Liatris aspera*
blazing star	*L. ligulistylus*
dwarf dandelion	*Krigia biflora*
black-eyed Susan	*Rudbeckia hirta*
showy goldenrod	*Solidago speciosa*
gray goldenrod	*S. nemoralis*
rigid goldenrod	*S. rigida*
big blue stem	*Andropogon gerardii*
blue grass, June-grass	*Koeleria macrantha*
blue-eyed grass	*Sisyrinchum montanum*
blue-eyed grass	*S. campestre*
bergamot	*Monarda fistulosa*
Canada milk vetch	*Astragalus canadensis*
leadplant	*Amorpha canescens*
white prairie-clover	*Petalostemon candidum*
purple prairie-clover	*P. purpureum*
wild onion	*Allium stellatum*
wood-lily	*Lilium philadelphium*
starry-flowered false Solomon's-seal	*Smilacina stellata*
Solomon's-seal	*Polygonatum commutatum*
yellow lady slipper	*Cypridedum calceolus*
violet wood-sorrel	*Oxalis violacea*
prairie-phlox	*Phlox pilosa*
thimbleweed	*Anemone cylindrica*
pasque flower	*Pulsatilla nuttaliana*
prairie smoke	*Geum triflorum*
sand-cherry	*Prunus pumila*
alumroot	*Heuchera richardsonii*
wood betony	*Pedicularus canadensis*
ground-cherry	*Physalis virginiana*
golden Alexander	*Zizia aptera*
prairie violet	*Viola pedatifida*

Although existing evidence fails to confirm either hypothesis, reasonable grounds for both can be argued. That all collection sites were originally covered by jack pine, *Pinus banksiana,* forest with lesser inclusions of white and red pines, *P. strobus* and *P. resinosa* and black (=northern pin) oak, *Quercus ellipsoidalis* (Marschner, 1974; original surveyor's notes ca. 1884) suggests that *ochrogaster minor* could have been resident in fire generated clearings, some of which were extensive. Original surveyor's notes (1884) for example describe site 3 (Fig. 3) as being "land, gently rolling prairie and scattering black (= jack) pine". Such clearings contained substantial numbers of prairie flora some of which still persist in more open or young pine woodlands in the area. Of 1326 vascular plant species analyzed from current distribution maps for Minnesota (Ownbey and Morley, 1991) that have or possibly occurred in Wadena County, 325 (23%) show centers of abundance falling primarily within the prairie and western edge of the transition zone of Minnesota. Many known important food plants of *ochrogaster minor* were common in areas bordering each trap site (Table 6). Banfield (1974) reported four of these (wood-lily, *Lilium* sp., wild prairie onion, *Allium stellatum,* pasque flower, *Pulsatilla nuttaliana,* and sunflowers, *Helianthes* spp.) in one cache containing 2854 rhizomes, tubers, roots, and bulbs weighing 2.7 kg. In addition, Jokela and Lorenz (1959) reported *ochrogaster* to be a major consumer of pine seedlings, including jack pine, in young plantations. Significantly, Schmidt (1931) found *ochrogaster minor* in jack pine and northern pin oak woods in the transition zone of north-central Wisconsin which had soils and ground vegetation virtually identical to those in Wadena County. It is also of interest to note that the nearest eastward extant population of *ochrogaster minor* at Camp Ripley in Morrison County about 100 km. distant, similarly exists on a site formerly occupied by jack pine and oak woodlands.

The occurrence of all trap stations on agricultural lands only, on the other hand, suggests that the voles could have followed roads and railroads presumably from the west into the cleared lands. However, trapping efforts at the habitats most resembling true prairie including roadsides, fencerows and railroad rights-of-way in the southern and western portions of the county and outside of the jack pine forest zone have produced no specimens (Table 3). It is unclear if these results support the contentions of Klatt and Getz (1987) that roads are unimportant as corridors or Swihart and Slade (1984) that roads however small are barriers to dispersal of *ochrogaster.* Stalling (1992) believed railroad rights-of-way serve as dispersal corridors throughout the range of *ochrogaster,* but despite their rather rich prairie flora and open structures in Wadena County, I found only *pennsylvanicus* in them. The presence of that species in most infrequently mown roadsides may either reflect that their vegetational structure is too tall and dense for *ochrogaster* or that *pennsylvanicus* has excluded *ochrogaster* from them. However, past occurrences of *ochrogaster* at these locations especially during droughty periods such as during the 1930s when vegetation structure would have favored it rather than *pennsylvanicus* are not precluded. Currently, the nearest known extant population of *ochrogaster minor* westward of Wadena County is near Felton, Clay County, Minnesota about 150 km. distant.

SUMMARY AND CONCLUSION

All known occurrences of *ochrogaster minor* in Wadena County were from well drained northerly slopes of gently rolling outwash plains and elevated drumlins having sandy, gravelly or sandy loam soils. These agree with most descriptive accounts of habitats for the subspecies and give credence to the name of little upland mouse (Anderson, 1946, and Herrick, 1892) or upland meadow mouse (Merriam, 1888). All sites were privately owned, disturbed agricultural habitats dominated by a variety of introduced plants, both cultivated and weed species. Most were common widespread species known to be food plants of *ochrogaster* (Zimmerman, 1965). All sites were originally covered with jack pine forests that contained a significant element of prairie flora. The vegetation structure at each site was sparse with virtually no litter.

Recent attempts to locate the species at the original trapsites and elsewhere in Wadena County have failed. Although the species probably no longer exists at the original trapsites, its time of disappearance is uncertain. It was possibly discovered during high cycle years during which times it can be highly visible and show unusual behavior and diets under conditions of stress (Crawford, 1971).

If *ochrogaster minor* still exists in reduced numbers and at restricted sites, its detection might be difficult. If its extirpation has occurred, multiple causes of both biological and anthropogenic nature are indicated. Since trapping efforts ceased at site 1 before the population showed signs of decrease, collecting could not have contributed significantly to the ultimate disappearance of the colony. However, changes in land uses and practices have subsequently been pervasive. Most involve increased mechanization and efficiency in harvesting crops. These leave less waste grains for food. In addition, winter cover formerly provided by shocking of grain crops has been lost. Irrigation systems have been added to site 3 (Fig. 3), to which *ochrogaster* in Kansas reportedly avoids (Fleharty and Navo, 1983). Increased local applications of fertilizers and herbicides also represent potential factors of unknown importance in altering the habitats of the trap sites or poisoning the animals.

Biologically, the land uses have changed more unfavorably the vegetation structure than its composition. Most plant species including introduced crops and attendant weeds found both formerly and presently at the trap sites are known foods of *ochrogaster.* Although brief grazing of dairy cattle during the years of collection was apparently tolerated by the species, the more recent intensive and routine post harvest grazing by large numbers of beef cattle in autumn reduced the plant cover to minimal amounts during the period between late fall and early summer. The reduced ground cover favors only open country mammals most of which are either predators or possible competitors with *ochrogaster.* The predator species reported from the sites, with the exception of the badger, *Taxidea taxus,* have either remained stable or perhaps increased at sites 1, 2, and 3. The prairie deer mouse, *Peromyscus maniculatus bairdii,* shares the same habitat and is reportedly a strong competitor of *ochrogaster* (Abramsky and Tracy, 1979). It is also abundant and may be increasing at all three sites. No direct contact or interaction with *pennsylvanicus*

was found. Both selection of dry soils and an observed propensity of *ochrogaster* to dig more may represent behavioral adaptations to a specific habitat different from that chosen by *pennsylvanicus.* Possible physiological adaptations to droughty conditions as well have been suggested for *ochrogaster* by Klatt and Getz (1987).

The separation of human and natural causes or their combined effects in influencing both the appearance and disappearance of *ochrogaster minor* from sites in Wadena County is difficult. And as elsewhere, small mammal sampling has been biased in favor of the least disturbed environments. Fleharty and Navo (1983) address this issue and stress the need for investigators of intensive agricultural systems to identify mammalian interactions and responses. Efforts are needed to resolve the thresholds of tolerance of *ochrogaster minor* for agricultural lands wherever it is found in Minnesota. Because populations of *ochrogaster* are geographically (subspecifically) and genetically variable, expectations that the species behaves similarly throughout its range are unwarranted.

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FIGURE I. Site 1 at T136N R33W S11 NE 1/4 of NE 1/4 viewed from the northwest. The vole colony was located slightly above and left of the center of the photograph. Taken 23 April 1993.

FIGURE 2. Site 2 at T137N R33W S36 NW 1/4 of NW 1/4. One specimen was trapped at the center of the photograph. Taken 23 April 1993.

FIGURE 3. Site 3 at T135N R33W S30 SW 1/4 of SE 1/4 viewed from the south. Two *ochrogaster minor* were trapped slightly below the center of the photograph. Taken 23 April 1993.

LITERATURE CITED

Abramsky, Z., M. I. Dyer, and P. D. Harrison. 1979. Competition among small mammals in experimentally perturbed areas of the shortgrass prairie. *Ecology,* 60: 530-536.

Abramsky, Z., and C. R. Tracy. 1979. Population biology of a "non-cycling" population of prairie voles and a hypothesis on the role of migration in regulating microtine cycles. *Ecology,* 60: 349-361.

Allen, P. F. 1936. *Microtus ochrogaster* in Minnesota. *Journal of Mammalogy,* 17: 291.

Anderson, Rudolph Martin. 1946. Catalogue of Canadian recent animals. *Canada Dept. of Mines and Resources Mines, and Geology Branch National Museum of Canada Bulletin,* 102 Biol. Series No. 31, Ottawa. Edmond Clouber, CMG, BA, L. PH. Kings Printer and Controller. p. 163.

Armstrong, David M., Jerry R. Choate, and J. Knox Jones, Jr. 1986. Distributional patterns of mammals in the great plains states. *Occasional Papers of the Museum of Texas Tech University,* Lubbock, Texas. No. 105: 1-27.

Bailey, Bernard. 1929. Mammals of Sherburne County Minnesota. *Journal of Mammalogy,* 10: 153-164.

Banfield, A. W. F. 1974. *The mammals of Canada.* University of Toronto Press, Toronto, Ontario, Canada. 205-207.

Batzli, G. O. and F. Russel Cole. 1979. Nutritional ecology of microtine rodents: digestibility of forage. *Journal of Mammalogy,* 60: 740-750.

Bowles, J. B. 1981. Iowa's mammal fauna: an era of decline. *Proceedings of the Iowa Academy of Science,* 88: 38-42.

Clark, B. K., Donald W. Kaufman, Elmer J. Finch, and Glennis A. Kaufman. 1989. Small mammals in tall-grass prairie: patterns associated with grazing and burning. *Prairie Naturalist,* 21: 177-184.

Coffin, B. A. and L. A. Pfannmuller, eds. 1988. *Minnesota's Endangered Flora and Fauna.* University of Minnesota Press. Minneapolis, Minnesota. 473 pp.

Corthum, Kenneth Wm., Jr. 1967. Reproduction and duration of placental scars in the prairie vole and the eastern vole. *Journal of Mammalogy,* 48: 287-292.

Crawford, Richard D. 1971. High population density of *Microtus ochrogaster. Journal of Mammalogy,* 52: 478.

Findley, J. S. 1954. Competition as a possible limiting factor in the distribution of *Microtus. Ecology,* 35: 418-420.

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

Getz, L. L. 1962. Aggressive behavior of the meadow and prairie voles. *Journal of Mammalogy,* 43: 351-358.

Getz, L. L., Joyce E. Hofmann, and Carol S. Carter. 1987. Mating system and population fluctuations of the prairie vole, *Microtus ochrogaster. American Zoologist,* 27: 909-920.

Hall, E. Raymond and Keith R. Kelson. 1959. *The mammals of North America.* The Ronald Press Company, New York. Vol 2: 748-749.

Hamilton, William J. Jr., and John O. Whitaker, Jr. 1979. *The mammals of the eastern United States.* Comstock Publishing Associates. Cornell University Press. pp. 221-223.

Hazard, Evan B. 1982. *The mammals of Minnesota.* University of Minnesota Press, Minneapolis. pp. 95-96.

Heaney, Lawrence R. and Elmer C. Birney. 1975. Comments on the distribution and natural history of some mammals in Minnesota. *The Canadian Field Naturalist,* 89: 29-34.

Herrick, C.L. 1892. Mammals of Minnesota. *Geological and Natural History Survey of Minnesota.* Bulletin No. 7. Harrison and Smith, State Printers, Minneapolis. pp. 204-208.

Huggins, James A. and V. R. McDaniel. 1984. Intraspecific variation within a southeastern population of the prairie vole, *Microtus ochrogaster (Rodentia). The Southwestern Naturalist,* 29: 403-406.

Jackson, Harley H. T. 1972. *Mammals of Wisconsin.* University of Wisconsin Press, Madison. pp. 236-239.

Jokela, J. J. and Ralph Lorenz. 1959. Mouse injury to forest plantings in the prairie region of Illinois. *Journal of Forestry,* 57: 21-25.

Jones, J. Knox Jr. and Elmer C. Birney. 1988. *Handbook of mammals of the north-central United States.* University of Minnesota Press. Minneapolis. pp. 212-213.

Klatt, Brian J. and Lowell L. Getz. 1987. Vegetation characteristics of *Microtus ochrogaster* and *M. pennsylvanicus* habitats in east-central Illinois. *Journal of Mammalogy,* 68: 569-577.

Long, Charles A. 1976. *Microtus ochrogaster minor* in Wisconsin. Reports on mammals. Part I in *Reports on the Fauna and Flora of Wisconsin No. 11.* The Museum of Natural History, Stevens Point, Wisconsin. p. 1.

Marschner, Francis J. 1974. The original vegetation of Minnesota (map). U.S. Department of Agriculture Forest Service, North Central Forest Experiment Station, St. Paul, Minnesota. (Redraft of the original 1930 edition).

McGovern, M. and C. R. Tracy. 1987. Demographic characteristics of fenced and unfenced populations of *Microtus ochrogaster* in manipulated plots of short grass prairie. *Mammalia,* 51: 65-79.

Merriam, C. H. 1888. Description of a new prairie meadow mouse (*Arvicola austerus minor*) from Dakota and Minnesota. *The American Naturalist,* 22: 598-601.

Meserve, Peter L. 1971. Population ecology of the prairie vole, *Microtus ochrogaster,* in the western mixed prairie of Nebraska. *The American Midland Naturalist,* 86: 417-433.

Miller, William C. 1969. Ecological and ethological isolating mechanisms between *Microtus pennsylvanicus* and *Microtus ochrogaster* at Terre Haute, Indiana. *The American Midland Naturalist,* 82: 140-149.

Minnesota Department of Natural Resources checklist of endangered and threatened animal and plant species of Minnesota, 1986. Minnesota Department of Natural Resources, St. Paul, Minnesota.

Minnesota Soil Atlas, Brainerd Sheet. Agricultural Experiment Station. *University of Minnesota Miscellaneous Report 90-1969.*

Nordquist, G. E., and E. C. Birney. 1988. Mammals: endangered, threatened, and special concern. pp. 293-322 in *Minnesota's Endangered Flora and Fauna* (B. Coffin and L. Pfannmuller, eds.). University of Minnesota Press, Minneapolis. 473 pp.

Ownbey, G. B. and T. Morley, 1991. *Vascular plants of Minnesota, checklist and atlas.* University of Minnesota, Minneapolis. 307 pp.

Pfanmuller, Lee A. and Barbara Coffin, eds. 1989. *The uncommon ones: Minnesota's endangered plants and animals.* Section of Nongame Wildlife and Natural Heritage Program. Minnesota Department of Natural Resources, St. Paul, Minnesota.

Reed, Michael P. and Jerry R. Choate. 1986. Noteworthy southwestern records of the prairie vole. *Southwestern Naturalist,* 33: 495-496.

Rose, Robert K. and Michael S. Gaines. 1976. Levels of aggression in fluctuating populations of the prairie vole, *Microtus ochrogaster,* in eastern Kansas. *Journal of Mammalogy,* 57: 43-57.

Schmidt, F. J. W. 1931. Mammals of western Clark County, Wisconsin. *Journal of Mammalogy,* 12: 99-117.

Soper, Dr. J. Dewey. 1964. *Mammals of Alberta.* The Hamly Press, LTD. Edmonton, Alberta, Canada. pp. 228-230.

Stalling, Dick T. 1990. *Microtus ochrogaster* in *Mammalian Species*, 355: 1-9. The American Society of Mammalogists.

Swihart, Robert K. and Norman A. Slade. 1984. Road crossing in *Sigmodon hispidus* and *Microtus ochrogaster. Journal of Mammalogy,* 65: 357-360.

Taitt, M. J. and C. J. Krebs. 1985. Population dynamics and cycles in *Biology of New World Microtus*. R. H. Tamarin, ed. Special Publication, The American Society of Mammalogists, 8:567-620.

Turner, Ronald W. 1974. Mammals of the Black Hills of South Dakota and Wyoming. *University of Kansas Museum of Natural History Miscellaneous Publication No. 60,* Museum of Natural History, University of Kansas, Lawrence, Kansas. pp. 110-114.

Wendt, K. M. and B. A. Coffin. 1988. Natural vegetation of Minnesota at the time of the public land survey 1847-1907. *Biological Report No. 1,* Natural Heritage Program, Minnesota Department of Natural Resources, St. Paul, Minnesota. 4 pp.

Zimmerman, Earl G. 1965. A comparison of habitat and food of two species of *Microtus. Journal of Mammalogy,* 46: 605-612.