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Population Estimate of the Endangered American Burying Beetle, *Nicrophorus americanus* Olivier (Coleoptera: Silphidae) in South Dakota

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Abstract

Annual monitoring surveys for the endangered American burying beetle, *Nicrophorus americanus* Olivier, have been conducted in south central South Dakota since 1995. The population has been stable in abundance and distribution. Two mark and recapture surveys were conducted in June and August, 2005 in southern Tripp County, South Dakota, U.S.A. Using baited pitfall traps, we captured and marked 168 specimens of *N. americanus* during 410 trap-nights in June. In August, 323 specimens were captured and marked in 450 trap-nights. We estimated the population size of *N. americanus* in an area of approximately 220 km^2. Estimates were obtained using a family of models (program CAPTURE) that incorporate several sources of variability in probability of capture. The June population estimate (±1 SE) was 442 ± 73 and a 95% confidence interval of 333–624 adults. The August population estimate (±1 SE) was 901 ± 117 with a 95% confidence interval of 714–1,177 tenerals and adults combined.

Historically, *Nicrophorus americanus* Olivier, the American burying beetle, occurred in 35 states, the District of Columbia, and three Canadian provinces in eastern and central North America. The species has disappeared from most of its former range, and prior to federal listing, populations were known to exist only on Block Island off the coast of Rhode Island and in eastern Oklahoma (Raithel 1991). On August 14, 1989, *N. americanus* was placed on the federal list of endangered and threatened wildlife and plant species.

Table 1. Records of the American burying beetle, *Nicrophorus americanus*, at the Severin-McDaniel Insect Research Collection, South Dakota State University, Brookings, South Dakota.

County	Location	Date	Number of specimens	Method of capture
Brookings	Brookings	8 July 1945	1	light trap
Brookings	Brookings	24 July 1945	1	light trap
Brookings	Brookings	5 August 1945	1	light trap
Haakon	Nowlin	(no data)	1	(no data)
Union	Elk Point	7 June 1945	1	(no data)
Union	Elk Point	8 August 1945	1	light trap
Union	Elk Point	12 August 1945	1	light trap

Since federal listing, additional populations have been found in South Dakota, Arkansas, Nebraska, and Oklahoma. A few collections have been made in Kansas in recent years (U.S. Fish and Wildlife Service 2006). More recently, a population was discovered in northeast Texas (Godwin and Minich 2005).

Historic South Dakota records of *N. americanus* specimens deposited at the Severin-McDaniel Insect Research Collection, South Dakota State University, indicate the species ranged from Brookings and Union counties in eastern South Dakota to Haakon County in the west (Table 1). Numerous surveys have been conducted specifically for *N. americanus* in various parts of the state since 1990 (Backlund and Marrone 1997). These previous surveys failed to find *N. americanus*.

A large population of *N. americanus* was discovered in south-central South Dakota in 1995 (Backlund and Marrone 1997). The population has been monitored almost annually and has remained stable in abundance (catch per trap-night) and distribution (Backlund unpubl. data). This population is associated with a metapopulation that occurs in the Nebraska Sand Hills region (W. W. Hoback pers. comm.).

In 2005, we conducted a mark and recapture study to estimate the population size of *N. americanus* in southern Tripp County, South Dakota, U.S.A. The goal of the project was to demonstrate that the population meets the requirements of the American Burying Beetle (*Nicrophorus americanus*) Recovery Plan (Raithel 1991) for a population that contributes to reclassification of listing status. The recovery plan requires three populations of *N. americanus* to have been reestablished (or additional populations discovered) within each of four broad geographical areas of its historical range (the New England states, the southeastern states, the midwestern states, and the Great Lakes states) before reclassification of federal listing status can be considered. Criteria for a population are as follows:

1. Each population contains a minimum of 500 adults as estimated by capture rates per trap-night and blacklight effort.
2. Each population is demonstrably self-sustaining for at least five consecutive years.
3. Ideally, each primary population contains several satellite populations to which beetles disperse and from which new habitats are colonized.

Nicrophorus americanus Life History

Life history information is taken from Raithel (1991). Like other members of the genus, *N. americanus* relies on carrion as a food supply. During brood-

rearing, carrion is interred in an underground chamber, where one or both adults provide protection and parental care to the young. *Nicrophorus americanus* is the largest *Nicrophorus* species in North America. While smaller species may reproduce on small carrion, *N. americanus* has optimal reproduction utilizing carrion weighing in the range of 100 to 250 g. The species is univoltine. In Rhode Island, most breeding activity occurs in June and July. Burying beetles locate carrion using antennal chemoreceptors. Once a suitable carrion source is located, the beetles bury the carcass, clean it of feathers or fur, and preserve the food supply with anal and oral secretions. Eggs are laid in the brood chamber. At least one adult remains in the chamber until tenerals emerge. The larvae pupate in the soil for about 48–60 days. Teneral beetles emerge in July and August in Rhode Island.

Tenerals overwinter and constitute the entire breeding population of the next year. Breeding age adults become senescent following breeding and perish sometime after emergence of the tenerals.

Materials and Methods

The study area is located in southern Tripp County, South Dakota, U.S.A. (Fig. 1). Habitat in the area is characterized by sandy grasslands with scattered stands of trees dominated by cottonwood (*Populus deltoids* Marsh). Subirrigated meadows and groundwater streams are common features. Most of the study area remains in native grassland and is primarily used for range and hayland. Low meadows are dominated by grasses and forbs typical of tallgrass prairie while the uplands consist mostly of mixed grass prairie flora. Turtle Butte, a Tertiary formation, supports a ponderosa pine community.

The study area has a typical continental climate with an average annual precipitation of 51.76 cm (Springer 1979). Temperatures range from an average daily high of 32.7°C in July to an average daily low of minus 12.3°C in January (Springer 1979).

Soils consisting of >40% sand are preferred by *N. americanus* in Oklahoma and Arkansas (Lomolino *et al.* 1995). Soils in the study area are primarily sandy and sandy loam (Springer 1979).

Baited pitfall traps are the most effective method of surveying large areas for *N. americanus* (Raithel 1991; Bedick *et al.* 2004). Each pitfall trap consisted of two plastic buckets stacked together and buried with the opening at ground level. Buckets were 5 L in volume, 20.32 cm in height, and 20.96 cm in diameter. A trap cover, constructed from a 30 × 30 cm piece of plywood mounted on 7.5 cm wooden legs, was staked over each trap to deter scavengers and protect captured beetles from sunlight and rain. Each trap cover was held in place by a 60 cm long metal rod. Plastic surveyors tape was tied to each rod to help relocate traps. The bait, consisting of 20 g of ripened beef kidney, was placed in 118 ml glass containers (baby food jars). Small holes were punched in each jar lid to allow bait odor to escape. Pitfall traps were checked daily.

A trapping grid of 220 km^2 was established in the core of the known distribution of *N. americanus* in southern Tripp County (Fig. 1). Most of the area is private land so access was limited to public road right of ways. Traps were spaced so that no trap was more than 3.22 km from another trap and no closer than 0.2 km. We sampled from 17 June to 24 June for a population estimate of the overwintering generation and from 10 August to 18 August for a population estimate of the new generation. The sampling periods coincide with the peak activity periods reported in Nebraska (Bedick *et al.* 2004) and with our experience

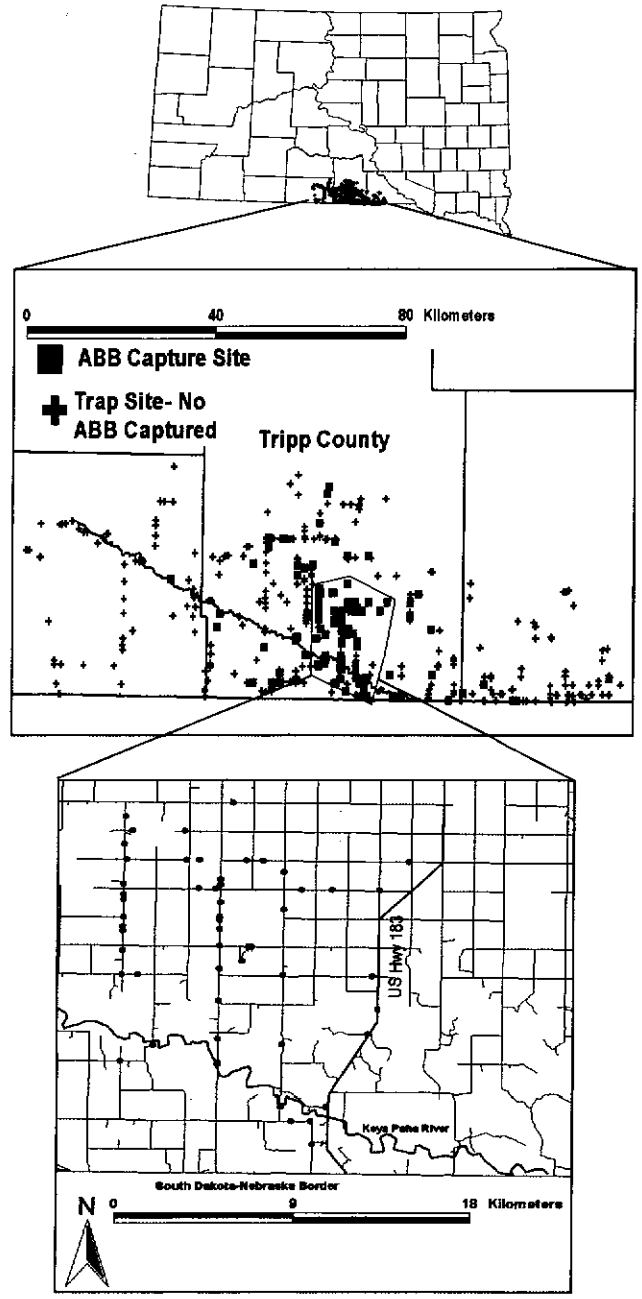

Fig. 1. From top to bottom: South Dakota, U.S.A. showing location of the extant *Nicrophorus americanus* population; total area sampled for *Nicrophorus americanus* from 1995–2004 illustrating positive and negative sampling results; sampling sites used for the population estimate in 2005.

sampling in South Dakota (Backlund and Marrone 1997; Backlund unpubl. data). Fifty-four traps were set in June. Two traps were pulled after a few days due to a landowner request. Two traps were stolen. Fifty trap sites were used for the remainder of the sampling period in June and for the entire sampling period of August. *Nicrophorous americanus* were individually marked with 2 mm diameter color-coded, numbered markers (Queen Marking Kit manufactured by E. H. Thorne, Beehive Works, Wragby, Market Rasen, Lincolnshire, UK). Markers were in five color sets, and each color set was numbered 1–99. Markers were attached to the pronotum. The pronotum was roughened using a small file and Super Glue was then used to attach the markers. Each marked beetle was additionally marked by clipping a v-notch into the lower elytron. Beetles captured in June were clipped on the right elytron, those in August were clipped on the left elytron. Beetles were aged as teneral or adult using methods described by Bedick *et al.* (1999). We did not attempt to separate adult and senescent beetles, instead we classified both as adult.

We assumed populations during the trapping periods were constant and were not subject to significantly measurable death or migration. Our assumption of a constant population size during each week led us to explore closed mark–recapture models. We conducted mark-recapture trapping in June (for 8 consecutive days) and in August (for 9 consecutive days) and in each case summarized data from *t* multiple censuses into "capture histories", where each individual was represented by a row of *t* binary digits, in which 0 indicates absence of an individual (*i.e.*, failure to be observed) at a census, 1 indicates presence, and 2 indicates death during census procedures. Estimates of abundance were obtained using a family of models (program CAPTURE; Rexstad and Burnham 1991) that incorporate several sources of variability in probability of capture. First, the probability of capture may vary over time (*t*) (*e.g.*, due to capture probability changing with weather). Second, individual behavior (*b*) may change in response to being captured. Marked individuals may either be more or less likely to be captured than individuals that have never been captured. Third, individual heterogeneity (*h*) in probability of capture among individuals may exist, such that some individuals are always more or less likely to be captured than others. We ran program CAPTURE on both the June and August data sets to identify the appropriate model (8 possible models existed: *null*, *t*, *b*, *h*, *tb*, *th*, *bh*, *tbh*) and estimation of population size for the appropriate model (Rexstad and Burnham 1991). Because *N. americanus* will move to traps based on activity level and chemoreception, we predicted that temporal variation in weather (humidity, rain, temperature) could influence the probability of detecting the bait trap. We also predicted, *a priori*, that a "behavioral" effect might be minimal due to low possibility that *N. americanus* develop positive or negative feelings toward a bait trap. Our third *a priori* prediction was that individual heterogeneity in capture would exist because individuals that are already reproducing on an existing carcass would have little reason to come to our traps. Because of these three causes of variation in probability of detection, we predicted the best fit for our *N. americanus* data would be CAPTURE model M_{th}.

Results

During our June trapping effort, 168 unique individuals were caught with a total of 213 capture events. Supporting our *a priori* prediction, the M_{th} model had the best fit (model selection criterion of 1) and the second best fit model was model M_{tb} (model selection criteria of 0.75). All other models had a model

Table 2. Results of pitfall trapping for the American burying beetle (ABB), *Nicrophorus americanus*.

17–24 June Sampling Period				
Total ABB	Male/Female	Adult/Teneral	Greatest Movement	Greatest Time Between Recapture
168	115/53	168/0	4.43 km	18 June to 24 June*
10–18 August Sampling Period				
Total ABB	Male/Female	Adult/Teneral	Greatest Movement	Greatest Time Between Recapture
323	164/159	14/309	4.46 km	12 August to 18 August

* None of the *N. americanus* marked in June were recaptured in August.

selection criterion <0.65 (Otis *et al.* 1978). With the Chao estimator for M_{th}, the estimate of total population size (±1 SE) was 442 ± 73 and a 95% confidence interval of 333–624. Estimated probabilities of capture were 0.12, 0.09, 0.05, 0.02, 0.05, 0.10, 0.05, and 0.00 in days 1–8, respectively. The estimate (±1 SE) from the M_{tb} model was 5,612 ± 36,295 with a 95% confidence interval of 287–250,698,139, therefore we consider the M_{tb} was not a reasonable alternative model.

During our August trapping effort 323 unique individuals were caught with a total of 374 capture events. Supporting our *a priori* prediction, the M_{th} model had the best fit (model selection criterion of 1) and second best fit model was model M_t (model selection criteria of 0.94). All other models had a model selection criterion <0.65 (Otis *et al.* 1978). With the Chao estimator for M_{th}, the estimate of total population size (±1 SE) was 901 ± 117 with a 95% confidence interval of 714–1,177. Estimated probabilities of capture were 0.04, 0.09, 0.04, 0.01, 0.01, 0.07, 0.06, 0.10, and 0.02 in days 1–9, respectively. The estimate (±1 SE) from the Chao estimator for the M_t model was 794 ± 91 with a 95% confidence interval of 648–1,007.

Table 2 presents data on sex and age ratios, movements of individuals, and length of time between recaptures. All *N. americanus* captured in June were adults. More than twice as many males than females were captured in June. The results may indicate that males are more active in searching for brood carrion or possibly that most females were already restricted to the brood chambers. Nearly all of the beetles captured in August were tenerals and the sex ratio was nearly equal. The greatest movement recorded for individual *N. americanus* was 4.43 km in June and 4.46 km in August. During both sampling periods individual *N. americanus* marked and released early in the sampling period were recaptured on the last day of trapping. We had no recaptures in August of beetles marked in June.

Discussion

Our data and population estimates indicate that the population size exceeds the requirements of the recovery plan, since the study area is only a small portion of the current distribution of *N. americanus* in South Dakota. The population estimates for the 220 km^2 study area, using the M_{th} model, are 442 ± 73 for the June period and 901 ± 117 for the August period. The known distribution of *N. americanus* in South Dakota is approximately 1,900 km^2, based on presence/absence at sampling sites (Fig. 1). Using catch per trap-night data from 1995–2004, we estimate that the core population area, delineated by the area where

catch per trap-night of >1 *N. americanus* has been recorded, is approximately 1,230 km^2. The highest density area, where catch rates of two or more *N. americanus* per trap-night has been recorded, encompasses approximately 493 km^2.

It is our prediction that individual heterogeneity in capture exists because individuals that are already reproducing on an existing carcass would have little reason to come to our traps. In addition, during the August sampling period, it is possible that many teneral *N. americanus* had not emerged from brood chambers or emerged late in the sampling period. We believe our population estimates are conservative. The population estimate of *N. americanus* in South Dakota exceeds 500 individuals, the minimal population size required by the American Burying Beetle (*Nicrophorus americanus*) Recovery Plan (Raithel 1991).

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