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NEW RECORDS OF CARRION BEETLES IN NEBRASKA REVEAL INCREASED PRESENCE OF THE AMERICAN BURYING BEETLE, NICROPHORUS AMERICANUS OLIVIER (COLEOPTERA: SILPHIDAE)

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ABSTRACT—Surveys for the American burying beetle, *Nicrophorus americanus* Olivier (Silphidae), between 2001 and 2010 in Nebraska resulted in 11 new county records for this endangered species and 465 new county records for 14 other silphid species. A total of 5,212 American burying beetles were captured in more than 1,500 different locations. Using mark-recapture data, we estimated the population size of the American burying beetle (ABB) for six counties in the Sandhills. Blaine County (2003) had the largest population, with an estimated 56 ABBs per km^2 (1,338 ± 272 ABBs). The remaining estimates were between 2 and 36 ABBs per km^2, which were calculated for Loup (2010) and Holt (2010) Counties, respectively. We calculated movement distances, finding that some American burying beetles moved as far as 7.24 km in a single night. This new information greatly contributes to efforts to conserve the American burying beetle in the Great Plains and provides knowledge about other silphid species distributions, which may play a role in recovery of the American burying beetle.

Key Words: American burying beetle, carrion beetles, conservation, endangered species, Nebraska, Silphidae

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INTRODUCTION

Carrion beetles (Coleoptera: Silphidae) are important saprophagous and predaceous insects because they recycle carcasses and compete with or consume many pest fly species (Pukowski 1933; Ratcliffe 1972; Scott 1998). Although Silphidae is a small family having only about 200 species, they are distributed worldwide, except for in Antarctica, and occur across numerous temporal and spatial niches (Ratcliffe 1996; Bishop et al. 2002; Sikes et al. 2006). North America (north of Mexico) contains 31 species of carrion beetles, four of which are shared with Europe (Peck and Kaulbars 1987). Over half of the North American silphid species have been recorded in Nebraska (18 species), with seven species in the subfamily Silphinae and 11 species (all in genus *Nicrophorus*) in the subfamily Nicrophorinae (Ratcliffe 1996). Members of the genus *Nicrophorus*, characterized by their burial of small carcasses for reproduction, are better known as burying beetles (Pukowski 1933; Scott 1998). Comprehensive descriptions and identification keys for the carrion beetles in Nebraska can be found in Ratcliffe (1996).

Nicrophorus americanus Olivier, the American burying beetle (ABB), once occurred throughout temperate eastern North America and was found in 35 states of the United States and in three of the Canadian provinces (U.S. Fish and Wildlife Service 1991). This species is the largest silphid in the Western Hemisphere (Anderson 1982). Its absence became apparent in the 1980s, and by 1989 the American burying beetle was thought to occur only on Block Island, Rhode Island, and on a military installation in Oklahoma (Davis 1980; Kozol et al. 1988; U.S. Fish and Wildlife Service 1991). It was listed as federally endangered in 1989 (*Federal Register* 54 [133]: 29652–55). At present, the American burying beetle is found in less than 10% of its historic range, with localized, extant populations now found in seven states (Lomolino et al. 1995; Miller and McDonald 1997; U.S. Fish and Wildlife Service 2008a). Although the specific reasons for its rapid decline are still undetermined, human impacts are suspected to have played a role (Sikes and Raithel 2002). Reclassification criteria (endangered to threatened) for the American burying beetle consists of the discovery or reestablishment of three populations with 500 or more individuals within each of the four geographic regions designated by the recovery plan (U.S. Fish and Wildlife Service 1991). As of 2008, these criteria have been met by the Midwest region (U.S. Fish and Wildlife Service 2008a).

ABB specimens were recorded from two Nebraska counties prior to 1950 (Antelope and Lancaster) and one county (Custer) in 1970 (Ratcliffe 1996). The American burying beetle was rediscovered in Nebraska by Ratcliffe and Jameson (1992) and was later captured from seven additional counties (Cherry, Dawson, Frontier, Gosper, Keya Paha, Lincoln, and Thomas), which formed a broken band through central Nebraska and included a sizable population of ABB in the Loess Canyon region (Ratcliffe 1996; Bedick et al. 1999; Peyton 2003). Bedick et al. (1999) and Peyton (2003) established population estimates for the Loess Canyon region. In 1996, June and August population estimates calculated for an assumed area of 1,943 km^2 (Bedick et al. 1999) resulted in 1,174 and 3,046 ABB estimated, respectively. A larger sample area of 4,500 km^2 was reported to have over 3,000 ABB individuals in June 1998 (Peyton 2003). Most sampling efforts for ABB prior to 1996 were limited to the south-central, northern, and eastern portions of Nebraska; there was relatively little effort in the north-central region. As of 1999, ABB distribution records indicated two disjunct ABB populations (Bedick et al. 1999).

The purpose of this paper is to update all silphid county records in Nebraska, with a special focus on the American burying beetle. The estimated number of ABBs occurring in the Sandhills is presented along with additional survey information, including recapture distances.

MATERIALS AND METHODS

From 2001 to 2010, various surveys involving carrion beetles were conducted across the state of Nebraska. A majority of the surveys were concentrated in central Nebraska (north to south), and other traps were scattered in the eastern and western portions of the state. Many of the traps were placed to identify ABB presence or absence. Also, voucher specimens in the University of Nebraska at Kearney (UNK) insect collection are included for county records.

Trapping in 2001 followed the Fish and Wildlife Service (1991) protocol for ABB as modified by Bedick et al. (1999). Baited pitfall traps were constructed using a 9.5 L plastic bucket with a diameter of 28.5 cm. These buckets were placed at selected sample sites and buried so that the lip of the bucket was approximately 2 cm above the ground surface. The bottom of the bucket was filled with about 10 cm of damp soil to reduce mortality from desiccation and from inter- and intraspecific competition or predation. The carrion bait consisted of 300 ± 50 g of

rat, which was allowed to decompose at environmental temperatures of 35°–40°C for four days prior to trapping. During trapping, the bait was placed in a plastic screw-cap container covered with a 0.5 cm screen top, which prohibited beetles or flies from contacting the carrion. A 2.8 cm screen (chicken wire) was placed over the top of the bucket and was staked in place to deter scavenging vertebrates from disturbing the trap. A rain cover consisting of a piece of plywood approximately 30 cm by 30 cm was suspended 2.5 cm above the trap by 5 cm stakes. Traps were placed a minimum of 0.8 km apart and were checked once per day. The traps were baited by 6:00 p.m. and were checked the following morning by 10:00 a.m. Many trap sites were chosen by driving into a county and visually seeking habitat that was minimally disturbed. Most traps were checked for three or five consecutive days before being removed. At each trap location, GPS coordinates were recorded. During extended trapping periods, bait continued to degenerate through time, and bait was changed after three, six, and eight nights of trapping.

Unless otherwise stated, surveys conducted from 2002 to 2010 followed the American burying beetle Nebraska sampling protocol (U.S. Fish and Wildlife Service 2008b), which is similar to the protocol in Bedick et al. (2004), except the bait was kept exposed. Traps were checked every 24 hours, except during a 31-county survey in 2004, in which traps were checked at 48 to 72 hours after baiting. Occasionally, bait deterioration required earlier bait change, and on these occasions, pitfall traps were rebaited with roadkill or decomposed rats between the scheduled changing of the bait.

Trapped silphid beetles were identified to species, then counted and released. Most ABB specimens were sexed, marked with a small spot of automobile touch-up paint (different sequences of colored dots placed on the beetle's pronotum or elytra) or with a 2 mm disk (colored-coded numbered disks superglued to the elytra or pronotum) (The Bee Works, Ontario, Canada) to monitor recaptures, and released. American burying beetles captured in August were usually identified as senescent, which indicated they had already overwintered the year before, had reproduced, and had very darkened pronotal markings, or were teneral, which indicated they had recently eclosed and had very bright orange-red pronotal markings. In our 2004 survey, two vouchers of each silphid species, except for the American burying beetle, were killed with ethyl acetate, pinned, and deposited in the collections at the University of Nebraska at Kearney.

Mark-recapture surveys for ABB were conducted in four Nebraska Sandhills counties in 2003 for two ten-day survey periods. A late June survey consisted of 12 baited pitfall trap locations at least 0.8 km apart in Loup and Rock Counties (six traps per county). A mid-August survey also consisted of 12 baited pitfall trap locations at least 0.8 km apart, six each in Blaine and Brown Counties. The baited pitfall traps for these surveys used 11.4 L buckets and guinea pigs as bait, but all other aspects were the same. The age (i.e., senescent or teneral) was not recorded for captured ABBs in August for these surveys to avoid variability and errors in the evaluation of age between multiple research crews.

Subsamples of surveys in 2009 and 2010 were used for additional population estimates in the Sandhills region. All trap locations were a minimum of 1.6 km apart. Holt County was sampled in June 2009, June 2010, and August 2010 in various locations using six traps for 10 trap nights, four traps for five trap nights, and four traps for 10 trap nights, respectively. Rock County and a small portion of Brown County were sampled in August 2009 using two transects with 11–12 traps for five trap nights. In 2010, Cherry and Loup Counties were sampled over five trap nights using 19–25 traps in each transect. Two areas in Cherry County were sampled in June, and the Loup County transect was sampled in August. All August ABBs were recorded as senescent or teneral. Teneral ABB data were used for all August population estimates unless otherwise noted.

All mark-recapture data used for population estimates were analyzed using ECO-STAT software (Young and Young 1998) following the same procedure as Bedick et al. (1999). The trapping radius used to calculate total area for the population estimates was 1 km^2 per trap, as used by Bedick et al. (1999). The estimated number of ABBs per km^2 was calculated to compare ABB numbers between years and seasons and should not be assumed to represent an equal distribution of the American burying beetle in the sampled areas.

RESULTS AND CONCLUSIONS

Seventy-six of the 93 Nebraska counties (Fig. 1) were sampled between 2001 and 2010 at more than 1,500 sampling locations. ABB numbers were recorded from 537 different trap locations in 18 counties, with 11 counties being new county records (Fig. 2). Our earliest capture of ABB was May 26 (of five ABBs), and the latest capture (of one ABB) was October 11 (September 28 was the second-latest capture); however, the majority of ABBs were captured in June and August. A total of 5,212 ABBs were captured and recorded, with 321 recaptured once,

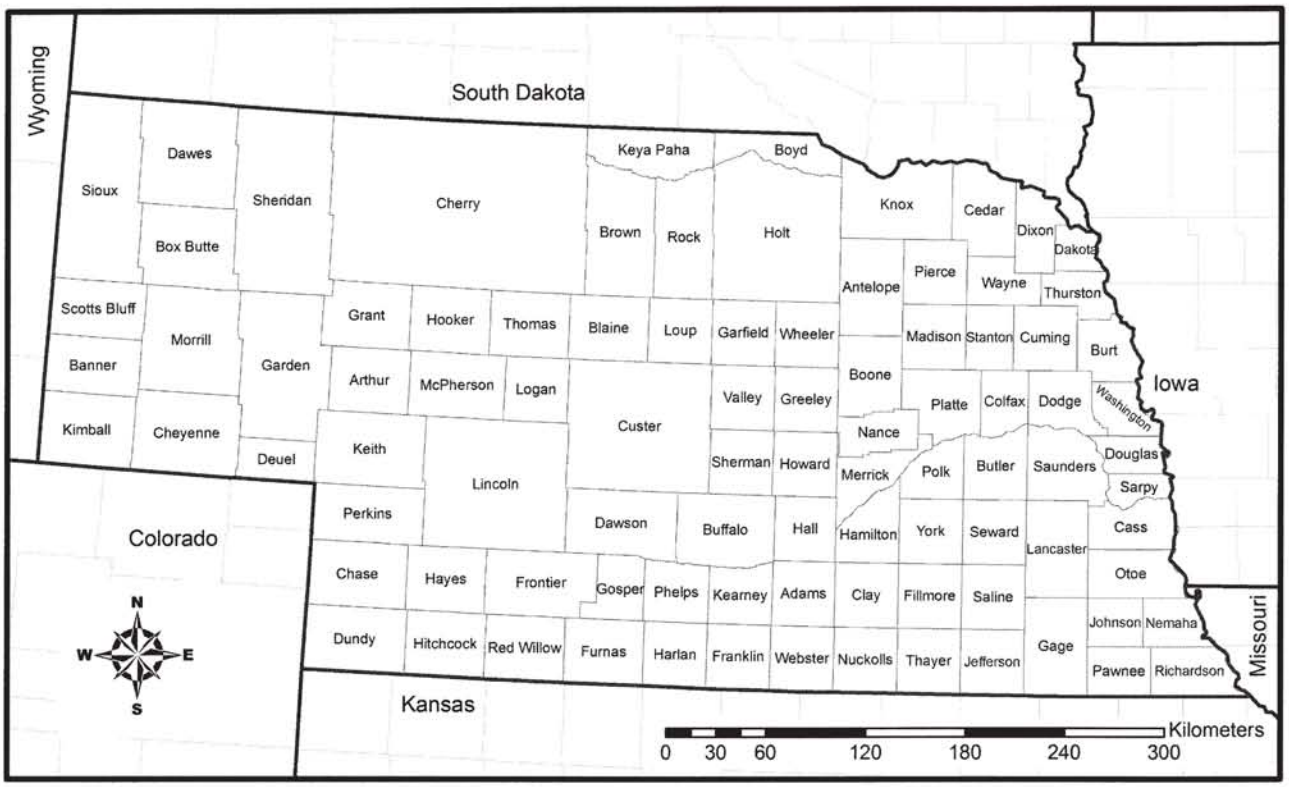


Figure 1. Map of Nebraska's counties.

38 twice, 8 three times, and 2 four times. The known occurrence of the American burying beetle in Nebraska counties was increased from 10 to 21 counties, but only 18 of the 21 counties have had the presence of American burying beetle recorded in the last 15 years. The presence of the American burying beetle in Lancaster and Antelope Counties before 1950, and in Gosper County before 1995, has not been reconfirmed. The captures from 2001 to 2010 substantially expand the distribution of the American burying beetle in Nebraska, connecting the known populations occurring in Keya Paha and Custer Counties and extending the range almost 300 km farther west than that recorded before 1999. A large gap of approximately 90 km remains between the northern Sandhills population (4,082 ABBs captured) and the southern Loess Canyons population (1,130 ABBs captured).

Mark-Recapture Population Estimation

In the 2003 mark-recapture surveys, a total of 378 (219 ♀, 156 ♂, and 3 undetermined) American burying beetles were trapped a total of 416 times over a period of 240 trap nights for an average of 1.73 ABBs per trap night. A total of 64 captures of American burying beetles occurred over a period of 120 trap nights during the early survey from Loup and Rock Counties, for an average trapping ratio of 0.53 ABBs per trap night. In Blaine and Brown Counties, American burying beetles were captured a total of 352 times over a period of 120 trap nights during the late survey, for an average trapping ratio of 2.93 ABBs per trap night. Overall, 9.1% of the ABBs were recaptured in the 10-day surveys.

These data were used to estimate the population size of the American burying beetle in Blaine, Brown, and Rock Counties (Figs. 3 and 4); however, the absence of recaptures in Loup County prevented the estimate of population (Table 1). Each estimate was calculated from a sample area of 18.84 km^2. The population estimate was largest for Blaine County (1338 ± 272 sd), followed by Brown County (277 ± 68 sd), and then Rock County (157 ± 70 sd) (Table 1). Given the same sample area size that was used for the estimates, the ABB per km^2 follows a similar trend of 56, 12, and 7 for Blaine, Brown, and Rock Counties, respectively.

In 2009, 1,097 (561 ♀, 529 ♂, and 7 undetermined) American burying beetles were captured in Brown, Holt, and Rock Counties, in which 59 recaptures traveled a mean distance of 0.41 (± 1.41 sd) km per night; however,

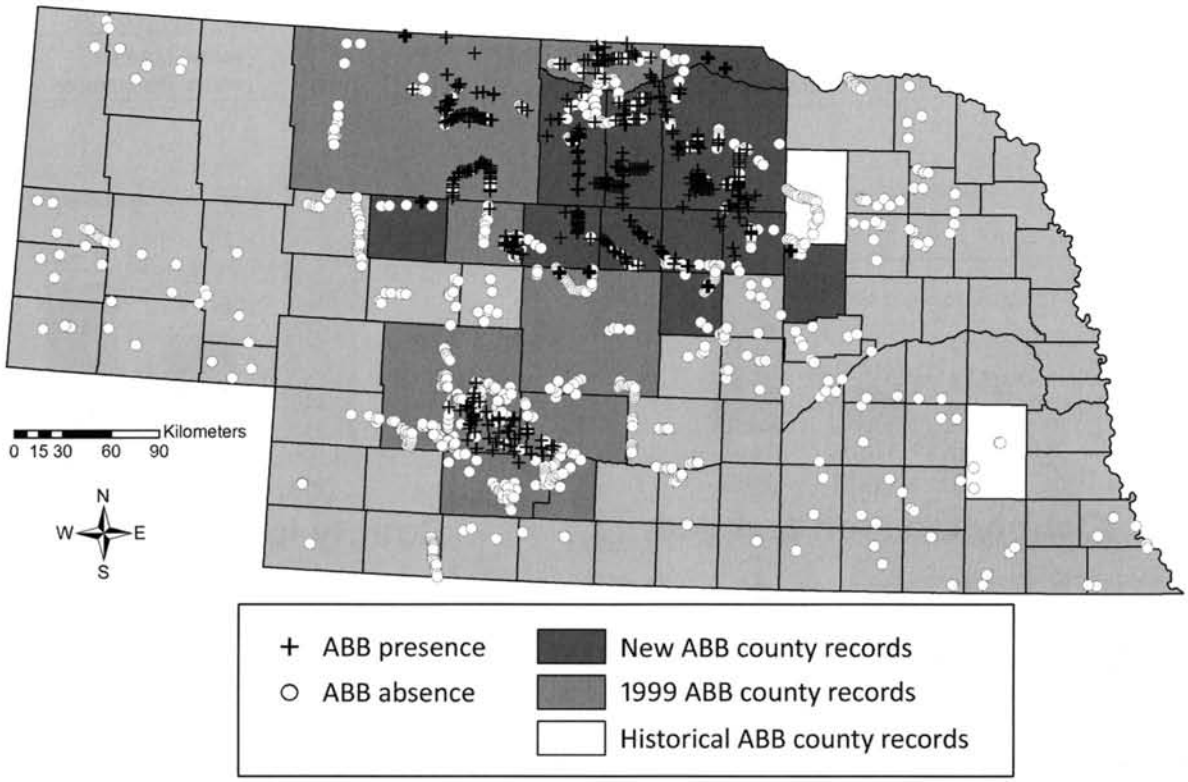
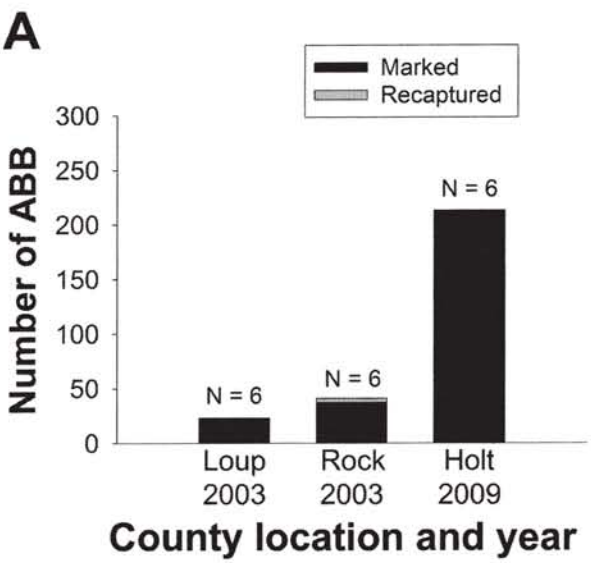


Figure 2. Baited bucket pitfall trap results from 2001 to 2010, showing the presence and absence of the American burying beetle (*Nicrophorus americanus*) in Nebraska. Absence is defined as three or more survey nights without ABB capture. County records illustrated as either 1999 or historical ABB county records are as reported in Bedick et al. (1999). Boyd county records were provided by Doug Backlund and Gary Marrone.

85% of the American burying beetles did not move to a different trap (distance equaled zero), and 90% traveled 1.6 km or less. In June, one American burying beetle traveled 7.41 km in a single night and another was recaptured 29.19 km east-southeast from the original trap in which it was captured and marked the day before (this distance was excluded from average distance calculations). The latter American burying beetle individual traveled unusually far, and during the night the winds ranged from calm to 13.04 kph, with a majority of the wind blowing southeast to east-southeast. In comparison, an Oklahoma study found that recaptured American burying beetles moved an average of 1.23 (± 0.73 sd) km per night with the maximum distance moved over one night being 2.9 km (Creighton and Schnell 1998). A beetle recaptured twice in the Oklahoma study traveled a total of 10 km over the six nights between the first and last capture.

In 1995, Peyton (2003) recaptured 11 specimens out of 201 marked in the Loess Canyons in Nebraska, with all but one recaptured within the same trap. In 1996, a single American burying beetle was recaptured 30 days after initial marking and had traveled 11 km (Peyton 2003). A total of 21 American burying beetles (out of 379 initial captures) recaptured by Peyton (2003) in 1998 were caught within five days in the same trap in which they were originally marked. Bedick et al. (1999) also trapped American burying beetles in 1995 and 1996 in the Loess Canyons and found that most recaptures occurred over distances of less than 1 km. More recently, Walker (2005) recaptured 56 out of 202 marked ABBs in a 2004 and 2005 study located in the same area as the studies by Peyton (2003) and Bedick et al. (1999). These beetles were found to travel between 0 km (39% of marked beetles) and 6.2 km (single ABB over four nights), with a mean distance of 0.54 km.

The 2009 mark-recapture survey in Holt County had zero recaptures, thus preventing an estimate of population size, but the 213 ABBs captured or 11 ABB per km^2 serves as a conservative population estimate (Table 1). In June 2010, the Holt County pitfall traps yielded approximately eight ABB per km^2, and in August 2010, traps were more widely separated in distance in Holt County resulting in a larger estimate of 36 ABB per km^2. From our experience sampling in these areas, the estimated



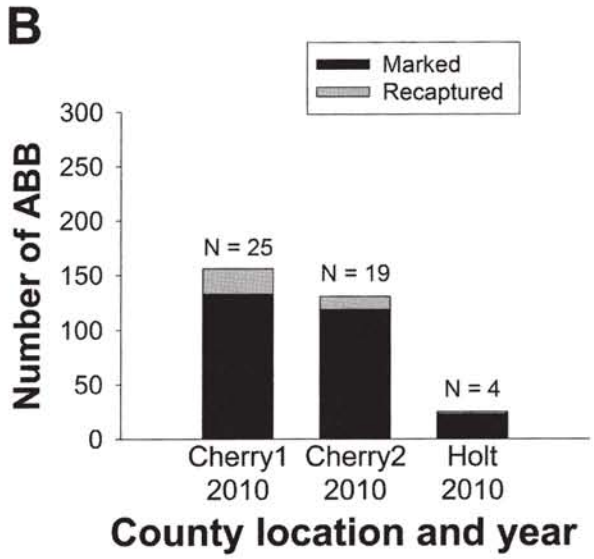
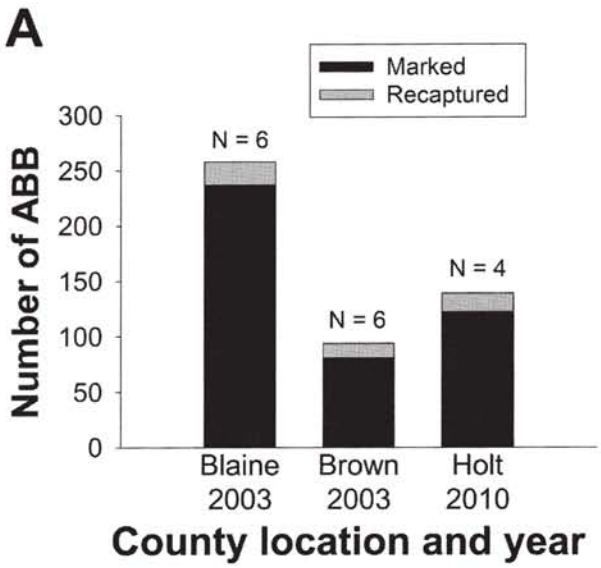


Figure 3. The number of ABB marked and recaptured in six survey areas during June. Surveys conducted over 10 survey nights (A) and 5 survey nights (B) are reported. The number of pitfall traps used are indicated by N = *x*. These data were used to calculate population estimates (Table 1).



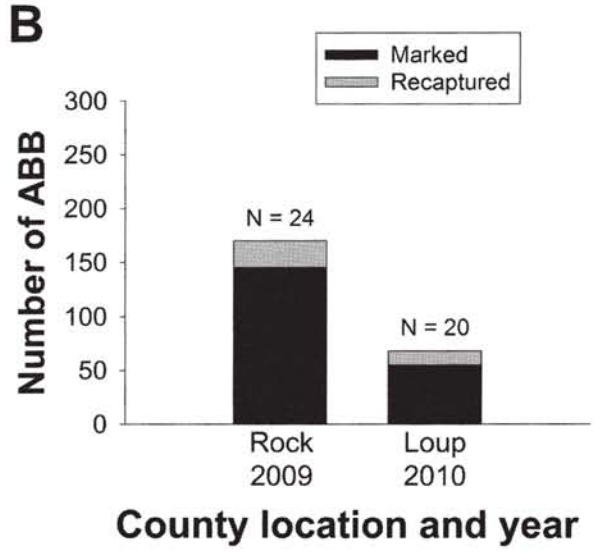


Figure 4. The number of ABB marked and recaptured in five survey areas during August. Surveys conducted over 10 survey nights (A) and 5 survey nights (B) are reported. The number of pitfall traps used are indicated by N = *x*. These data were used to calculate population estimates (Table 1).

population of 451 ± 97 (sd) ABBs, or 36 ABB per km^2, better reflects the number of ABBs in Holt County. An area sampled in August 2009 in Rock County and part of Brown County had an estimated six ABBs per km^2. The remaining mark-recapture samples in 2010 provided estimates of six, nine, and two ABBs per km^2 for two areas in Cherry County and one area in Loup County, respectively. Three of the six counties sampled using mark-recapture methods showed estimates greater than 10 ABBs per km^2 and overall did not show any distinct decreases or increases in ABB population over time.

Population estimates using June sampling data should not directly be compared to the August estimates, because June estimates were calculated using the number of mature adults that survived overwintering, whereas teneral adults emerging from summer broods were used to calculate August estimates (Fig. 3). June sampling may have lower recapture probabilities because mature beetles

TABLE 1
MARK-RECAPTURE POPULATION ESTIMATES FOR AMERICAN BURYING BEETLES IN SIX NEBRASKA COUNTIES

County/Location	Year	Approx. area (km^2)	Population estimate (± S.D.)		Estimated ABB/km^2	Comments
			June	August		
Loup	2003	18.84	n/a		1†	No population estimate possible
Rock	2003	18.84	157 ± 70		7	
Holt	2009	18.84	n/a		11†	No population estimate possible
Northeast Cherry (1)	2010	65.91	374 ± 65		6	
Southeast Cherry (2)	2010	52.47	498 ± 124		9	
Holt	2010	12.56	99 ± 62		8	
Blaine	2003	18.84		1338 ± 272	56	Unknown number of senescents
Brown	2003	18.84		277 ± 68	12	Unknown number of senescents
Holt	2010	12.56		451 ± 97	36	Only tenerals (removed 5 senescents)
Rock (Brown*)	2009	65.87		927 ± 113	14	Both senescents and tenerals
Rock (Brown*)	2009	65.87		487 ± 85	7	Only senescents
Rock (Brown*)	2009	65.87		391 ± 65	6	Only tenerals (removed 156 senescents)
Loup	2010	55.78		118 ± 25	2	Only tenerals (removed 3 senescents)

* Five traps followed a road into eastern Brown County.
†The total number of ABB marked was used in this estimate, not the population estimate.

are removed from the available population when they secure a source for reproduction. A visual comparison of recapture numbers in August (Fig. 4) and in June (Fig. 3) illustrates a potential trend in which recaptures are more likely in August. Please note these results are for separate locations in June and August (Figs. 3 and 4) and cannot be directly compared for population growth. Future research using multiple mark-recapture surveys in June and August in the same location is needed to test for trends in recapture rates. Additionally, consecutive surveys would allow for an estimate of population growth in a specific habitat from June to August, whereas consecutive surveys in August and the following June would allow for estimates in mortality rates.

Bedick et al. (1999) found that their extrapolated population of 1,174 American burying beetles in June increased in August to 3,046 ABBs (only teneral adults). They suggested the approximate 159% increase in population size was a result of either population growth or overwintering mortality, which would indicate an approximate 61% decrease in population size. A smaller overwintering mortality rate of 40% was found by Schnell et al. (2008) in 2005 at sites located in Fort Chaffee, Arkansas. In South Dakota, Backlund et al. (2008) found an approximate 104% increase from June to August population estimates, which may reflect either a smaller population growth rate or estimate a lower mortality rate (i.e., 51% decrease) farther north. Assuming an average 132% population increase calculated from Bedick et al. (1999) and Backlund et al. (2008), then Rock County in 2003 (Table 1) could have had as many as 249 American burying beetles in August, which is similar to the adjacent Brown County's estimate of 277 American burying beetles in 2003 (Table 1). Given the differences in experimental methods between the three aforementioned studies, we cannot make assumptions concerning differences in latitude or climate and mortality rates for American burying beetles.

Overall, the population sizes estimated using mark-and-recapture data should be cautiously interpreted because of assumed lack of emigration and immigration and because all individuals are assumed to be available

for recapture during the sampling period. Often, short sampling intervals (relative to the overall active season of the organism) are used to limit the variability of the first assumption. Five- to ten-day sampling periods are equal to or less than a third of the observed activity period for American burying beetles in either June or August. The availability of individuals is likely skewed for recapture in June, because ABBs are seeking out and securing carcasses for reproduction, which would continually reduce the number of available adults in an area. Similarly, August sampling could violate this assumption if sampling occurs too early, when many ABB tenerals have not yet eclosed, or if senescent adults are included in the calculations. To test the effects of these differences, we calculated the population size of American burying beetles in Rock County in 2010 using both senescent and teneral beetles, only senescent beetles, and only teneral beetles (Table 1). The use of both ages of beetles inflated the population size by 536 ABBs when compared to the estimate for only teneral ABBs. Also, the estimate using only senescent ABBs was greater than the estimate for only teneral ABBs, suggesting the sampling period was too early.

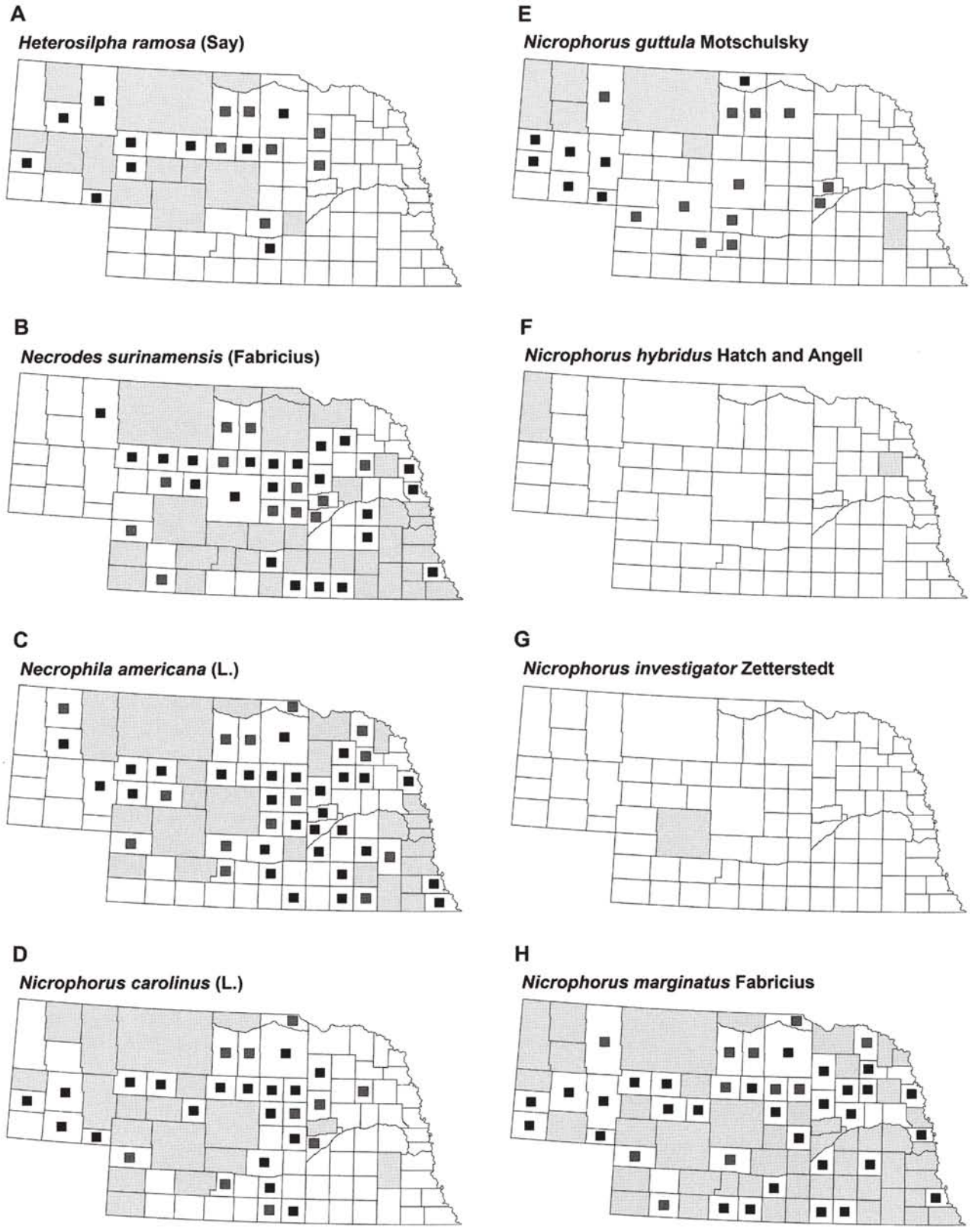
Additional Silphid Records

A total of 15 species of silphids were collected during surveys conducted in Nebraska from 2001 to 2010, resulting in 465 new county records (based on Ratcliffe 1996) (Fig. 5A–Q). Each species captured in our survey is listed and the number of new county records follows within the parentheses: *Heterosilpha ramosa* (Say) (17), *Necrodes surinamensis* (Fabricius) (34), *Necrophila americana* (L.) (43), *Nicrophorus americanus* (11), *N. carolinus* (L.) (28), *N. guttula* Motschulsky (19), *N. marginatus* Fabricius (40), *N. obscurus* Kirby (20), *N. orbicollis* Say (33), *N. pustulatus* Herschel (19), *N. tomentosus* Weber (50), *Oiceoptoma inaequale* (Fabricius) (36), *O. novaboracense* (Forster) (40), *Thanatophilus lapponicus* (Herbst) (35), and *T. truncatus* (Say) (40). Three species with few historical records, *Nicrophorus hybridus* Hatch and Angell, *N. investigator* Zetterstedt, and *N. mexicanus* Matthews, were not captured during our surveys.

Prior to this study, there were 358 known county records for silphid beetles in the state of Nebraska (Ratcliffe 1996). This study more than doubled the number of silphid county records. In addition to new information at the county level, distributional ranges were greatly increased. Counties with few or no carrion beetle records, such as Colfax, Dakota, Dodge, Furnas, Hayes, Kimball, and Thurston, are likely to have similar species found in surrounding counties and should be surveyed (Fig. 6).

A South Dakota survey in three counties along the northern border of Nebraska captured 13 silphid species, all of which were also captured in our surveys, except for *N. hybridus* (Backlund and Marrone 1997). In surveys conducted from 1992 to 1994, Kansas researchers identified 11 of their 13 historically recorded species, all of which were found in the Nebraska surveys (Lingafelter 1995). Guarisco (1997) reconfirmed the presence of six silphid species and reported the discovery of extant populations of ABB in a 1996 survey of the Chautauqua Hills of southeastern Kansas. Further sampling in 1997 and 1998 on the Konza Prairie Biological Station (north-central Kansas) did not result in capture of American burying beetle but did find eight species previously documented by Lingafelter (1995). Trapping results from a northeastern Iowa study in 1996 showed the presence of 10 silphid species of which two, *N. hybridus* and *N. investigator,* were not identified in our surveys (Coyle and Larsen 1998). We found no current research on Wyoming silphids, but two resources provided some baseline information on silphid occurrence. Peck and Kaulbars (1987) reported the presence of 10 silphid species in Wyoming, including four species not found in our surveys, *Aclypea bituberosa* (LeConte), *N. hybridus*, *N. investigator*, and *Thanatophilus sagax* (Mannerheim). In addition, *Nicrophorus defodiens* Mannerheim were collected in Wyoming and used for laboratory research by Trumbo and Eggert (1994).

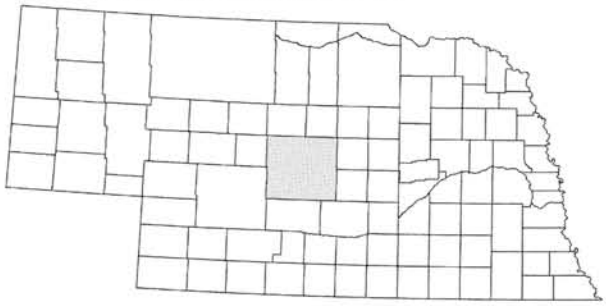
Despite the apparent population size and range in Nebraska, the American burying beetle is still rare compared to most other silphid species. For example, *N. marginatus* appeared in a majority of the traps reported in this paper and has been recorded in 89 of Nebraska's 93 counties. It is unknown why the American burying beetle has a patchy distribution in Nebraska. Additional studies of carrion resources, similar to research conducted in Arkansas comparing available biomass of birds and mammals to the presence of the American burying beetle (Holloway and Schnell 1997), should be conducted to better understand the ABB distribution in Nebraska. Some counties have apparently suitable ABB habitats but have not been surveyed extensively (both limited number of trap nights and coverage of the county) or have an unexplained absence of the American burying beetle. For example, Custer County is a large county that resides between our two known population areas and has large tracts of land without row crops and undisturbed rangeland with suitable water resources



Figures 5A–Q. County-level distributions of 17 Nebraska carrion beetle species. Shaded counties represent counties with records from Ratcliffe (1996). Gray squares within a county represent records from various research surveys without voucher specimens and black squares within a county represent records with voucher specimens housed at the University of Nebraska at Kearney.

I

***Nicrophorus mexicanus* Matthews**



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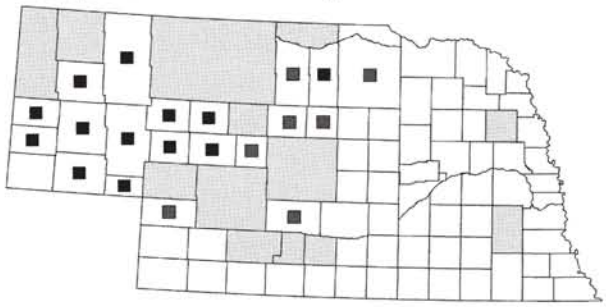
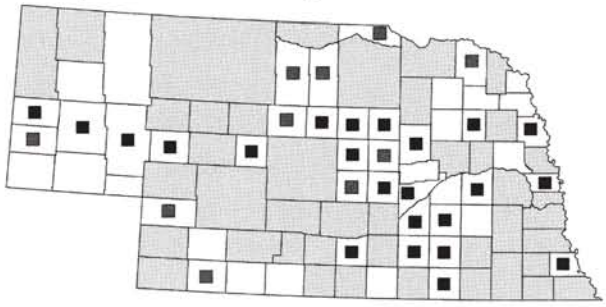
***Nicrophorus obscurus* Kirby**



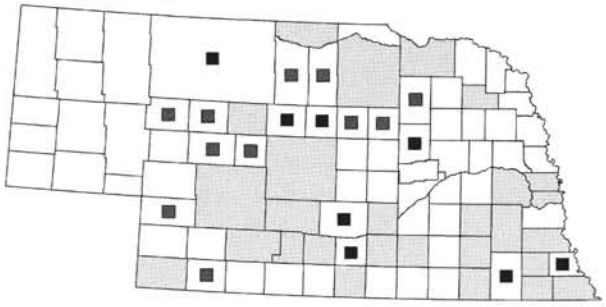
K

***Nicrophorus orbicollis* Say**



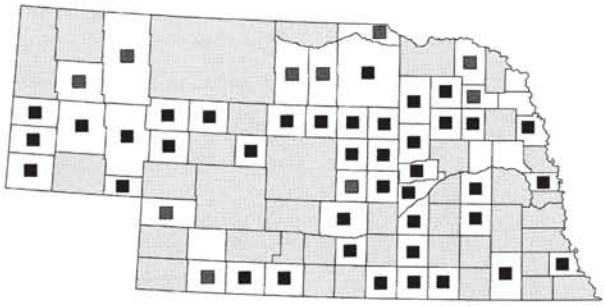
L

***Nicrophorus pustulatus* Herschel**



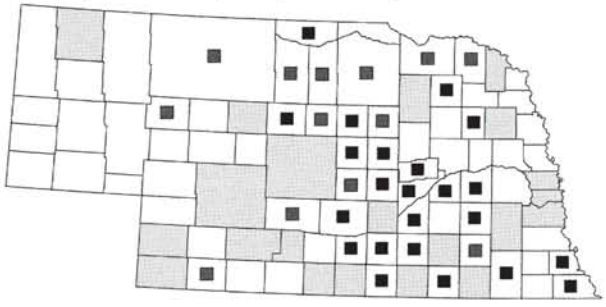
M

***Nicrophorus tomentosus* Weber**



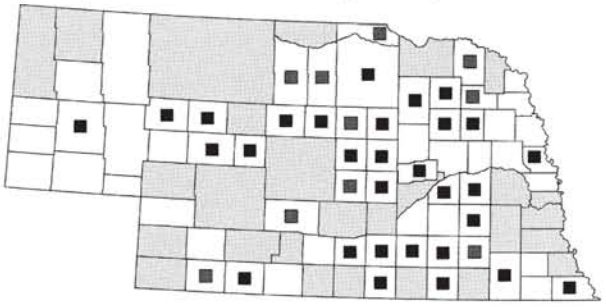
N

***Oiceoptoma inaequale* (Fabricius)**



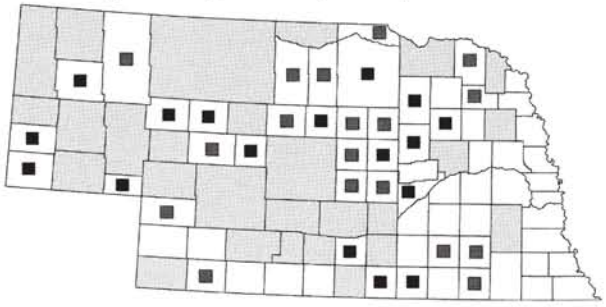
O

***Oiceoptoma novaboracense* (Forster)**



P

***Thanatophilus lapponicus* (Herbst)**



Figures 5A–Q continued.

Q

***Thanatophilus truncatus* (Say)**

Figures 5A–Q continued.

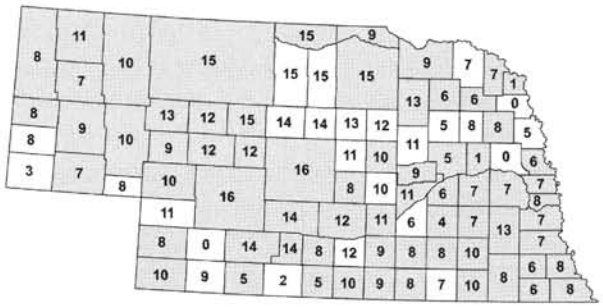


Figure 6. The number of silphid species recorded from each Nebraska county. The unshaded counties represent counties with zero species recorded in 1995 (Ratcliffe 1996).

(Hoback and Jurzenski, personal observation). Only small portions of the county have been sampled, which makes it difficult to assume or explain the presence or absence of ABB. In an Oklahoma study, Lomolino and Creighton (1996) found that habitat characteristics and competition influenced ABB occurrence and breeding success at some spatial scales but not others. The development of Nebraska ABB habitat suitability models, made possible by the dataset presented in this paper, is intended to discover candidate areas for conservation or management, along with enhancing our understanding of ABB habitat and breeding criteria in both the Sandhills and Loess Canyons. Crawford and Hoagland (2010) presented an evaluation of habitat suitability models for ABB in Oklahoma, which details the important complications encountered in this process.

Overall, we found that ABBs are locally abundant (>200 adult beetles per sampled area) in at least five counties in the Sandhills. By assessing both our data and other published reports, standardized population estimates of ABB in Nebraska should be performed using at least five survey nights and teneral beetle data collected in mid- to late August. These data would be complimented by the identification of an overwintering survival rate via June sampling, which could allow for adjustments of mark-recapture data collected in June. The movement of ABBs during trapping periods varied greatly, with a majority of beetles moving 1.6 km or less over a single night, but beetles were capable of traveling distances as far as 7.41 km on a calm night or 29.19 km on a wind-aided night. This information may impact the way conservation measures are implemented, especially the assessment of nearby suitable habitat and the use of trap-and-relocate or baiting-away methods. Our research provides a more complete view of the distribution of silphid species in Nebraska, all of which are important ecologically, and may help in conservation efforts of the American burying beetle.

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