A Report on the 22 year Effort to Establish the American burying beetle (*Nicrophorus americanus Olivier*) to Nantucket Island, Massachusetts

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ABSTRACT

The American burying beetle (*Nicrophorus americanus*, ABB) is a federally listed endangered beetle. Once common throughout the eastern half of the United States, *N. americanus* now survives in a small number of isolated or undisturbed habitats in eight states. Since 1993, multiple organizations have collaborated to reintroduce the ABB to Nantucket Island, Massachusetts. The project is now in a monitoring phase and, in 2014, we trapped and marked 36 adult *N. americanus* as part of this effort. We provisioned 29 pairs and seven individual males with a quail carcass on conservation land for a total of 22 broods. The provisioned broods had a 50% success rate, producing an estimated 130 larvae. During our late summer trapping we captured 35 teneral beetles in three trap intervals. One late summer trap interval was specifically timed to look for teneral beetles from wild broods (not provisioned by us) and we did no capture any beetles. Our results show that the minimal provisioning effort is possibly the only thing maintaining the population on Nantucket.

INTRODUCTION

The American burying beetle (ABB, *Nicrophorus americanus* Oliver (1790)) is the largest of North America's carrion beetles (Family *Silphidae*). Its historical range covers 35 states in the eastern temperate areas of North America (Raithel 1991). However, the species is extirpated across much of its native range in the eastern U.S. Today, there are only scattered populations in Arkansas, Kansas, Massachusetts, Missouri, Nebraska, Ohio, Oklahoma, Rhode Island, South Dakota, and Texas (TESS). The only naturally occurring population east of the Mississippi River is located on Block Island, RI, and is comprised of an estimated 1,000-2,000 individuals (USFWS 2008).

The last wild *N. americanus* on Nantucket Island, Massachusetts was recorded in 1926 (Johnson 1930). Nantucket is approximately 42 km south of Cape Cod and is one of the more remote islands off the Northeast coast. Extensive trapping surveys in 1992 and 1993 were unsuccessful in catching any *N. americanus* on Nantucket (Amaral 1993, Northrup 1994). In the summer of 1994, 22 pairs of beetles and four individuals were provisioned on the island in the Massachusetts Audubon Society's Sesachacha Heathland Wildlife Sanctuary, hereafter referred to as site 6(USFWS Memorandum 1998). Releases continued until 2006; to date, a total of 2,923 beetles have been released on Nantucket. Annual reports

from Nantucket have been submitted to USFWS since 2004 (Mckenna-Foster et al. 2004, 2005, 2006a, 2006b, 2007, 2009, 2010; Shuster et al. 2008, LoPresti et al. 2011, Morse *et al.* 2012, Hawkins *et al* 2013). Between 2007-2010, every beetle caught was provisioned with a quail carcass and as many as possible with mates. In 2011, provisioning was reduced to 25 broods to assess the viability of a self-sustaining population. We have continued this level of provisioning since then.

METHODS

Early Summer Trapping

We set traps on the night of 13 June 2014, and kept traps open continuously until 27 June 2014 (Table 1). At all sites we placed five traps approximately 20 meters apart in a line. Trapping followed the procedure described by Kozol (1991). Each trap consisted of a 946 mL mason jar buried with the top flush with ground level and covered with a two-sided "tent" of thick aluminum to keep out the rain and sun. Inside each jar was a plastic container with a screw-on screen lid filled to three quarters volume with small pieces of rotted chicken. We prepared the chicken beforehand in plastic containers left it at room temperature for 7-8 days. Each trap also contained a wet ~9 cm^3 sponge to provide moisture.

We checked traps every morning between 0500 and 1000 hours to ensure that all ABB were removed before traps became lethally warm.

While in captivity beetles were stored in a dark cooler chilled with ice packs to an average of 18.3 + 2.3 C. We housed beetles in groups of one to four individuals, separated by sex, in plastic containers with a moist paper towel and we provided mealworms *ad libitum* for food.

Late Summer Trapping

During the late summer we trapped for three intervals: 11 August – 15 August (four nights), 22 August – 29 August (Seven nights), and 2 September – 7 September (five nights). During the first interval we trapped at all sites (except site 10, five traps at each site) and during the next two intervals we only trapped at the provisioning site with 20 traps. Trapping protocol was identical to the early summer protocol.

Temperature Data Collection

We obtained air temperature, humidity, and wind speed data from the Weather Underground (www.wunderground.com). We used iButtons at trap sites 1, 3, 6, 9, and 12 to collect ground-level temperatures from 16 June to 27 June at 30 minute intervals. We calculated mean nightly temperature from approximately 2000 ($\pm$ 10 min) to 0730 ($\pm$ 10 min) from these data.

2014 Trap Site Locations

We set traps for ABB at 12 sites on the eastern side of the island (Fig. 1). We used the same grid system as in 2013 to assess the distribution of the population across the eastern side of the island. The average distance between a site and its four closest neighbors is 1.96 ± 0.571km. Assuming each trap line has an effective range of 0.8 Km, the grid system covers 22.7 Km^2.

Figure 1

Provisioning Site: Centrally located among the trap sites, this area is predominated by lowbush blueberry (*Vaccinium angustifolium*) and small scrub oak (*Quercus ilicifolia*). This is a different site than in 2013 and it was selected for moister soils.

Measurements and ID Marking

During the early-summer trapping, we sexed, massed, and measured pronotal width on all captured beetles, notched them according to trap site, and glued a bee tag (www.beeworks.com) with a unique number/color combination to each individual.

For newly emerged beetles trapped in the late summer, we sexed, measured body mass and pronotal width, notched each individual and glued on a bee tag while in the field and released the beetles on-site.

Provisioning

We provisioned 22 pairs of beetles with a quail carcass buried approximately 20 centimeters underground. We kept all captured beetles in captivity until 23 June 2014, at which time we paired and provisioned 11 pairs. We provisioned four more pairs and seven individual males on 28 June 2014. Quail carcasses averaged 140 ± 6.74g SD (range 104-153 g). To protect the carrion and beetles from

scavengers, we stapled hardware cloth to the ground over the filled-in hole. Provisioned broods were parented by paired male and female ABB captured at the same site when possible, and adjacent sites in some cases. All broods were provisioned at the central provisioning site (Fig. 1).

Abundance of other Carrion Beetle Species

We recorded the abundance of other carrion beetle species in traps during the early-summer trapping interval and can make that data available upon request.

RESULTS

Early Summer Trapping

We trapped 36 beetles between 13 June 2014 and 3 July, 2014 at 14 traps sites (Table 1). Fourteen of these individuals were female and twenty-two were male. This ratio was not significantly different from the expected 1:1 male to female ratio observed in previous years (X^2 =1.78, df = 1, $p > 0.05$). As in previous years, we caught the greatest number of beetles at site 6 (Fig. 2).

Table 1: Summary of early-summer trapping. Lost nights are nights when bait was stolen by scavengers and no beetles were captured, or nights when a trap was not set. Values represent new beetle captures and not recaptured beetles.

Trap Site	Trapping Dates	# Traps	Lost Trap Nights	Total Trap Nights	Total Females	Total Males	Total Beetles	New Beetles/Trap Night
1	14 June- 27 July	5	6	64	0	0	0	0
3	14 June- 27 July	5	0	70	1	4	5	0.07
4	14 June- 27 July	5	0	70	0	3	3	0.04
5	14 June- 27 July	5	0	70	1	0	1	0.01
6	14 June- 27 June	5	0	70	4	5	9	0.13
7	14 June- 27 June	5	1	69	1	2	3	0.04
8	14 June- 27 June	5	0	70	0	2	2	0.03
9	14 June- 27 June	5	2	68	4	3	7	0.10
10	14 June- 27 June	5	22	23	0	0	0	0
11	14 June- 27 June	5	0	70	1	0	1	0.14
12	14 June- 27 June	5	6	64	2	3	5	0.08
14	14 June- 27 June	5	0	70	0	0	0	0
		Overall	37	778	14	22	36	0.05

Total summer beetle capture in 2014 was the lowest since 2005, though the trap rate was slightly higher than in 2013 (Table 2).

Table 2: Total early-summer trap nights and ABB captures with trap rates since 2004.

Year	Total Nights	Total Wild ABBs	Number ABBs/Trap Night
2004	360	33	0.092
2005	480	38	0.079
2006	640	50	0.078
2007	1,022	97	0.095
2008	1,348	112	0.083
2009	1,791	150	0.083
2010	1,663	191	0.115
2011	1,011	212	0.210
2012	1,237	115	0.093
2013	1,386	52	0.038
2014	778	36	0.046

We accumulated beetles at a higher rate compared to 2013 and had the lowest number of trap nights since 2007 (Fig. 2).

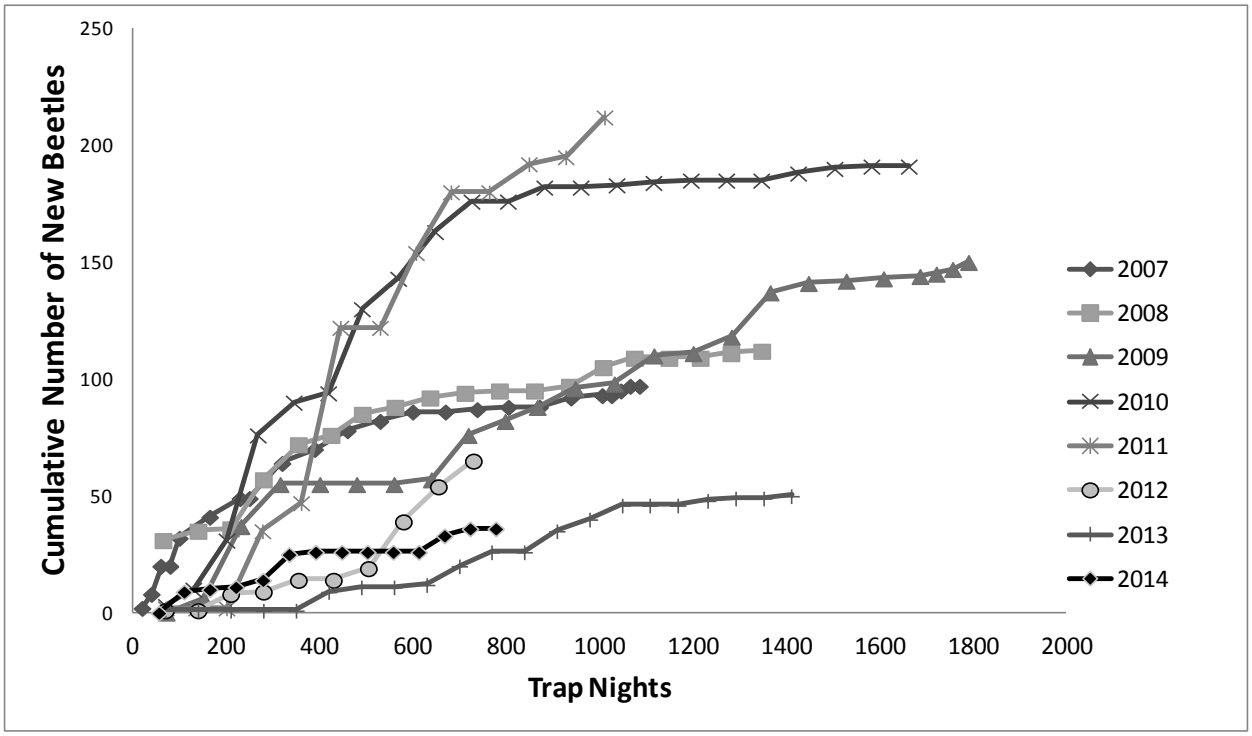

Figure 2: Accumulation curves of total ABB captures as a function of trap nights for years 2007 to 2014.

We only recaptured one beetle during the early summer trapping. This was a female that had been provisioned the night before. She moved south from the provisioning site to site 12.

Recapture of 2013 Teneral Beetles

We captured six beetles marked during the late summer trapping season of 2013 for an overwinter survival rate of 14.3% (Table 3).

Table 3: The number of beetles marked one year and recaptured the following year.

Year of recapture	# Marked Previous year	# Recaptured	% Recaptured
2007	82	12	14.6
2008	87	9	10.3
2009	112	21	18.8
2010	372	51	13.8
2011	434	63	14.5
2012	139	31	22.3
2013	77	15	19.5
2014	42	6	14.3

A majority of bee tags survived the winter well. Of the six recaptures from 2013, five (83%) were readable and only one (17%) was missing. These beetles moved an average of 2.01 ± 1.32 Km (SD) between fall and spring.

Provisioned Broods

We excavated eight broods (36%) 12 days after provisioning. Mean brood size for all ten broods exhumed in 2014 was 6 ± 10 SD larvae (range 0-27). Mean successful brood size was 12 ± 11 SD. We counted zero 3rd instar larvae, 10 2nd instar larvae, and 36 1st instar larvae in the broods we exhumed.

Fifty percent of the broods were successful and we estimate that they produced a total of 132 larvae (Table 4). We estimated total ABB larvae production by multiplying the number of un-checked broods by mean successful brood size, and then multiplying this figure by the brood success rate observed in the eight broods that we exhumed.

Table 4: Descriptive data for broods provisioned from 2009-2014. Means are reported (± SD).

Year	# Broods Provisioned	# Broods Exhumed	Brood Success Rate	Mean Successful Brood Size	Est. Larvae Produced	Counted Larvae	Est. Total Production
2009	104	37	70%	17 (±3)	750	416	1,166
2010	153	58	43%	18 (±1)	694	445	1,139
2011	25	8	63%	16 (±2)	171	82	253
2012	25	8	63%	21 (±3)	225	105	330
2013	25	10	30%	18 (±5)	79	53	132
2014	22	8	50%	12 (±11)	84	46	130

One female was recaptured the day after provisioning. Her brood was not checked for success. Of the three broods we checked that were provisioned with a single male, only one was successful and that male had attracted a new female (never captured in our traps). Two failed broods had *Nicrophorus orbicollis* adult with the carrion and one had an adult *Nicrophorus tomentosus* with 22 larvae.

Mass and Pronotal Width

Beetle size and mass were similar among sexes, adults and tenerals, and previous years (Tables 5 and 6,).

Table 5: Mean pronotal width (±SE) for males and female beetles for the 2014 early (adult) and late (teneral) summer trapping intervals.

Trapping Period	**Summer (n =36)**		**Late Summer (n = 35)**	
Sex	Male (n = 22)	Female (n = 14)	Male (n = 19)	Female (n = 16)
Average (mm)	11.7 ± 0.2	11.5 ± 0.2	10.2 ± 0.1	10.2 ± 0.1
Range (mm)	10.0-13.0	9.80-13.0	10.0-11.0	9.6-10.8
Overall Average (mm)	11.6 ± 0.1		10.2 ± 0.05	

Table 6: Mean mass (±SE) for males and female beetles for the 2013 early (adult) and late (teneral) summer trapping intervals

Trapping Period	**Summer (n =36)**		**Late Summer (n = 35)**	
Sex	Male (n = 22)	Female (n = 14)	Male (n = 19)	Female (n = 16)
Average (g)	1.7 ± 0.1	1.5 ± 0.1	1.4 ± 0.1	1.4 ± 0.1
Range (g)	1.1-2.1	1.1-2.1	0.8-2.1	0.8-1.8
Total Average (g)	1.6 ± 0.05		1.4 ± 0.05	

Late Summer Trapping

In three separate trap intervals and in 460 total trap nights, we captured 36 teneral beetles (Table 7). No beetles were captured in the first interval. This interval was timed before the scheduled emergence of teneral beetles from our provisioned broods to detect teneral beetles from broods we did not provision (i.e. wild broods). We recaptured teneral beetles 12 times representing nine beetles. One beetle was captured three times and one was captured twice.

Table 7: Trap nights, rates, and captures at sites during late summer trapping periods.

Date	Trap Nights	Trap Rate	New Males	New Females	Recaptures	Total New Beetles
11 Aug – 15 Aug	220	0	0	0	0	0
22 Aug – 29 Aug	140	0.007	0	1	0	1
2 Sept – 7 Sept	100	0.34	19	15	12	34
Overall	**460**	**0.08**	**19**	**16**	**12**	**35**

DISCUSSION

Results from 2014 further support the premise that ABB's on Nantucket are dependent on human intervention in the form of provisioning to maintain a healthy population. The lack of ABB captures during the first late summer trapping interval is especially telling. The nightly temperature was within the range for ABB's to be active and we were trapping across their known range on Nantucket, yet did not catch a single beetle. No captures strongly suggests there was no successful reproduction on natural carrion sources.

This year's results are relatively similar to previous years' except for colder nightly temperatures. The cooler temperatures may be the cause for delayed maturation in the broods. We excavated broods expecting to find 3rd instar larvae but consistently only found 1st and 2nd instars. This delay may also explain why we caught so few teneral beetles in the second trap interval, which was timed to coincide with the teneral emergence had it been on schedule. Beetle size (Fig. 3) was larger than in 2013 and more comparable with pre 2013 sizes. The over winter survival rate (Table 3) was similar to previous years as was the distance moved between 2013 and 2014 (about 2Km).

Site 6 and site 9 had the highest capture rates and this may be due to topographic and or vegetative characteristics that enhance the trap effectiveness. They are both is very open, grassy areas with little vegetation covering the traps.

Recommendations for 2015:

1. Consider using the above ground trap designs suggested in the USFWS Range Wide Survey Guidance (2012).
2. Continue trapping using the grid arrangement.
3. Consider tethering carrion in transects to determine effectiveness of just providing quail to maintain the population. Seeding the ABB range on Nantucket with vertebrate carcasses could be an efficient way of increasing the reproductive resource.

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