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Impacts Of Agricultural Landscapes On The Breeding Biology And Behavioral Ecology Of Grassland Birds

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Impacts of Agricultural Landscapes on the Breeding Biology and Behavioral Ecology of Grassland Birds

(TITLE)

BY

Susan Allison Linn

THESIS

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF

BIOLOGY

IN THE GRADUATE SCHOOL, EASTERN ILLINOIS UNIVERSITY
CHARLESTON, ILLINOIS

2004

YEAR

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IMPACTS OF AGRICULTRAL LANDSCAPES ON THE BREEDING BIOLOGY AND BEHAVIORAL ECOLOGY OF GRASSLAND BIRDS

BY

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B.S., S.U.N.Y. College at Cortland, 2000

THESIS

Submitted in partial fulfillment of the requirements for the degree of Master of Science
in the Department of Biological Sciences
in the Graduate School of
Eastern Illinois University, 2004

Charleston, Illinois

IMPACTS OF AGRICULTRAL LANDSCAPES ON THE BREEDING BIOLOGY AND BEHAVIORAL ECOLOGY OF GRASSLAND BIRDS

Susan Allison Linn
Department of Biological Sciences
Eastern Illinois University, 2003

Population declines of grassland birds in the Midwest have caused great concern in recent decades. Dominant factors contributing to these declines are increases in rowcrop agriculture and habitat loss. Few studies have examined the influence of surrounding farmland on the nesting and behavioral ecology of grassland birds. In an attempt to document the interactions that occur between grassland birds and agricultural landscapes, we examined the nest distribution and success of Eastern Meadowlarks and Bobolinks in relation to different edge habitats. In addition, the foraging patterns and nestling diets of Eastern Meadowlarks were studied.

To determine nest distributions and success, 263 Eastern Meadowlark and 59 Bobolink nests were located and monitored. Foraging patterns of Eastern Meadowlarks were assessed by observing 19 active nests during the nestling period and nestling diets were determined by applying esophageal ligatures to 3- and 6-day old nestlings. Surprisingly, nests located within 50 m of most edges appeared to have higher success than more interior nests for both species. Furthermore, meadowlarks nested near roadside edges significantly more than expected. However, Bobolinks avoided nesting near roadsides and cornfield edges.

Adult meadowlarks were most likely to feed arachnids to their young nestlings but fed older nestlings a more variable diet. Observations of foraging trips revealed that overall, meadowlarks did not prefer or avoid any habitat within the landscape, foraging at random. However they did seem to feed more often than expected in soybean fields.

Agricultural landscapes potentially can have a positive affect on the nesting success of grassland bird species and provide supplemental food and cover for breeding Eastern Meadowlarks. Therefore, even small grassland areas within an agricultural matrix can provide sufficient breeding and foraging habitat for declining populations of some species of grassland birds.

ACKNOWLEDGMENTS

I am immensely grateful to many people for assisting me in the completion of this project as well as furthering my educational development. First I would like to thank my advisor, Eric Bollinger, who has provided me with unwavering support during my time at Eastern and was always in his office to hear my ideas and give advice. In addition, he is the only person who was able to alleviate my concerns and calmly deal with my high-strung personality. Thank you to my committee members, Paul Switzer and Tom Nelson, whose courses were truly invaluable and shaped my views on issues regarding animal behavior and wildlife management. A special thanks to Richard Funk who spent countless hours identifying the numerous spider specimens I collected and to Scott Meiners, who answered all my ridiculous stats questions. I would like to thank my undergraduate advisor, Dr. R. L. Klotz, whose friendship and guidance gave me the confidence to pursue this endeavor and who made me the scientist I am today. I also thank Dr. Steve Broyles for introducing me to the world of ornithology—his passion and enthusiasm for this and other subjects is absolutely amazing.

Funding for this project was provided by the Council for Faculty Research (CFR) from Eastern Illinois University, a creative research award from the EIU graduate school, and the Champaign County Audubon Society's Kendeigh Memorial Student Research Fund.

I am sincerely grateful for the help I received during the two seasons of nest searching. All those who helped endured inclement weather, long hot days, tick-infested fields and the joy of dragging a rope in hopes of finding one more nest. I am especially indebted to Nathan Hudson, Evanielis 'Van' Grissam, Brian Towey, and

Patrick Enstrom who worked tirelessly alongside me for little monetary return (In Pat's case, no monetary return!). Mary Beth Brey, Emma Grieg and many fellow graduate students also gave me a hand whenever possible.

The Illinois Department of Natural Resources (DNR) and the Charleston Farm Bureau were immensely helpful in finding local landowners who were willing to allow me to work on their property. I also appreciate the support from the Department of Biological Sciences for providing me with summer assistance and the use of the blue Suburban (aka 'the blue dog), that I will miss dearly.

I would like to express my gratitude to my incredibly supportive Mom and Dad who listened to every tearful phone call when I was frustrated and gave me guidance and support whenever it was needed. The Wal-Mart gift cards and frequent 'pity grants' were truly appreciated. Last but certainly not least, I would like to thank my fiancé, Ken Ostrand, who for the past year has *absolutely* supported and encouraged me through the frustrating times during this process. He has the uncanny ability to put things in perspective when I'm discouraged and is always there for me when I need him. I will be forever grateful for his loving patience and support. Thank you.

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CHAPTER 1:

Eastern Meadowlark (*Sturnella magna*) and Bobolink (*Dolichonyx oryzivorus*) nest distribution and success in relation to different edge types

Abstract: Grassland birds in the Midwest are dependent upon anthropogenic grasslands that are commonly situated within an agricultural land matrix. Effects of agricultural edges undoubtedly influence avian distributions and reproductive success; however, these edge effects in grassland areas are poorly understood. Nests of Eastern Meadowlarks (*Sturnella magna*) and Bobolinks (*Dolichonyx oryzivorus*) were located and monitored in order to examine how different edge types affected nest placement and success. Nest distributions of the two species were very different, with meadowlarks preferring to nest near roadside edges (< 50 m) and Bobolinks avoiding roadside and corn edges. Despite contrasting nesting behavior, reproductive success of both species improved when nesting within 50 to 100 m of most edge types. Results indicated that agricultural edges may generate positive edge effects for these or some grassland birds and that small grassland patches in an agricultural landscape can provide productive habitat for these species.

Introduction: Habitat fragmentation has negatively influenced avian nest success and has contributed to dramatic population declines for many species in the last 50 years (Herkert 1990, Askins 1993, Peterjohn & Sauer 1999, Sauer et al. 2003). Habitat fragmentation increases the relative abundance and influence of habitat edges. These edges can attract damaging edge species (Hickman 1990, Miller et al. 1998), alter reproductive behavior (Gutzwiller et al. 1994), and increase nest predation and the abundance of brood parasites (Wilcove & Robinson 1990, Miller et al. 1998).

Historically, research efforts involving the negative effects of fragmentation and edge habitats have focused on forests and forest interior species. Conclusions from these initial investigations of forest fragmentation identified threats associated with edge habitat and increased awareness concerning the negative consequences of habitat fragmentation. The generality of these results for other habitats, however, has been disputed (Donovan et al. 1997, Woodward et al. 2001). Although some evidence supports detrimental fragmentation and edge effects in shrublands and grasslands (Johnson & Temple 1986, Winter et al. 2000, Walk 2001, Herkert et al. 2003), a wide range of results have been found in these habitats, indicating that other factors also may be involved (Donovan et al. 1997).

Midwestern populations of grassland birds have experienced significant declines, which have been attributed to agricultural expansion as well as the loss of secondary grasslands (Knopf 1994, Herkert 1995, Kershner 2001). The Eastern Meadowlark (*Sturnella magna*) and the Bobolink (*Dolichonyx oryzivorus*) are two species nesting in grassland habitats throughout the Midwest. Although populations of both species have decreased by over 60 % since the turn of the century (Herkert 1990), Bobolinks are currently experiencing more substantial declines in central Illinois (Sauer et al. 2003). Numerous similarities exist between meadowlarks and Bobolinks during the breeding season, most noticeably in the structure and composition of nest sites (Lanyon 1990, Martin & Gavin 1990). Both are ground nesters preferring to construct nests with interwoven pieces of surrounding living and dead herbaceous material (Lanyon 1990, Martin & Gavin 1990). Despite similarities in breeding behavior, differences in area requirements and habitat preferences have also been documented, with Bobolinks being more area sensitive (Bollinger & Gavin 1992, Johnson & Igl 2001) than meadowlarks (Johnson & Igl 2001). Many studies examining fragmentation in grassland areas have focused on the relationship between nest success and wooded edges (Johnson & Temple 1990), whereas few studies have considered other possible edge types such as agricultural and road edges as factors affecting avian reproductive success. This study examined nest distributions and success of Eastern Meadowlarks and Bobolinks in relation to edges commonly found in agricultural Midwestern landscapes.

Methods: Research was conducted at eight separate Conservation Reserve Program (CRP) fields of various sizes (1.35 ha - 20.80 ha), consisting of mixed grasses dominated by redtop (*Agrostis alba*) and orchard grass (*Dactylis glomerata*). The surrounding landscape mainly consisted of rowcrop agriculture (soybeans and corn) along with small forest fragments and wooded hedgerows. Sites were chosen based on their proximity to soybean and cornfields.

Nest searches were conducted between April and August 1997-2002 using the rope dragging technique (Higgins et al. 1969). Each nest was marked 5 m to the north with flagging tape. Nest status was recorded, noting date, number of eggs or nestlings, female presence, condition of eggs (warm or cold), and location. Nests were monitored every two to three days until fledging or nest failure and nests were mapped based on distance to habitat edge using a laser rangefinder.

Nest survival rate was estimated for each species for the duration of each breeding season as well as all seasons combined using Mayfield's (1975) method. Nest success was also calculated separately for those nests within 50 and 100 m of edge types (soybean, corn, road, all combined edge types) and the interior habitat. Edge habitat was defined as an area within 50 or 100 m of any edge type, whereas interior habitat was defined as an area 50 or 100 m away from all edges. Variance and standard errors were calculated based on Johnson (1979). To compare survival rates among different study areas and years, program CONTRAST (Hines & Sauer 1989) was utilized.

Nest locations were mapped for each study site. Areas of habitat within 50 and 100 m of all edge types (corn, soybeans, roadsides, and all combined edges) were then calculated to determine the number of nests one would expect to find if nest placement occurred at random with respect to these edges. A Chi-square goodness of fit test was then performed among the observed and expected numbers of nests within each area to determine whether either species exhibited on-site locational preferences.

Results:

Nest distributions.

A total of 263 meadowlark nests and 59 bobolink nests were located and monitored during the 1997-2002 breeding seasons. Eastern Meadowlarks nested within 50 m of roadsides significantly more than expected ($\chi^2 = 9.44$, df = 1, $P < 0.01$). Nest densities within 50 m of corn, soybeans, and all edge types combined did not differ from random expectations(Figure 1). When nest densities were assessed within 100 m of edge habitat, no significant differences were found for any edge type(Figure 2). Significantly fewer Bobolink nests were found within 50 ($\chi^2 = 7.89, 11.19$, df = 1, $P < 0.01$) and 100 m ($\chi^2 = 5.4, 21.15$, df = 1, $P < 0.01$) of corn and roadside edges, respectively (Figures 3 & 4).

Nest success and predation.

Overall nest success for Eastern Meadowlarks from 1997-2002 was 23.5% varying between 61.8% and 13.5% (Table 1). Bobolinks typically experienced higher survival rates, with overall nest success from 1997-2001 estimated at 39.8%. Highest nest success was recorded in 1998 with a survival rate of 80%, whereas 2001 had a survival rate of only 2%. Depredation of nests for Meadowlarks occurred at 50.2% of the time and 35.6% for Bobolinks. Remaining nests were unsuccessful due to inclement weather and nest abandonment.

Nest success in relation to edge.

Nest success for Meadowlarks was higher within 50 m of corn, roadsides, and all edges combined than in the interior habitat ($\chi^2_{corn} = 13.00$, $\chi^2_{road} = 27.37$, $\chi^2_{all\ edges} = 45.12$, df = 1, $P < 0.001$; Figure 5). Success was also significantly higher within 100 m of corn, soybeans, roadsides, and all edges combined ($\chi^2_{corn} = 38.98$, $\chi^2_{soybean} = 45.10$, $\chi^2_{road} = 19.89$, $\chi^2_{all\ edges} = 65.78$, df = 1, $P < 0.001$; Figure 6). Similarly, Bobolinks had higher nesting success within 50 m of all edge types ($\chi^2_{corn} = 18.31$, $\chi^2_{soybean} = 10.39$, $\chi^2_{all\ edges} = 169.40$,df = 1, $P < 0.01$; Figure 7), as well as higher success rates within 100 m of corn, roadsides, and all edges combined ($\chi^2_{corn} = 34.38$, $\chi^2_{all\ edges} = 80.75$, df = 1, $P < 0.001$; Figure 8).

Discussion: Eastern Meadowlarks and Bobolinks exhibited contrasting preferences regarding the placement of nests in relation to edge habitat. Meadowlarks nested near road edges significantly more than expected and did not seem to avoid nesting near other edge types. Bobolinks, on the other hand, significantly avoided nesting near both corn and roadside edges. These patterns are similar to those found in other studies. For example, Camp and Best (1994) and Warner (1992) both found that meadowlarks will nest in edge-dominated habitats such as roadsides and road rights-of-way. In contrast, Bobolinks have clear preferences for interior nesting habitat (O'Leary & Nyberg 2000, Johnson & Igl 2001, Bollinger & Gavin 2004, Fletcher & Koford 2003).

Several possible explanations have been discussed concerning edge sensitivity in Bobolinks (Bollinger & Gavin 2004). For example, competition for habitat with dominant species may be excluding Bobolinks from edge habitat. Edge habitat accommodated several species at my study sites including Eastern Meadowlarks, Red-winged Blackbirds (*Agelaius phoeniceus*), Ring-necked Pheasants (*Phasianus colchicus*), Northern Bobwhite (*Colinus virginianus*), and Dickcissels (*Spiza americana*). Red-winged Blackbirds and Eastern Meadowlarks are dominant over Bobolinks (Bollinger & Gavin 2003, Linn pers. obs) and Eastern Meadowlarks, Northern Bobwhite, and Ring-necked Pheasant are all ground nesters, possibly excluding Bobolinks from available edge/nesting habitat. Dickcissels are an unlikely competitor, as they are considerably smaller than Bobolinks, are not ground nesters, and prefer different habitat (Walk 2001). In addition, Bobolinks may have avoided habitat within 50 and 100 m of cornfields and roads because of variations in vegetation structure (corn edges). Diversity in macro- and micro- nutrient characteristics has been reported along agricultural edges (Osborne & Kovacic 1993) including increases in nitrogen concentration from agricultural runoff as well as possible temperature fluxes, increased wind activity, and changes in the local water cycle due to fragmentation (Saunders et al. 1991). Other factors possibly affecting nest site selection could include periodic mowing of field edges bordering roadsides, and vehicular traffic (Bollinger & Gavin 2004).

In contrast to Bobolinks, Meadowlarks nested near roads significantly more than expected. Contrary to prevalent thoughts concerning the effects of habitat fragmentation, potential benefits of selecting nest sites near roadsides and other edge types may occur for some species. Advantages may exist if these edges are closer to foraging areas than interior areas; and indeed, all roadside edges used in this study were bordered by either rowcrop fields or other grasslands. Studies have shown that agricultural crops such as corn and soybeans tend to contain abundant arthropod communities (Young & Edwards 1990) even before crops have been planted (Culin & Rust 1980). The small county roads adjacent to study sites ranged from 10-12 m in width and had low rates of vehicular use. This could contribute to the lack of meadowlark sensitivity towards this type of edge. In addition, edge habitat may influence site choice as a result of reduced predator activity at specific edge types—in other words, a positive edge effect. This concept has been examined by Pasitschniak-Arts et al. (1998) who concluded that nest predation rates were "not necessarily [positively] related to edge proximity".

Other factors possibly contributing to habitat selection in relation to edge are the interactions with other bird species for territory and nest sites. As noted before, common species include Bobolinks, Red-winged Blackbirds, Ring-necked Pheasants, Northern Bobwhite and Dickcissels. It is unlikely that any of the species mentioned out compete Meadowlarks for habitat, as Dickcissels and Red-winged Blackbirds do not nest on the ground, Bobolinks are much smaller, and meadowlarks do not interact behaviorally with either Bobwhite or Ring-necked Pheasants (Linn pers. obs).

Nest success for both species improved within 50 to 100 m of most edge types. The similar patterns in nest success were unexpected when considering that meadowlarks and Bobolinks clearly demonstrated different responses towards nest placement and edge sensitivity. Several factors may explain higher nest success near edge habitat. Studies examining nest success in grassland environments have shown that distance to road, wetland, and agricultural edges had little or no effect on nest survival (Pasitschniak-Arts et al. 1998, Winter et al. 2000, Walk 2001), suggesting that edge effects in grassland located within an agricultural matrix are not as severe as those within forested areas.

There are two main reasons for a reduction in predator activity along the edge types we studied. First, scientists studying mammalian activity along forest-farm edge types found no significant difference when compared to the habitat interior (Heske 1995). Proximity to woody cover has been considered to be an influential aspect in relation to predator abundance, specifically Raccoons (*Procyon lotor*) (Burger et al. 1994, Bergin et al. 1997), and since forested areas in close proximity to research sites were relatively uncommon, mammalian predators such as Raccoons and Coyotes (*Canis latrans*) might not have readily used these edges as travel corridors. Not only could agricultural field edges provide potentially inadequate cover, but they could also serve as poor foraging areas as no mammal exclusively feeds on corn and soybeans (Heske 1995). Second, although specific predators were not monitored during this study, it is believed that snakes were the primary nest predators. Most depredated nests were not disturbed beyond the removal of the nest's contents. Shell fragments (evidence typical of mammalian predators) were typically absent (Best 1978, Thompson et al. 1999, Pietz & Ganfors 2000). Snakes have been found to be important predators of bird nests (Thompson et al. 1999, Renfrew & Ribic 2003) and species such as the Black Rat Snake (*Elaphe obsolete*), Prairie Kingsnake (*Lampropeltis calligaster*), Blue Racer (*Coluber constricter*), and

Garter Snake (*Thamnophis sirtalis*) were all observed regularly at our research fields throughout the study. Even though black rat snakes are commonly known to inhabit forested areas and frequent forest-field edges (Durner & Gates 1993), higher activity levels were not found at edges in Illinois (Keller & Heske 2000) and cropfield use has been reported to be very low (Durner & Gates 1993). Elevated activity levels of Blue Racers also were not found at forest-field edges (Keller & Heske 2000). No studies were found to have examined activity levels and demography of the prairie kingsnake or the garter snake near different edge types but factors such as abrupt road and crop edges could lead to lack of protective cover and poor foraging areas for these snakes (Durner & Gates 2000).

Another explanation for higher nest survival rates along edges could be that differences in vegetation composition and structure between corn or soybean-grassland edges are not distinct enough (Pasitschniak-Arts et al. 1998) to compromise the nest success of Eastern Meadowlarks or Bobolinks. This is a plausible explanation once the rowcrops have matured; however, most soybeans and corn did not start developing until the middle of June and edges bordering grasslands were decidedly well defined during most of the nesting season. Thus, vegetative uniformity between habitats is an unlikely rationale for positive edge effects.

Implications: Although fragmentation and the loss of habitat in grassland areas are major factors contributing to decreasing populations of common grassland birds in Illinois (Herkert 1995), surrounding agriculture did not adversely affect the breeding success of Eastern Meadowlarks or Bobolinks. In fact, the results indicate that certain edges positively influenced the reproductive success of both species. This outcome leads to the conclusion that small areas of grassland within an agricultural land matrix is a more suitable landscape than that of surrounding forested areas. However, an explanation for why Bobolinks avoid these edges even though reproductive success is higher, remains unclear.

Table 1. Nest survival rates and exposure days for Eastern Meadowlarks and Bobolinks from 1997-2002.

	1997	1998	1999	2000	2001	2002	Overall
Eastern Meadowlark	---	0.618	0.234	0.482	0.135	0.165	0.235
Exposure Days	---	504.000	279.000	332.000	839.000	653.500	2607.500
Bobolink	0.671	0.800	0.221	0.429	0.020	---	0.398
Exposure Days	167.000	99.000	105.500	106.000	37.000	---	514.500

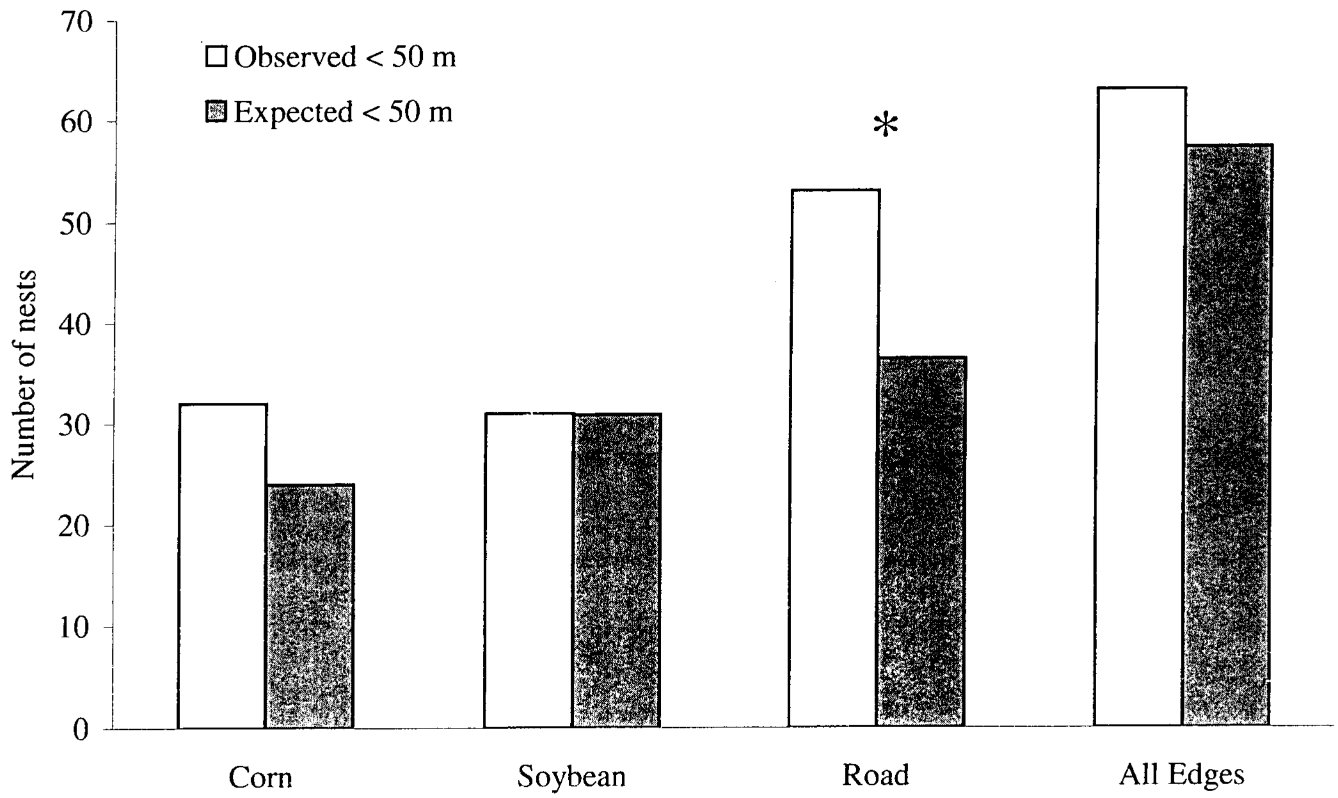

Figure 1. Observed and expected numbers of Eastern Meadowlark nests within 50 m of different edge types. Meadowlarks were found to nest within 50 m of roadsides significantly more than expected, denoted by an asterisk ($X^2 = 9.44$, df = 1, $P < 0.01$).

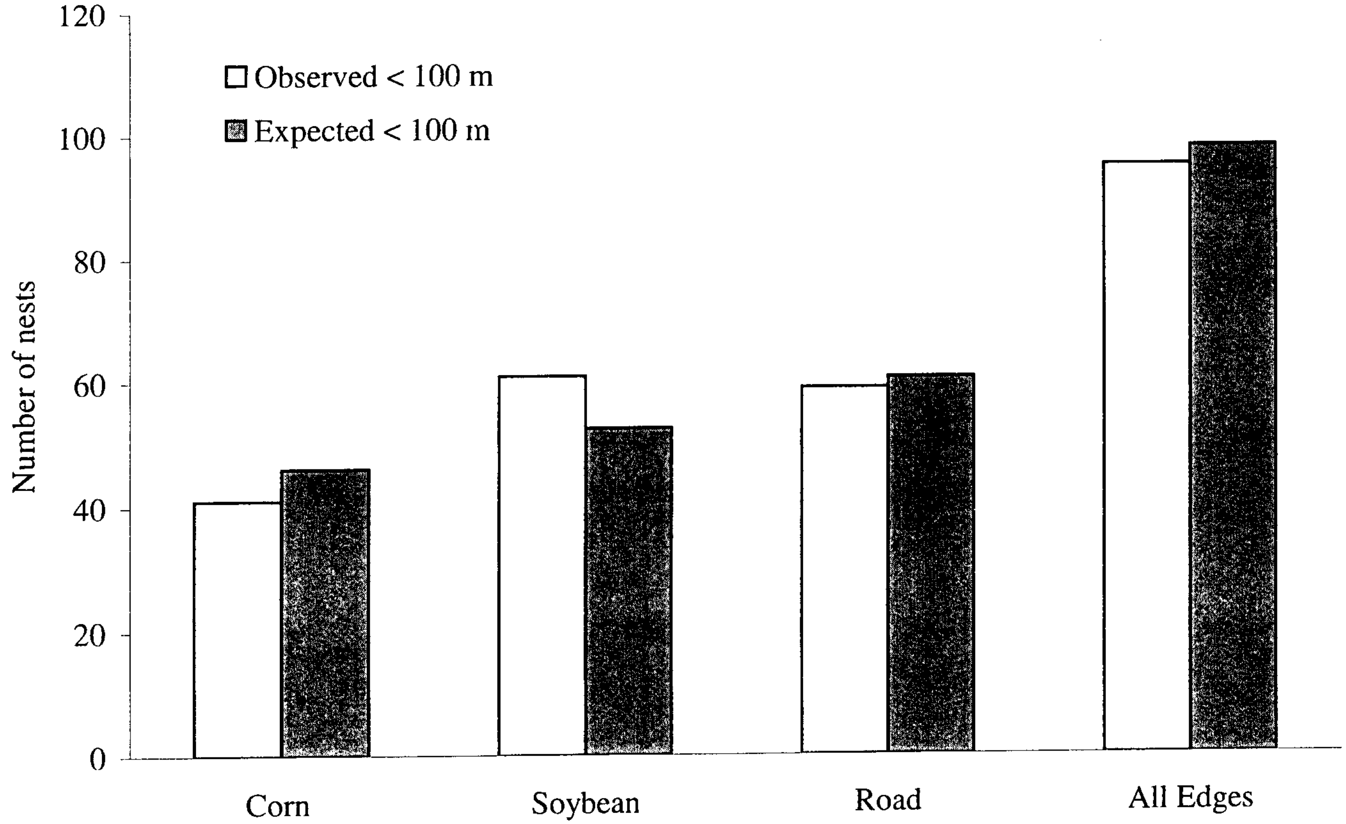

Figure 2. Observed and expected numbers of Eastern Meadowlark nests within 100 m of different edge types. Meadowlarks were not found to nest within 100 m of any edge significantly more than other edge types and interior habitat.

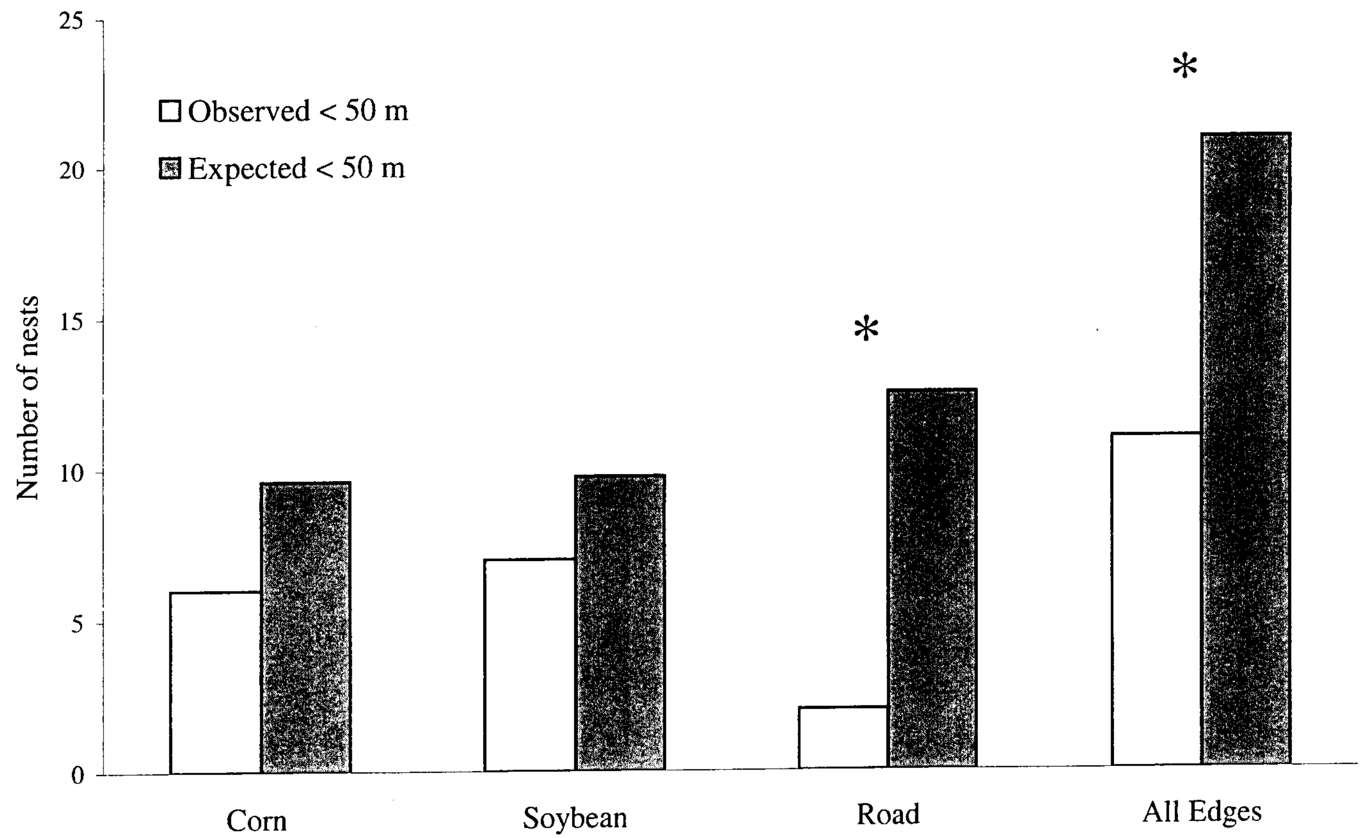

Figure 3. Observed and expected numbers of Bobolink nests within 50 m of different edge types. Bobolinks were found to nest within 50 m of road edges and all edges significantly less than expected, denoted by an asterisk (X^2 = 7.89, 11.19, df =1, $P < 0.01$).

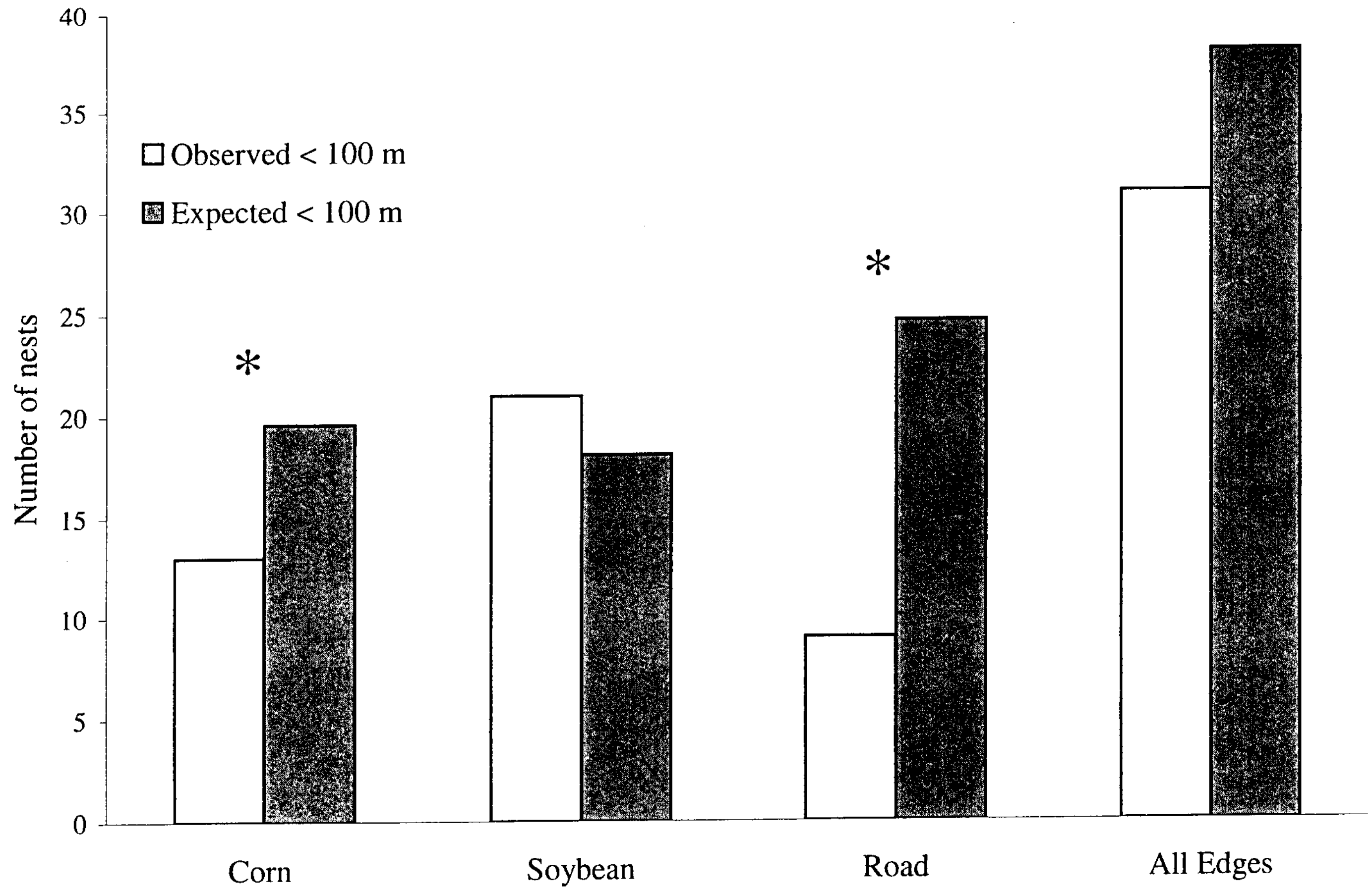

Figure 4. Observed and expected numbers of Bobolink nests within 100 m of different edge types. Bobolinks were found to nest within 100 m of corn rowcrops and road edges significantly less than other edge types, denoted by an asterisk ($X^2 = 5.4$, 21.15, $df = 1$, $P < 0.01$).

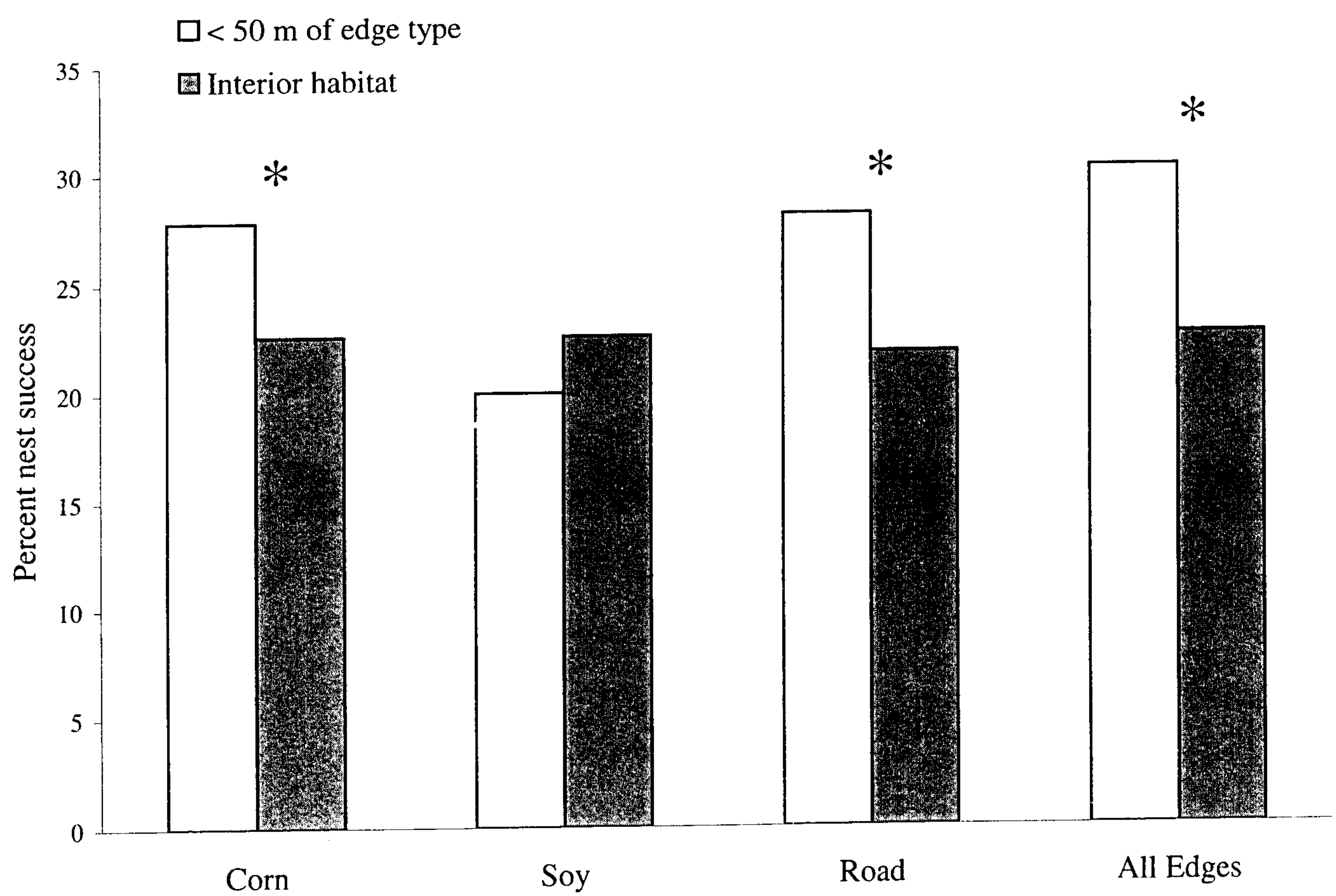

Figure 5. Eastern Meadowlarks were found to have significantly higher nest success within 50 m of corn, roadsides and all edges combined than the available interior habitat, denoted by an asterisk (X^2 = 13.00, 27.37, 45.12, df =1, P < 0.001).

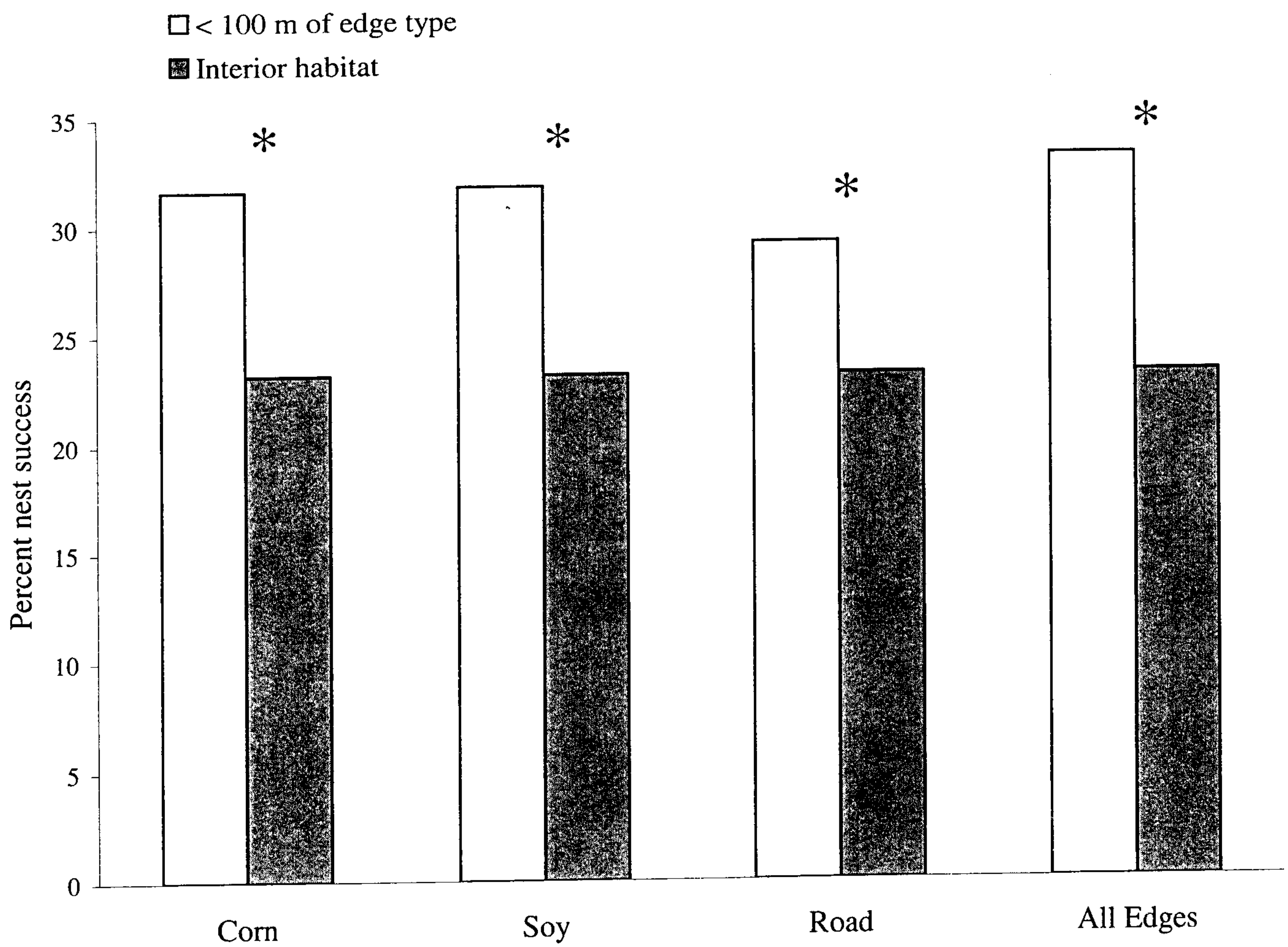

Figure 6. Eastern Meadowlarks were found to have significantly higher nest success within 100 m of corn, soybeans, roadsides, and all edges combined than the available interior habitat, denoted by an asterisk(X^2 = 38.98, 45.10, 19.89, 65.78, df =1, $P < 0.001$).

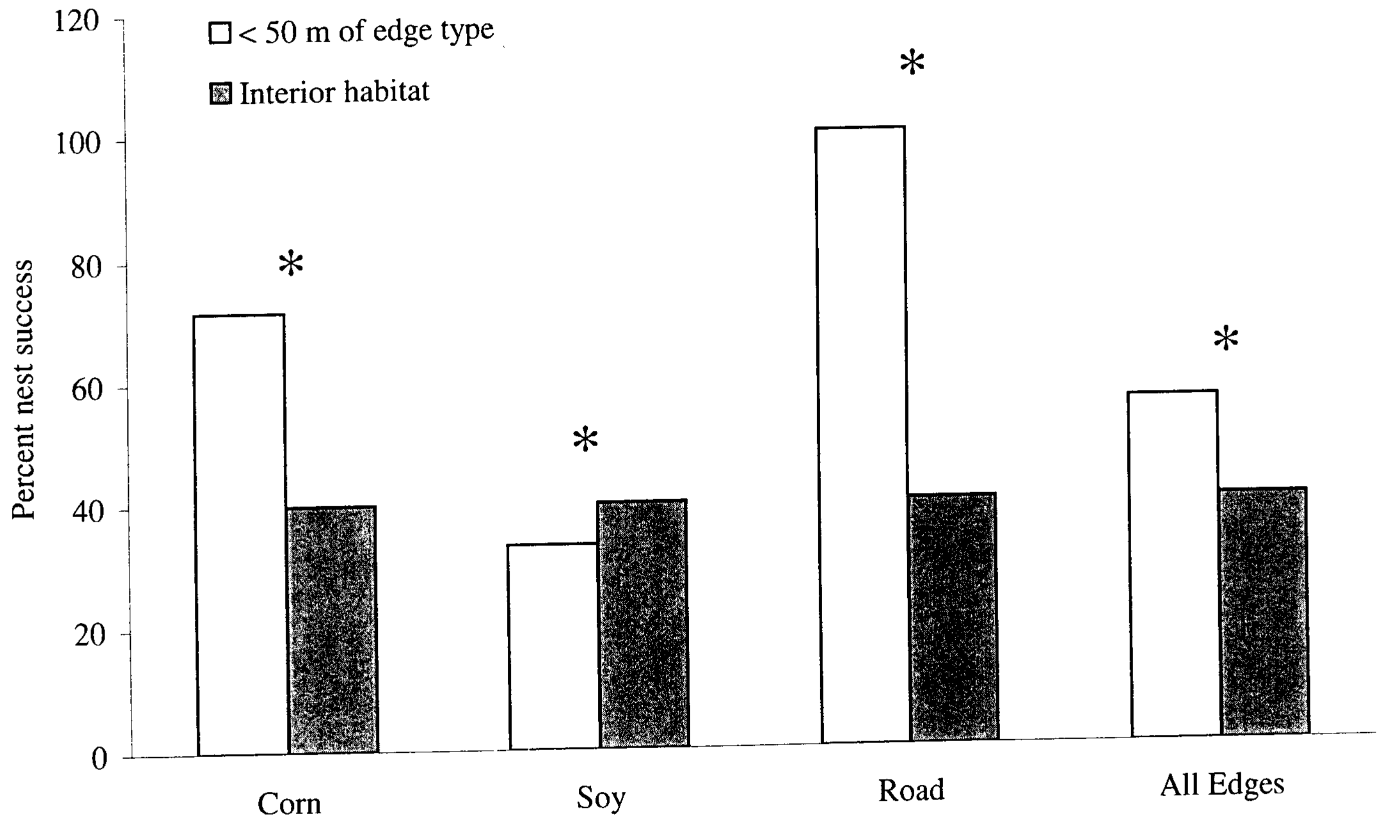

Figure 7. Bobolinks were found to have significantly higher nest success within 50 m of corn, soybeans, roadsides, and all edges combined than the available interior habitat, denoted by an asterisk (X^2 = 18.31, 10.39, 169.40, df =1, P < 0.01).

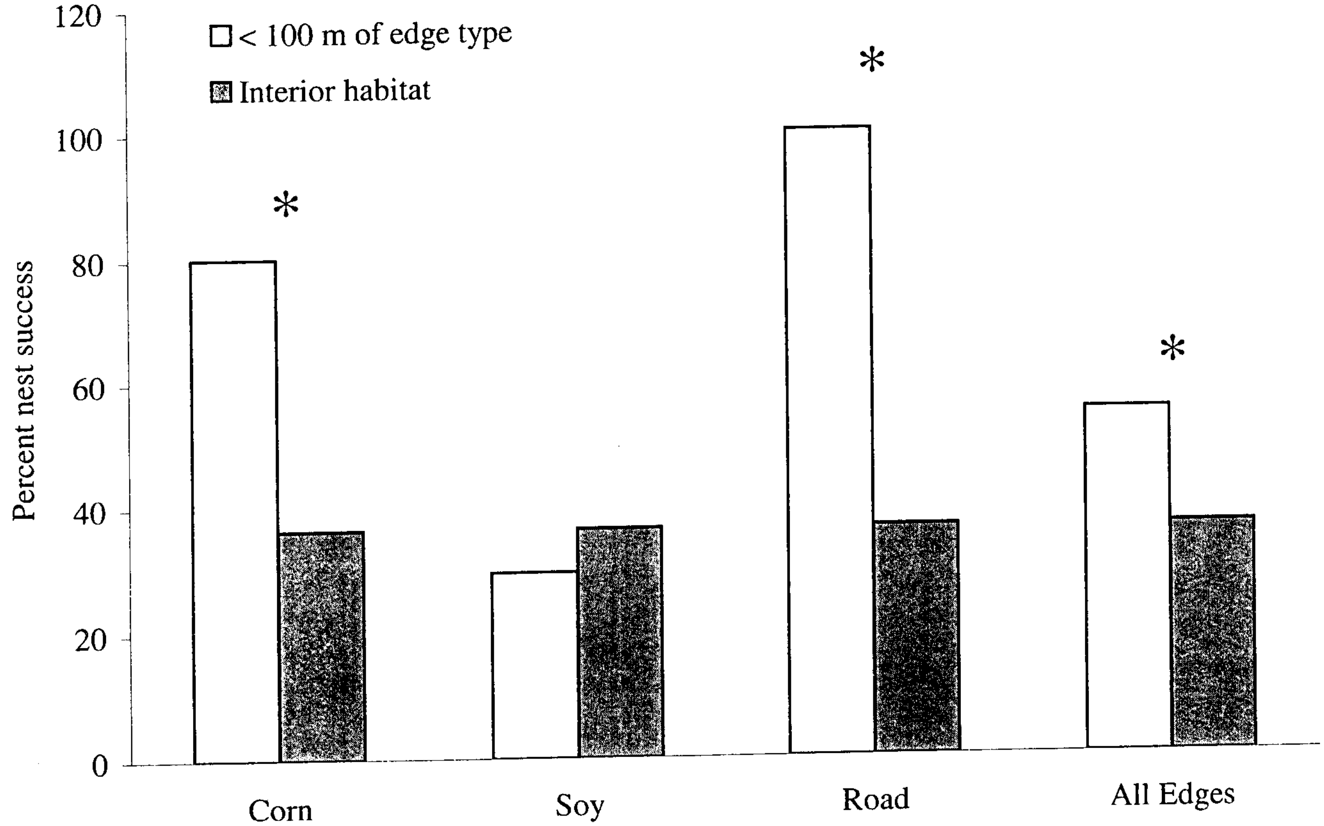

Figure 8. Bobolinks were found to have significantly higher nest success within 100 m of corn, roadsides, and all edges combined than the available interior habitat, denoted by an asterisk (X^2 = 34.38, 80.75, df = 1, P < 0.001).

Literature Cited

Askins, R. A. 1994. Open corridors in a heavily forested landscape: impact on shrubland and forest interior birds. *Auk* 111: 28-37.

Bergin, T. M., Best, L. B., and K. E. Freemark. 1997. An experimental study of predation on artificial nests in roadsides adjacent to agricultural habitats in Iowa. *Wilson Bulletin* 109: 437-448.

Best, L. B. 1978. Field sparrow reproductive success and nesting ecology. *Auk* 95: 9-22.

Bollinger, E. K., and Gavin, T. A. 1992. Eastern Bobolink populations: Ecology and conservation in an agricultural landscape, p. 497-506. J. M. Hagan III, and D. W. Johnston [eds.], *Ecology and Conservation of Neotropical Migrant Landbirds*. Smithsonian Institute Press, Washington, D. C.

Bollinger, E. K, and Gavin, T. A. 2004. Responses of nesting Bobolinks to habitat edges. *Auk* 121, in press.

Burger, L. D., Burger jr., L. W., and J. Faaborg. 1994. Effects of prairie fragmentation on predation on artificial nests. *Journal of Wildlife Management* 58: 249-253.

Camp, M. and L. B. Best. 1994. Nest density and nesting success of birds in roadsides adjacent to rowcrop fields. *American Midland Naturalist* 131: 347-358.

Culin, J. D. and R. W. Rust. 1980. Comparison of the ground surface and foliage dwelling spider communities in a soybean habitat. *Environmental Entomology* 9: 577-582.

Donovan, T. M. Jones, P. W., Annand, E. M., and F. R. Thompson III. 1997. Variation in local-scale edge effects: mechanisms and landscape context. *Ecology* 78: 2064-

Durner, G. M., and J. E. Gates. 1993. Spatial ecology of black rat snakes on Remington Farms, Maryland. *Journal of Wildlife Management* 57: 812-826.

Fletcher, R. J. Jr., and R. R. Koford. 2003. Spatial responses of Bobolinks (*Dolichonyx oryzivorus*) near different types of edges in Northern Iowa. *Auk* 120: 799-810.

Gutzwiller, K.J, Wiedernmann, R. T., Clementa, K. L. and S. H. Anderson. 1994. Effects of human intrusion on song occurrence and singing consistency in subalpine birds. *Auk* 111: 28-37.

Herkert, J. R. 1990. Prairie birds of Illinois: population response to two centuries of habitat change. *Illinois Natural History Bulletin* 34: 393-399.

Herkert, J. R. 1995. An analysis of Midwestern breeding bird population trends: 1966-1993. *American Midland Naturalist* 134: 41-50.

Herkert, J. R., Reinking, D.L., Wiedenfeld, D. A., Winter, M., Zimmerman, J. L., Faaborg, J. and S. K. Robinson. 2003. Effects of prairie fragmentation on the nest success of breeding birds in the midcontinental United States. *Conservation Biology* 17: 587-594.

Heske, E. J. 1995. Mammalian abundances on forest-farm edges versus forest interiors in southern Illinois: is there an edge effect? *Journal of Mammalogy* 76: 562-568.

Hickman, S. 1990. Evidence of edge species attraction to nature trails within deciduous forest. *Natural Areas Journal* 10: 3-5.

Higgins, H. F., L. M. Kirsch, and J. J. Ball. 1969. A cable-chain device for locating duck nests. *Journal of Wildlife Management* 33: 1009-1011.

Hines, J. E. and J. R. Sauer. 1989. Program CONTRAST: a general program for the analysis of several survival or recovery rate estimates. *U. S. Fish and Wildlife Service, Fish and Wildlife Technical Report*. 24.

Johnson, D. H. 1979. Estimating nest success: the Mayfield method and an alternative. *Auk* 96: 651-661.

Johnson, D. H., and L. D. Igl. 2001. Area requirements of grassland birds: a regional perspective. *Auk* 118: 24-34.

Johnson, R. G., and S. A. Temple. 1986. Assessing habitat quality for birds nesting in fragmented tallgrass prairies, p. 245-249. In J. Verner, M. L. Morrison, and C. J. Ralph [eds.], *Wildlife 2000: modeling habitat relationships of terrestrial vertebrates* University of Wisconsin Press, Madison, WI.

Johnson, R. G., and S. A. Temple. 1990. Nest predation and brood parasitism of tallgrass prairie birds. *Journal of Wildlife Management* 54: 106-111.

Keller, W. L. and E. J. Heske. 2000. Habitat use by three species of snakes at the Middle Fork Fish and Wildlife Area, Illinois. *Journal of Herpetology* 34:558-564.

Kershner, E. 2001. Conservation of grassland birds in an agricultural landscape: the importance of habitat availability and demography. Ph.D. dissertation, University of Illinois, Urbana, IL.

Knopf, F. L. 1994. Avian assemblages on altered grasslands. *Studies in Avian Biology* 15: 247-257.

Lanyon, W. E. 1990. Eastern Meadowlark (*Sturnella magna*). In A. Poole and F. Gill [eds.], *The Birds of North America*, No. 160. The Academy of Natural Sciences, Philadelphia, and The American Ornithologists' Union, Washington, DC.

Martin, S. G., and T. A. Gavin. 1995. Bobolink (*Dolichonyx oryzivorus*). In A. Poole and F. Gill [eds.], *The Birds of North America*, No. 176. The Academy of Natural Sciences, Philadelphia, and The American Ornithologists' Union, Washington, DC.

Mayfield, H. 1975. Suggestions for calculating nest success. *Wilson Bulletin* 87: 456-466.

Miller, S. G., Knight, R.L. and C. K. Miller. 1998. Influence of recreational trails on breeding bird communities. *Ecological Applications* 8: 162-169.

O'Leary, C. H., and D. W. Nyberg. 2000. Treelines between fields reduce the density of grassland birds. *Natural Areas Journal* 20: 243-249.

Osborne, L. L. and D. A. Kovacic. 1993. Riparian vegetated buffer strips in water quality restoration and stream management. *Freshwater Biology* 29: 243-258.

Pasitschniak-Arts, M., Clark-Roberts, G. and F. Messier. 1998. Duck nesting success in a fragmented prairie landscape: Is edge effect important? *Biological Conservation* 85: 55-62.

Pietz, P. J., and D. A. Granfors. 2000. Identifying predators and fates of grassland passerine nests using miniature video cameras. *Journal of Wildlife Management* 64: 71-87.

Peterjohn, B. G. and J. R. Sauer. 1999. Population status of North American grassland birds from the North American breeding bird survey, 1966-1996. *Studies in Avian Biology* 19:27-44.

Renfrew, R. B., and C. A. Ribic. 2003. Grassland passerine nest predators near pasture edges identified on videotape. *Auk* 120: 371-383.

Sauer, J. R., J. E. Hines, and J. Fallon. 2003. The North American Breeding Bird Survey, results and analysis 1966-2002. Version 2003.1, USGS Patuxent Wildlife Research Center, Laurel MD.

Saunders, D. A., Hobbs, R. J., and C. R. Margules. 1991. Biological consequences of ecosystem fragmentation: a review. *Conservation Biology* 5: 18-32.

Thompson III, F. R., Dijak, W., and D. E. Burhans. 1999. Video identification of predators at songbird nests in old fields. *Auk* 116: 259-264.

Walk, J. W. 2001. Nesting ecology of grassland birds in an agricultural landscape. Ph.D. dissertation, University of Illinois, Urbana, IL.

Warner, R. E. 1992. Nest ecology of grassland passerines on road rights-of-way in central Illinois. *Biological Conservation* 59: 1-7.

Wilcove, D.S. and S. K. Robinson. 1990. The impact of forest fragmentation on bird communities in Eastern North America. p. 319-331. In Biogeography and Ecology of Forest Bird Communities. SPB Academic Publishing. Hague, Netherlands.

Winter, M., Johnson, D. H., and J. Faaborg. Evidence for edge effects on multiple levels in tallgrass prairie. *Condor* 102: 256-266.

Woodward, A. A., Fink, A. D., and F. R. Thompson III. 2001. Edge effects and ecological traps: effects on shrubland birds in Missouri. *Journal of Wildlife Management* 65: 668-675.

Young, O., and G. B. Edwards. 1990. Spiders in the United States field crops and their potential effect on crop pests. *Journal of Arachnology* 18: 1-27.

CHAPTER 2:

Impacts of Rowcrop Agriculture on Foraging Patterns and Nestling Diet of the Eastern Meadowlark (*Sturnella magna*)

Abstract: Midwestern landscapes are dominated by rowcrop agriculture. Corn and soybean fields border most small grassland areas used by Eastern Meadowlarks (*Sturnella magna*). Interactions between Eastern Meadowlarks and six different habitats (including corn and soybean fields) were observed to examine the influence of the surrounding landscapes on foraging patterns and nestling diets. Nests were located and esophageal ligatures were applied to nestlings to examine food items brought to the nest. The most common items fed to nestlings were Araneae and Orthoptera prey; however, differences were not found between the nestling diets of interior nests and edge nests, or early season nests and late season nests. Three-day-old nestlings were given more Orthoptera prey, whereas a wider variety of food items were given to the older nestlings. The frequencies of foraging trips to the six different habitats were found to correspond with random expectations. Despite the combined lack of significance, Eastern Meadowlarks did not avoid foraging in rowcrop agricultural fields and foraged more often than expected in soybean fields.

Introduction: Grassland ecosystems in the Midwestern United States have been reduced and fragmented, largely due to the expansion of rowcrop agriculture (Knopf 1994, Herkert 1995, Kershner 2001). The wildlife depending on these habitats consequently have suffered, including grassland birds, which have exhibited dramatic population declines in the last 50 years (Robbins et al. 1986, Herkert 1990, Bollinger & Gavin 1992, Askins 1993). In addition, Breeding Bird Survey data from 1966-2002 have demonstrated that approximately 50% of 28 grassland bird species in North America have experienced significant negative population trends during this time (Sauer et al. 2003). The remaining grasslands tend to occur in small, scattered patches surrounded by large tracts of agricultural land. Many birds have been shown to use rowcrop agriculture (Bollinger & Caslick 1985, Best et al. 1990, 1995, 1998, Boutin et al. 1998, Kershner 2001, Walk 2001) for multiple reasons including both foraging and nesting. Despite the ubiquity of rowcrop agriculture in the Midwest, relatively little information is available regarding the interactions between grassland birds and rowcrops (such as corn and soybeans) that have the potential to be mutually beneficial.

Eastern Meadowlarks inhabit a wide variety of grassland habitats throughout the Midwest (Lanyon 1990, Kershner 2001, Walk 2001), preferring to forage on the ground and primarily feeding on arthropods (Beal 1942; Lanyon 1995). Foraging patterns and nestling diet have not been closely studied. However, movement patterns have been monitored using radiotelemetry (Kershner 2001), indicating that Eastern Meadowlarks routinely forage in rowcrops, primarily those fields planted with soybeans (Kershner 2001). These findings suggest that further study of the importance of small grassland patches located within a rowcrop agricultural land matrix is warranted. Therefore, we examined the influence of rowcrop fields adjacent to grasslands on the foraging patterns of nesting Eastern Meadowlarks. In conjunction with foraging behavior, nestling diet also was examined to determine possible relationships between foraging patterns and food items fed to nestlings.

Methods:

Study Area.

We conducted research at 8 Conservation Reserve Program (CRP) fields ranging in size from 1.35 to 20.80 ha. These fields were planted primarily with redtop (*Agrostis alba*) and orchard grass (*Dactylis glomerata*). They were bordered on most sides by large tracts of rowcrop agriculture (typically corn and soybeans), with small forest fragments and wooded hedgerows located close by. Sites were chosen based on their proximity to soybean and cornfields.

Nest Location.

We located nests between 19 April and 20 July 2002 using the rope dragging technique (Higgins et al. 1969). Each nest was marked 5 m to the north with flagging tape. We recorded nest status and monitored each nest every third day until fledging or nest failure, noting the date, the number of eggs or nestlings, female presence, and the condition of eggs (warm or cold). We also determined the exact location of each nest within the field by determining its proximity to adjacent edges using a laser rangefinder.

Foraging observations.

Observations of adult foraging activity were conducted for 1-h at each nest during the nestling phase when nestlings were 3, 6, and 9 days old. Observation periods were selected randomly during daylight hours and were usually made inside a parked vehicle so conspicuous movement would not disturb the typical behavior of the meadowlarks. If nests were positioned in an area not visible from the road, observations were made from an area where the nest could be clearly seen but far enough away so as not to affect adult behavior. Observations began 10 minutes after we arrived at the observation site.

Stopwatches were used to record the time adults spent in and away from the nest. Distances to foraging areas were determined using a laser range finder. In addition, foraging location, distance, and general behaviors (perching, feeding, flying etc.) were noted. If no activity was seen at a nest for 30 min, the observer stopped recording and inspected the status of the nest.

Nestling diet.

To assess the types of foods being fed to the nestlings, we applied esophageal ligatures after each observation period. This technique was performed at each nest twice (3 and 6 day old nestlings) during the 10-day nestling period. After a parent had been observed leaving a nest, one person removed all of the nestlings and brought them to an area at least 100 m from the nest to apply ligatures. Ligature materials consisted of 10.2 cm cable ties (Mellot & Woods 1993). These were fastened around the necks and adjusted so individuals could breathe but not swallow food items. After ligature application (approximately 1 minute per bird), nestlings were returned to the nest and left for a period of 20-60 minutes or until two foraging trips had been observed. Nestlings were once again removed from the nest, and food was transferred from their esophagus and placed into a vial of 80 % ethanol. Food items from each nest were placed into separate vials. Mealworms were given to each nestling to replace the lost meal and nestlings were subsequently returned to the nest.

Analyses.

We constructed separate diagrams of each observed nest to examine potential patterns in foraging activity. The maximum distance traveled from the nest during each observation period was used as the radius of a circle drawn around that nest in order to assess the potential foraging habitats available to adult Meadowlarks. Percentages of each habitat type within the circular area were calculated and used to compare with the observed number of foraging trips to each habitat type. We used the proportions of trips made to the various habitats at each nest so that each nest contributed 1.0 to the total sample size. These data were then analyzed by a log-likelihood test among the observed and expected numbers of foraging trips. The log-likelihood ratio was used because sample sizes were too small to determine an unbiased chi-square calculation.

Differences in nestling diet were examined by comparing the food items of those nestlings inhabiting nests located in the interior (> 50 m from any edge type) of the grassland versus those located on the edge (< 50 m from any edge) of the field. Comparisons were also made between nests found early in the season (April through June 2002) to those found late in the breeding season (June through August 2002) as well as the diets of 3-day old nestlings and 6-day old nestlings. Chi-square tests of independence were used to detect any changes in diet in these groupings. The two largest orders that represented 67% of the volume of all collected prey items (Araneae and Orthoptera) were used as separate categories during the analysis, whereas all orders representing less than 20% of the nestling diet (Lepidoptera, Coleoptera, Hemiptera, and Homoptera) were combined into one category.

Results:

Foraging patterns.

Foraging activity was observed at 19 Eastern Meadowlark nests with a total of 48 separate observations conducted during the 2002 breeding season. Six different habitat types were present within the circular areas centered on the meadowlark nests: 1) grassland, 2) soybean fields, 3) corn fields, 4) wooded hedgerows and trees, 5) secondary roads and 6) buildings/yards. Meadowlark use of these habitats did not differ from random expectations ($G = 3.07$, $df = 5$, $P > 0.50$, Table 1).

Composition of nestling diet.

Twenty-nine samples were collected from 19 different Eastern Meadowlark nests between April and August 2002. Spiders (Araneae), including egg sacs, represented the largest percentage of individual food items examined (53%) as well as the largest percentage of specimen volume (44%; Table 2). Several families were identified (see Appendix I), but consisted primarily of the family Lycosidae (wolf spiders, 80% of spider specimens). Other families included jumping spiders (Salticidae), 10%; crab spiders (Thomisidae), 4%; orb weavers (Araneidae), 4%; and sac spiders (Gnaphosidae), 2%. Orthopterans comprised the second largest volume of food items (23%) including various crickets (Gryllidae), 46% of orthopterans; grasshoppers (Acrididae), 31%; and katydids (Tettigonidae), 23%. Lepidoptera larvae followed closely with 18% of the specimen volume, consisting mostly of cutworms (Noctuidae), 73% of lepidopterans; and sulphur butterfly caterpillars, (Pieridae), 27%. Mature Lepidoptera were not found in the ligature samples. Other rarer taxa were Coleoptera (mostly Carabidae and Scarabidae spp.), 10.8%; Hemiptera (Pentotomidae spp.), 1.9%; and Homoptera (Cicadidae spp.), 2.0%. A snail shell (Pulmonata) also was identified in one of the samples and comprised less than 0.5% of the entire specimen volume.

Nestling diet comparisons.

Regardless of age or season, no significant differences were found between the prey items fed at nests located in the interior (> 50 m from any edge type) of the field and those located < 50 m from the edge ($X^2 = 0.63$, df = 2, $P > 0.05$). Additionally, no significant difference was found between early season nests and late season nests ($X^2 = 0.73$, df = 2, $P > 0.05$). However, a significant difference was seen between the items fed to three-day-old nestlings and to 6-day old nestlings ($X^2 = 6.99$, df = 2, $P < 0.05$). A lower number of Orthoptera prey was fed to 6-day old nestlings and significantly larger numbers of insects in the combined orders (Lepidoptera, Coleoptera, Hemiptera, and Homoptera) were fed to older nestlings.

Discussion:

Foraging patterns.

We found that habitat did not seem to dramatically influence the foraging activity of nesting Eastern Meadowlarks. Although no significant effects were found, no meadowlarks were observed feeding in cornfields. It is likely that adequate amounts of prey can be found in cornfields. Studies have shown that arthropod density in these habitats is relatively high during the spring and summer months (Dondale 1971, Young & Edwards 1990). However, favored food items may not be as readily available in this type of habitat (corn). Little species similarity exists between the spiders in grassland habitats and rowcrop agriculture (Luczak 1980) and since meadowlarks were observed foraging in soybeans and wooded hedgerows, species of spiders in habitats such as soybean and trees may fulfill different nutritional requirements and/or search and handling times than those located in grass and corn. Soybean agroecosystems are well known for maintaining large populations of spiders (Culin & Rust 1980, Ferguson et al. 1984, Young & Edwards 1990, Carter & Rypstra 1995, Marshall & Rypstra 1999), the most common food item fed to nestlings. Furthermore, wolf-spiders of the *Hogna* genus were the most common taxa found in nestling diet samples and are common arthropods found in soybean fields of the eastern United States (Young & Edwards 1990, Marshall & Rypstra 1999)

Many species of birds coexist in grassland ecosystems and competition for food could occur during the breeding season. Male Eastern Meadowlarks will defend a territory from intrusion of other males to protect possible food sources, mates, and active nests (Lanyon 1990). Therefore, at different times during the breeding season, some areas of grassland may be restricted from other meadowlarks. In addition, other bird species do use cornfields as foraging areas (Bollinger & Caslick 1985, Best et. al. 1990) and, though unlikely, could be excluding feeding meadowlarks.

Another possible explanation could be that the vegetation structure and composition of cornfields prevent birds from foraging as efficiently as in soybean fields and grassland. During the course of the breeding season, vegetation in certain areas of the grassland became overgrown with noxious weeds such as Cow Vetch (*Vicia cracca*), Wild Parsnip (*Pastinaca sativa*), and various thistle (*Cirsium* & *Carduus*) and clover (*Trifolium*) species (Linn pers. obs.), making ground foraging particularly difficult. Soybean fields provide relatively little vegetative cover until late in the nesting season with ample areas of bare soil.

Predators can also influence foraging locations (Holmes 1986) and could be another reason grasslands and cornfields were foraged in less often. Predators such as Red-tailed Hawks (*Buteo jamaicensis*), Coyotes (*Canis latrans*), feral cats (*Felis catus*), and many species of snakes were observed in grassland habitats. Finally, Eastern Meadowlarks could avoid corn for a combination of the reasons listed above.

Composition of nestling diet.

Previous studies examining the diet composition of adult Eastern and Western Meadowlarks (*Sturnella neglecta*) reveal several dietary preferences. Orthopterans composed the largest proportion of animal matter, whereas beetles and caterpillars also were commonly found in the stomachs of these birds (Beal 1942, Bent 1958). Although spiders were occasionally identified, they were not observed in large numbers and contributed little to overall prey percentages (Beal 1942). Results from prey items fed to nestlings during this study indicated that adult Eastern Meadowlarks exhibited clear preferences for arachnids when feeding their young. Spotted flycatchers (*Muscicapa striata*) have also been observed to feed nestlings prey items deviating from their usual diet (Davies 1977), due to travel time pressures during active brood rearing. Possible time constraints could exist for meadowlarks during the breeding season, resulting from nestling nutritional and brooding requirements. Spiders were also found to be the primary invertebrates fed to nestling Eastern Bluebirds (*Sialia sialis*) and Great Tits (*Parus major*) (Royama 1970, Pinkowski 1978); this was attributed to their relatively soft body parts and appendages (Pinkowski 1978) as well as their higher caloric values compared to most orthopterans and annelids (Golley 1961, Van Hook 1971).

Interestingly, wolf spiders (primarily *Hogna* spp.) comprised the largest number of specimens and volume percentage fed to the nestlings. One probable explanation for the large quantity of Lycosidae could be that wolf spiders commonly occupy surface habitats in many different terrestrial ecosystems (Marshall & Rypstra 1999), making them reasonable prey items for ground-foraging meadowlarks. Size and detectability of available prey were influential factors in the food selection of House Martins (*Delichon* *urbica*) (Bryant 1973), and could possibly explain the abundance of spiders fed to the nestlings of meadowlarks. The majority of the spiders were females carrying egg sacs and because female wolf spiders are invariably larger than males, their size and prominent egg sacs could also make these particular arachnids more conspicuous to foraging meadowlarks. An equally important point is the fact that rowcrops appear to provide most of the food items, yet meadowlarks consumed few pest insects, preferring spiders, a generalist predator usually seen as beneficial to agricultural fields.

The second and third largest percentage of prey items consisted of orthopterans and Lepidoptera larvae—common foods of adult meadowlarks (Beal 1942) and easily found in surrounding grassland and agricultural lands throughout the breeding season. Cutworms were also found to be common food items fed to young Eastern Bluebirds (Pinkowski 1978). Few Coleoptera, Hemiptera, Homoptera and snail shells were fed to nestling meadowlarks during the breeding season. The scarceness of these types of taxa could result from the fact that these prey types are more difficult for nestlings to digest or could simply necessitate more handling time, thus decreasing its caloric value (Emlen 1966, Pinkowski 1978). Indeed, the immature gut of developing birds can lead to less efficient means of obtaining proper nourishment (Karasov 1990), and the possibility of feeding hatchlings more soft-bodied arthropods could potentially aid in brood survival. Snail shells are unusual items fed to young birds, but have been reported as material given to young birds to serve as grit, a substance assisting the process of digestion (Royama 1970, Pinkowski 1978). It has also been suggested that large amounts of calcium present in the snail shells are important items necessary for developing birds (Hagvar & Ostbye 1976, Davies 1977).

Nestling diet comparisons.

Feeding nestlings demands high energy resources from parents and may influence selection of nesting sites and foraging patches (Steele 1993). However, many studies have shown that the driving force in habitat selection during the breeding season are nesting site locations as opposed to foraging habitat (Brawn & Balda 1988, Steele 1993, Martin 1995). Differences in diet were not detected when analyzing the food items of those birds nesting in the interior of the field as compared with those nesting in the edge of the field; therefore indicating that equivalent types of prey are available regardless of nest location or that some birds are traveling farther distances to forage.

Prey abundance and variation have been found to change as the breeding season progresses (Evans 1964, Pinkowski 1978); however, food preferences of those nests found early in the breeding season did not differ significantly from those nests found later in the breeding season. The lack of difference suggests that the expected changes in arthropod abundances as the season progressed did not impact foraging selections of the meadowlarks. Another explanation could be that abundances did change but meadowlarks shifted foraging locations to find the preferred prey items.

While spiders have been found to be an important prey item for newly hatched young (Royama 1970, Pinkowski 1978), significant differences were not encountered between the volumes of arachnids fed to 3-and 6-day old nestlings. Despite this outcome, significantly more Orthoptera prey were fed to 3-day old nestlings, suggesting items in this order might have higher nutritional value or are less difficult for young nestlings to digest. Food items in the combined orders were found to differ between 3 and 6-day old nestlings, with older hatchlings receiving more varied food items in the different insect orders. These results once again illustrate the possibility that older nestlings can digest these types of insects better than younger nestlings.

Implications: Many questions surround the importance of small land fragments and their value to resident wildlife. Research from this study indicates that small grassland patches embedded in agricultural land can provide adequate nesting and foraging habitat for Eastern Meadowlarks. Although meadowlarks did not concentrate foraging activities in selective agricultural environments, they did not avoid soybean fields. Arachnid preferences are suggestive of soybean agroecosystems as likely food sources for nestling diets. If rowcrops do provide a large amount of arachnid prey items, they are certainly a benefit to Eastern Meadowlarks. However, Eastern Meadowlarks may utilize a valuable arthropod important for natural pest removal. Whether or not significant amounts of these arthropods are being consumed by avian predators is something that should be investigated further. Eastern Meadowlarks did not avoid any habitat, foraging in most surrounding environments indicating that the fragmentation and variable landscape does not negatively affect the foraging activity of these birds. Hence, small fragments of grassland should not be discounted as unsuitable habitat because of size and/or location within an agricultural type matrix.

Table 1. Observed and expected proportions of foraging trips based on circular nest areas (see text for detail).

Habitat	Observed	Expected
Corn	0.00	0.97
Soybean	3.94	1.53
Grassland	13.15	14.38
Trees	1.51	0.90
Road	0.07	0.79
Buildings/ Yard	0.33	0.43
Total	19.00	19.00

Table 2. Specimen and volume percentages of food items brought to nestlings

Order	Specimen %	Volume %
Araneae	53.2	44.1
Orthoptera	13.5	22.9
Lepidoptera	14.6	18.3
Coleoptera	15.6	10.8
Hemiptera	2.1	1.9
Homoptera	1	2

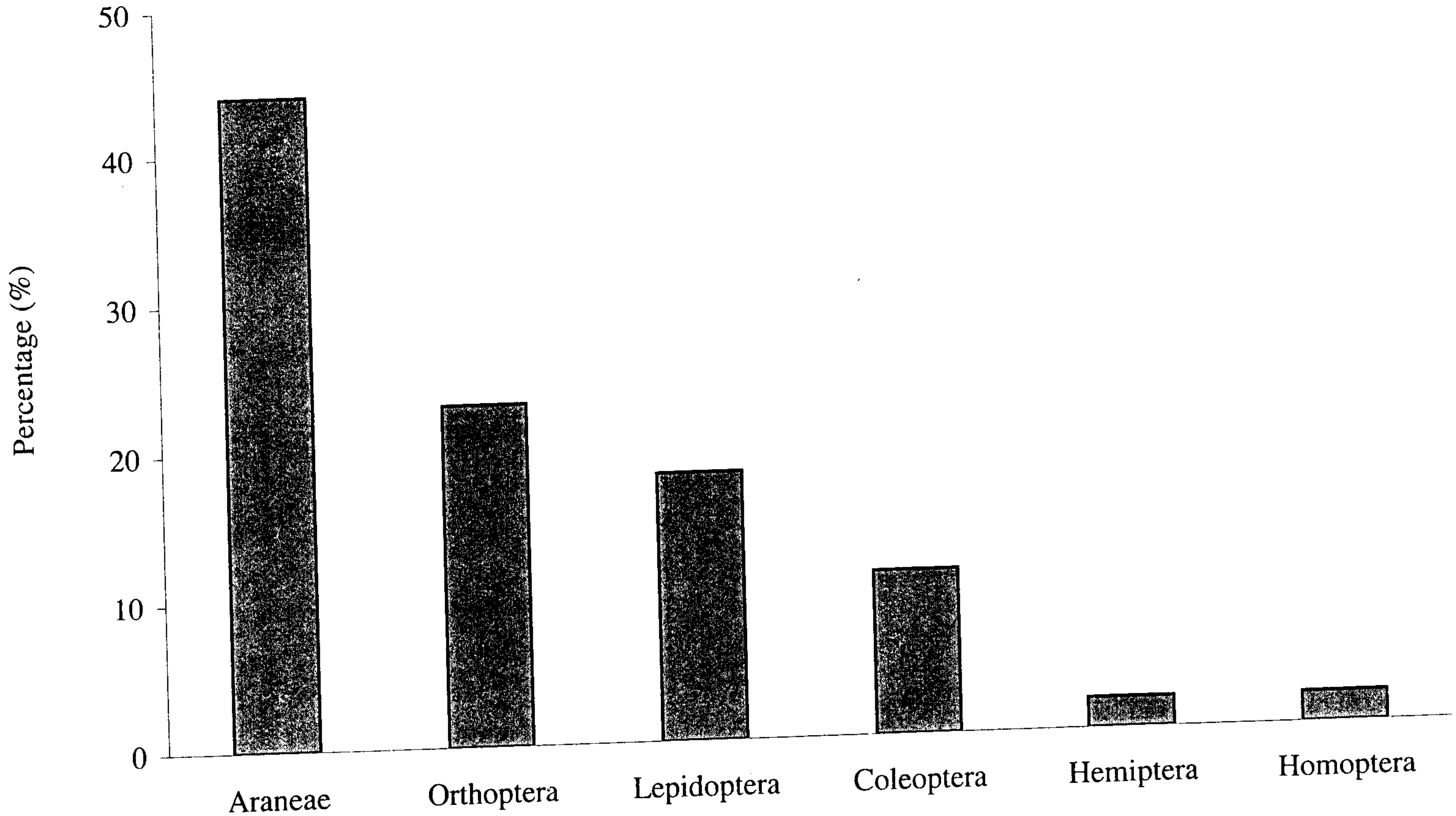

Figure 1. Percentage of prey items based on volumes fed to nestling Eastern Meadowlarks.

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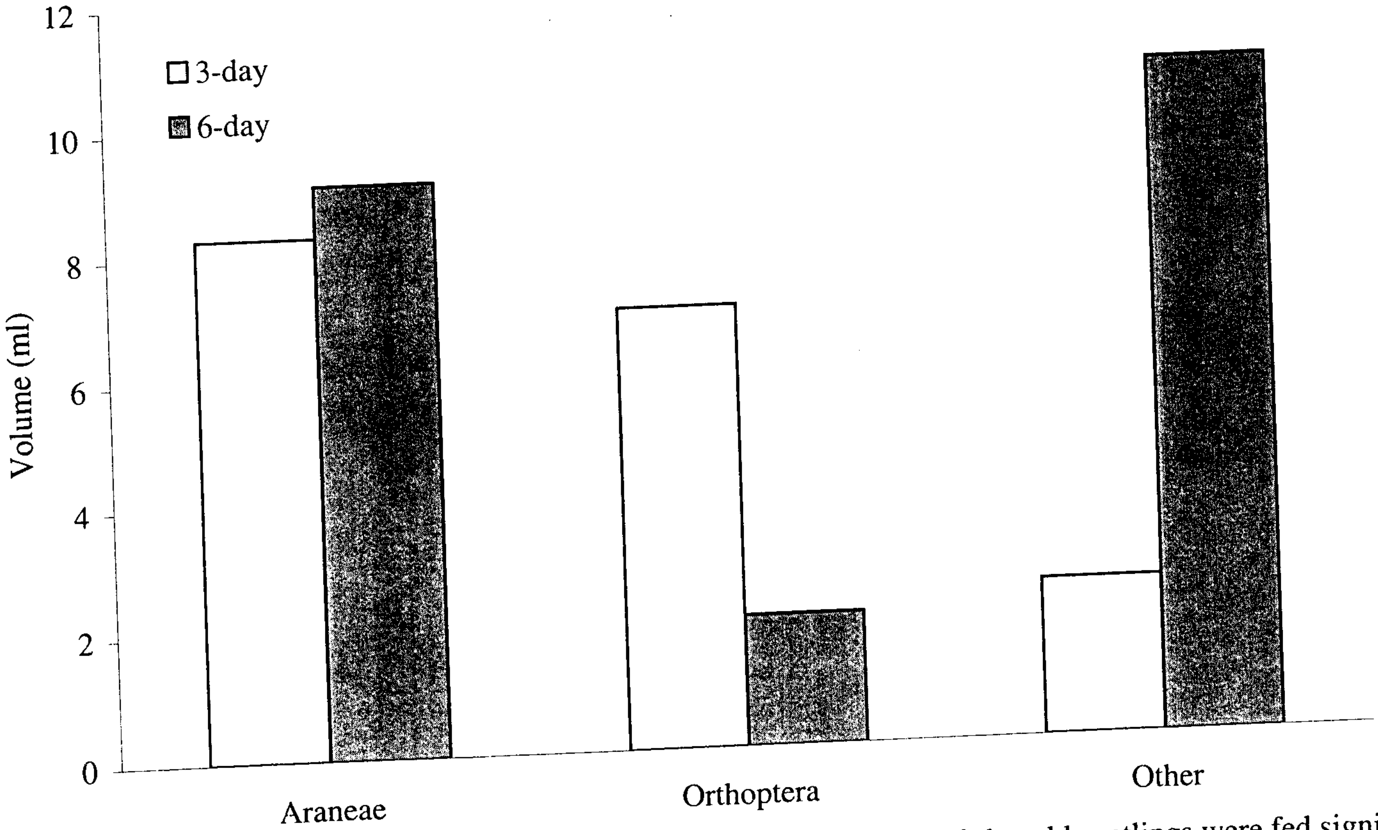

Figure 2. Comparison of prey items fed to 3 and 6 day old nestlings. 6-day old nestlings were fed significantly more spiders and other orders including Coleoptera, Lepidoptera, Hemiptera, and Homoptera, while 3-day old nestlings were given more Orthoptera than expected ($X^2 = 6.99$, df = 2, $P < 0.05$).

Literature Cited

Askins, P. A. 1993. Population trends in grassland, shrubland, and forest birds in Eastern North America, p. 1-34. In: D. M. Power (ed.) *Current Ornithology*, vol.11. Plenum Press. New York.

Beal, F. E. L. 1942. Some common birds useful to the farmer. In *Conservation Bulletin* 18. U. S. Fish and Wildlife Service.

Bent, A. C. 1958. Life histories of North American Blackbirds, Orioles, Tanagers, and Allies. Dover, New York.

Best, L. B., Whitmore, P. C., and G. M. Booth. 1990. Use of cornfields by birds during the breeding season: the importance of edge habitat. *American Midland Naturalist* 123:84-89.

Best, L. B., Freemark, K. E., and J. J. Dinsmore. 1995. A review and synthesis of habitat use by breeding birds in agricultural landscapes of Iowa. *American Midland Naturalist* 134: 1-29.

Best, L. B., Campa, H., and K. E. Kemp. 1998. Avian abundance in CRP and crop fields during winter in the Midwest. *American Midland Naturalist* 139: 311-324.

Bollinger, E. K. and J. W. Caslick. 1985. Red-winged blackbird predation on Northern corn rootworm beetles in field corn. *Journal of Applied Ecology* 22: 39-38.

Bollinger, E. K. and T. A. Gavin. 1992. Eastern Bobolink populations: Ecology and conservation in an agricultural landscape, p. 497-506. J. M. Hagan III, and D.W. Johnston [eds.], *Ecology and Conservation of Neotropical Migrant Landbirds*. Smithsonian Institute Press, Washington, D. C.

Boutin, C., Freemark, K. E. and D. A. Kirk. 1999. Farmland birds in Southern Ontario:

field use, activity patterns and vulnerability to pesticide use. *Agriculture, Ecosystems, and Environment* 72: 239-254.

Brawn, J. D., and R. P. Balda. 1988. Population biology of cavity nesters in northern Arizona: do nest sites limit breeding densities? *Condor* 90: 61-71.

Bryant, D. M. 1973. The factors influencing the selection of food by the House Martin (*Delichon urbica* (L)). *Journal of Animal Ecology* 42: 539-564.

Carter, P. E. and A. L. Rypstra. 1995. Top-down effects in soybean agroecosystems: spider density affects herbivore damage. *Oikos* 72: 433-439.

Culin, J. D. and J. W. Rust. 1980. Comparison of the ground surface and foliage dwelling spider communities in a soybean habitat. *Environmental Entomology* 9: 577-582.

Davies, N. B. 1977. Prey selection and the search strategy of the spotted flycatcher (*Muscicapa striata*): a field study on optimal foraging. *Animal Behavior* 25: 1016-1033.

Dondale, C. D. 1971. Spiders of Heasman's field, a mown meadow near Belleville, Ontario. *Proceedings of the Entomological Society of Ontario*. 101: 62-69.

Emlen, J. M. 1966. The role of time and energy in food preference. *American Naturalist* 100: 611-617.

Evans, F. C. 1964. The food of Vesper, Field, and Chipping sparrows nesting in an abandoned field in southeastern Michigan. *American Midland Naturalist* 72: 57-75.

Ferguson, H. J., McPherson, R. M., and W. A. Allen. 1984. Ground- and foliage-dwelling spiders in four soybean cropping systems. *Environmental Entomology*

13: 975-980.

Golley, F. B. 1961. Energy values of ecological materials. *Ecology* 42: 581-584.

Hagvar, S. and and E. Ostbye. 1976. Food habits of the meadow pipit, *Anthus pratensis*, in alpine habitats in Hardangervidda, South Norway. *Norwegian Journal of Zoology* 24: 53-64.

Herkert, J. R. 1990. Prairie Birds of Illinois: Population Response of Two Centuries of Habitat Change. *Illinois Natural History Bulletin* 34: 393-399.

Herkert, J. R. 1995. An analysis of Midwestern breeding bird population trends: 1966-1993. *American Midland Naturalist* 134: 41-50.

Higgins, H. F., Kirsch, L. M., and J. J. Ball. 1969. A cable-chain device for locating duck nests. *Journal of Wildlife Management* 33: 1009-1011.

Holmes, R. T., and S. K. Robinson. 1981. Tree species preferences by foraging insectivorous birds in a northern hardwoods ecosystem. *Oecologia* 48: 31-35.

Holmes, R. T. 1986. Foraging patterns of forest birds: male-female differences. *Wilson Bulletin* 98: 196-213.

Honza, M. 1993. Factors influencing the foraging patterns of the black-headed gull (*Larsus ridibundus*) from breeding colonies. *Folia Zoologica* 42: 243-249.

Karasov, W. H. 1990. Digestion in birds: chemical and physiological determinants and ecological implications. *Studies in Avian Biology* 13: 391-415.

Kershner, E. 2001. Conservation of grassland birds in an agricultural landscape: the importance of habitat availability and demography. Ph.D. dissertation, University of Illinois, Urbana, IL.

Knopf, F. L. 1994. Avian assemblages on altered grasslands. *Studies in Avian Biology*

15: 247-257.

Lanyon, W. E. 1990. Eastern Meadowlark (*Sturnella magna*). In A. Poole and F. Gill [eds.], *The Birds of North America*, No. 160. The Academy of Natural Sciences, Philadelphia, and the American Ornithologists' Union, Washington, D. C.

Luczak, J. 1980. Spider communities in crop fields and forests of different landscapes of Poland. *Poland Ecological Studies* 6: 735-762.

Marshall, S. D., and A. L. Rypstra. 1999. Patterns in the distribution of two wolf spiders (Araneae: Lycosidae) in two soybean agroecosystems. *Population Ecology* 28: 1052-1059.

Martin, T. E. 1995. Avian life history evolution in relation to nest sites, nest predation, and food. *Ecological Monographs* 65: 101-127.

Mellott, R. S., and P. E. Woods. 1993. An improved ligature technique for dietary sampling in nestling birds. *Journal of Field Ornithology* 64: 205-210.

Pinkowski, B. C. 1978. Feeding of nestling and fledgling Eastern Bluebirds. *Wilson Bulletin* 90: 84-98.

Robbins, C. S., Bystrak, D., and P. H. Geissler. 1986. The breeding bird survey: its first fifteen years, 1965-1979. Resource publication 157. U. S. Fish & Wildlife Service, Washington, D. C.

Royama, T. 1970. Factors governing the hunting behavior and selection of food by the Great Tit (*Parus major* L.). *Journal of Animal Ecology* 39: 619-668.

Sauer, J. R., J. E. Hines, and J. Fallon. 2003. The North American Breeding Bird Survey, results and analysis 1966-2002. Version 2003.1, USGS Patuxent Wildlife Research Center, Laurel MD.

Steele, B. B. 1993. Selection of foraging and nesting sites by black-throated blue warblers: their relative influence on habitat choice. *Condor* 95: 568-579.

Van Hook, R. I., Jr. 1971. Energy and nutrient dynamics of spider and orthoptera populations in a grassland ecosystem. *Ecological Monographs* 41: 1-26.

Walk, J. W. 2001. Nesting ecology of grassland birds in an agricultural landscape. Ph.D. dissertation, University of Illinois, Urbana, IL.

Young, O. P. and G. B. Edwards. 1990. Spiders in United States field crops and their potential effect on crop pests. *Journal of Arachnology* 18: 1-27.

Appendix 1. Esophageal ligature samples collected from Eastern Meadowlark nestlings.

Vial #	Order	Family	Genus	Species	Sex	Comments	Volume (ml)
1	Araneae	Lycosidae	*Hogna*	2	m		0.20
2	Araneae	Lycosidae	*Hogna*	2	f		1.80
3	Araneae	Araneidae	*Acanthepeira*	1	f		0.60
4	Orthoptera	Acridinae					1.00
5	Hemiptera	Pentatomidae					0.45
6	Araneae	Salticidae	*Eris*	1	m		0.10
7	Araneae	Lycosidae	*Hogna*	6	f		0.10
8	Araneae	Lycosidae	*Hogna*	6	f		0.05
9	Araneae	Salticidae	*Eris*	1	m		0.10
10	Araneae	Salticidae	*Eris*	1	f		0.30
11	Lepidoptera	Sphingidae					1.20
12	Araneae	Lycosidae	*Hogna*	4	m		0.30
13	Coleoptera	Scarabidae	*Popilla*	*japonica*			0.50
14	Araneae	Thomisidae	*Xysticus*	1	f		0.10
15	Araneae	Lycosidae	*Hogna*	6	f		0.05
16	Araneae	Lycosidae	*Hogna*	6	f		0.10
17	Araneae	Lycosidae	*Hogna*	6	f		0.15
18	Araneae	Lycosidae	*Hogna*	5	m		0.30
19	Araneae	Lycosidae	*Hogna*	6	f		0.15
20	Orthoptera	Gryllidae					0.85
21	Araneae	Lycosidae	*Hogna*	6	f		0.05
22	Coleoptera	Cantheridae					0.70
23	Hemiptera	Pentatomidae					0.30
24	Coleoptera	Carabidae					0.30
25	Coleoptera	Carabidae					0.20
26	Coleoptera	Carabidae					0.10
27	Coleoptera	Carabidae					0.20
28	Orthoptera	Tettigonidae					0.65
29	Orthoptera	Tettigonidae					0.90
30	Araneae	Gnaphosidae	*Henpyllus*	1	f		0.05
31	Araneae	Lycosidae	*Rabidosa puntulata*		f		0.50
32	Araneae	Lycosidae	*Hogna*	4	f		0.80
33	Araneae	Lycosidae	*Hogna*	6	f		0.10
34	Homoptera	Cicadidae					0.80
35	Araneae	Lycosidae	*Hogna*	6	f		0.05
36	Araneae	Lycosidae	*Hogna*	6	f		0.03
37	Lepidoptera	Pieridae					0.80
38	Araneae	Lycosidae	*Hogna*	4	f		0.80

Vial #	Order	Family	*Genus*	Species	Sex	Comments	Volume (ml)
41	Orthoptera	Tettigonidae					0.60
42	Lepidoptera	Sphingidae					1.80
43	Araneae	Lycosidae	*Hogna*	1	f		0.35
44	Araneae	Salticidae	*Eris*	1	f		0.20
45	Araneae	Lycosidae				legs only	0.10
46	Lepidoptera	Noctuidae					0.45
47	Lepidoptera	Noctuidae					0.35
48	Araneae	Lycosidae	*Rabidosa puntulata*		f		1.20
49	Araneae	Lycosidae	*Hogna*	4	f		0.40
50	Araneae	Lycosidae	*Hogna*	1	f		0.40
51	Orthoptera	Gryllidae					0.50
52	Coleoptera	Carabidae					0.40
53	Orthoptera	Gryllidae					0.30
54	Lepidoptera	Noctuidae					0.30
55	Coleoptera	Carabidae					0.20
56	Araneae	Araneidae	*Acanthepeira*	2	f		0.20
57	Lepidoptera	Pieridae					0.05
58	Lepidoptera	Noctuidae					0.05
59	Lepidoptera	Noctuidae					0.20
60	Lepidoptera	Pieridae					0.10
61	Coleoptera	Scarabidae					0.40
62	Araneae	Lycosidae				egg sac only	0.60
63	Araneae	Lycosidae	*Hogna*	4	f		0.40
64	Coleoptera	Carabidae					0.10
65	Lepidoptera	Pieridae					0.35
66	Araneae	Lycosidae	*Hogna*	6	f		0.80
67	Araneae	Lycosidae	*Hogna*	5	f		0.50
68	Araneae	Lycosidae	*Hogna*	8	f		0.30
69	Araneae	Salticidae	*Phidippus audax*		f		0.20
70	Orthoptera	Gryllidae					0.40
71	Snail						0.10
72	Lepidoptera	Noctuidae					0.40
73	Araneae	Thomisidae	*Xysticus*	2	f		0.10
74	Coleoptera	Carabidae					0.40
75	Orthoptera	Gryllidae					0.40
76	Coleoptera	Carabidae					0.30
77	Coleoptera	Carabidae					0.10
78	Coleoptera	Carabidae					0.20
79	Araneae	Lycosidae	*Hogna*	4	f		0.65

Vial #	Order	Family	Genus	Species	Sex	Comments	Volume (ml)
82	Araneae	Lycosidae	*Hogna*	4	f		0.60
83	Araneae	Lycosidae	*Hogna*	3	f		0.20
84	Araneae	Lycosidae				egg sac only	0.80
85	Orthoptera	Tettigonidae					1.30
86	Araneae	Lycosidae	*Hogna*	4	f		0.60
87	Araneae	Lycosidae	*Schizocosa*	1	f		0.20
88	Coleoptera	Carabidae					0.15
89	Orthoptera	Acridinae					0.65
90	Orthoptera	Acridinae					0.55
91	Araneae	Lycosidae	*Hogna*	5	f		0.30
92	Orthoptera	Gryllidae					0.40
93	Araneae	Lycosidae				egg sac only	0.40
94	Araneae	Lycosidae	*Hogna*	6			0.40
95	Lepidoptera	Noctuidae					0.90
96	Lepidoptera	Noctuidae					0.30