# Using NOREMARK to Estimate Populations of Tiger Beetles (Coleoptera: Cicindelidae) at Brookhaven National Laboratory

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## Abstract

**Tiger beetles (family Cicindelidae) are a group of insects which have been known to exist across the globe. More than 2600 species are described to date. It has been found that the family Cicindelidae is an appropriate indicator taxon for determining regional patterns of biodiversity therefore many conservation studies have utilized them as test organisms. The purpose of this study is to identify tiger beetle biodiversity at Brookhaven National Laboratory (BNL) and to estimate their populations using a mark recapture method.**

## Introduction

Tiger beetles (family Cicindelidae) are an intriguing group of insects which have been known to exist across the globe. More than 2600 species are described to date and have been found on every landmass with the exception of Antarctica, the Arctic north of 65º latitude, Tasmania and some isolated oceanic islands like Hawaii and the Maldives [1&2]. Inhabitable altitudes for tiger beetles are 3500 m above sea level to 220 m below sea level [1&2]. Favorite habitats, depending on the species, include sand dunes, ocean beaches and hardwood forest floors. Many tiger beetle species are restricted to one particular habitat [1]. As a result, they are among the most widely investigated families of insects in terms of their ecology and geographic distribution [1].

Most tiger beetles look very similar in body shape and behavior. They vary in size, color and elytra markings. Large, prominent compound eyes are set within a head that is wider than the pronotum and thorax [1&3]. On the head are antennae and large mandibles to grab and chew prey. Emerging from the thorax are segmented tarsi along with transparent flight wings which are hidden by hard protective elytra [1&3]. When approached, tiger beetles will remain motionless until they feel threatened. Once alarmed, they fly 5-10 m and tumble as they land [1&4]. Since they need to thermoregulate for activities, adults are usually diurnal [1&4].

Tiger beetles exhibit one of two types of life cycle patterns: spring-fall or summer. For spring-fall species, hibernating adults emerge in the spring, mature, mate, oviposit and die. The new brood emerges early fall, hibernate for the winter and emerge the following spring to repeat the cycle. The summer species emerge from the pupal stage in the early summer, mate, oviposit and die before the next winter. These species pass the winter in the larval, stage [1,3&5].

So, why study tiger beetles? It has been found that the family Cicindelidae is an appropriate indicator taxon for determining regional patterns of biodiversity because it has a stabilized taxonomy, individuals are easily observed and manipulated, the life history and biology is well understood, occurrences are global with a broad range of habitats while each species has a specific habitat, patterns of species richness are highly correlated with those of other vertebrate and invertebrate taxa and the taxon include species of potential economic importance [6&7]. When making policy decisions of national conservation efforts, governments focus on species richness or biodiversity [6,8]. Since tiger beetles meet the logistical and biological criteria to be used as a bioindicator taxon, many conservation studies have utilized them as test organisms [2,6,7&8].

## Purpose

To identify species richness of tiger beetles at eight sites on Brookhaven National Laboratory (BNL) property and to estimate their populations using mark recapture methods.

## Study Areas

Pitfall traps were buried at 4 sites (BB, NF, NB, TP) ( Figure1) while netting occurred at 4 sites (NF, FB, FBB, BL) (Figures 1-3)

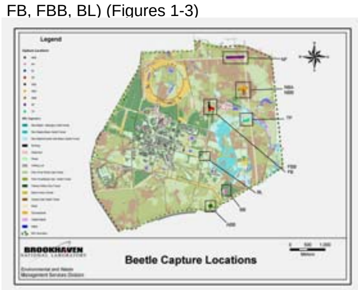


Figure 1


Figure 2


Figure 3

## Materials and Methods

Eight sites were chosen for tiger beetle capture: New Burn A and B (NBA, NBB), North Fire Break (NF), Treatment Plant (TP), Balloon Launch (BL), Burying Beetle (BB), Fire Break (FB) and Fire Break B (FBB) [4]. GPS coordinates were taken at each site and maps were created using GIS software Arc View 9.0 (Figures 1-3). Pitfall traps were fashioned by inverting the funneled top of a water bottle into the bottom (Figure 4) [1&9]. They were buried every 20 m apart at NBA, NBB, NF and TP (Figure 5). Netting occurred at NF, BL, FB and FBB (Figure 6). All captured beetles were measured (length and width), sexed, marked on the elytra with a xylene paint pen and released (Figures 7-9) [1&9]. Trap checks and netting occurred daily. New and recaptured beetles were documented. Population estimates were computed using the program NOREMARK [10].

Figure 4

Figure 5

Figure 6

Figure 7

Figure 8

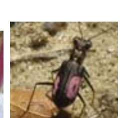

Figure 9

## Acknowledgements

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## Results

Table 1 indicates species richness at 8 sites on BNL property. Five different species were found within the genus *Cicindela*. Their total numbers captured for each site are given. Some individuals were recaptured either by netting or trapping. Table 2 shows the recaptured individuals and if immigration/ emigration took place from the marking site. Population estimates of 4 species were calculated using NOREMARK [10](Table 3). For statistical analysis purposes 4 different models were run (2 within a closed system and 2 within an open system) at a confidence interval of 95%. Estimates for each model were then be compared to each other for validity.

Table 1

**Tiger Beetle Species and Numbers Found at BNL**

| Species Name | Site Name* | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | BB | BL | FB | FBB | NBA | NBB | NF | TP |
| *C. formosa generosa* | 0 | 2 | 1 | 2 | 0 | 0 | 1 | 0 |
| *C. punctulata punctulata* | 0 | 14 | 14 | 18 | 0 | 0 | 0 | 0 |
| *C. scutellaris rugifrons* | 0 | 0 | 1 | 4 | 0 | 0 | 1 | 0 |
| *C. sexguttata* | 2 | 0 | 3 | 1 | 1 | 2 | 1 | 0 |
| *C. tranquebarica tranquebarica* | 0 | 3 | 1 | 0 | 0 | 0 | 6 | 0 |
| **Total** | 2 | 19 | 20 | 25 | 1 | 2 | 9 | 0 |

* BB = Burying Beetle BL = Balloon Launch FB = Fire Break FBB = Fire Break B NBA/B = New Burn A/B NF = North Fire TP = Treatment Plant

Table 2

**Tiger Beetle Recaptures**

| Individual ID # | Species | # Times Recaptured | Site Marked | Site Recaptured |
|---|---|---|---|---|
| 3 | *C. sexguttata* | 3 | NBA-B | NBA-B |
| 23 | *C. tranqueberica* | 1 | BL | BL |
| 25 | *C. tranqueberica* | 1 | BL | BL |
| 35 | *C. formosa* | 2 | BL | BL |
| 19 | *C. punctulata* | 1 | BL | BL |
| 6 | *C. sexguttata* | 1 | FB | FB |
| 7 | *C. sexguttata* | 2 | FB | FB |
| 9 | *C. tranqueberica* | 2 | FB | FB |
| 14 | *C. formosa* | 1 | FB | FB |
| 33 | *C. scutellaris* | 1 | FB | FB |
| 10 | *C. punctulata* | 1 | FB | FB |
| 11 | *C. punctulata* | 5 | FB | FB |
| 13 | *C. punctulata* | 1 | FB | FB |
| 51 | *C. punctulata* | 1 | FBB | FBB |
| 54 | *C. punctulata* | 1 | FBB | FBB |
| 50 | *C. formosa* | 1 | FBB | FBB |
| 41 | *C. scutellaris* | 1 | FBB | FBB |

Table 3

**Total Population Estimates Using NOREMARK**

| Site | Model Types | | | |
|---|---|---|---|---|
| | JHE Closed | | Immigration/Emigration | |
| | Pop Est. (95% CI) | MC Sim Est. (95% CI Length) | Pop. Est. (95% CI) | MC Sim Est. (95% CI Length) |
| ***Cicindela punctulata punctulata*** | | | | |
| FB | 31 | 31 ± 1.5 | 36 | 36 ± 1.2 |
| | 20 - 63 | 30.7 | 22.1-73.0 | 34.6 |
| FBB | 47 | 47 ± 4 | 70 | 70 ± 5 |
| | 21 - 249 | 67.4 | 20.4 - 382.5 | 110.6 |
| BL | 148 | 148 ± 26.5 | 178 | 178 ± 195.2 |
| | 39 - 2492 | 463.6 | 45.4 - 3022.3 | 676.8 |
| ***Cicindela scutellaris rugifrons*** | | | | |
| FB/FBB | 11 | 11 ± 0.6 | 13 | 13 ± 1 |
| | 6 - 53 | 16.5 | 6.7 - 68.8 | 31.2 |
| ***Cicindela sexguttata*** | | | | |
| FB/FBB | 10 | 10 ± 1.1 | 13 | 13 ± 113.7 |
| | 5 - 26 | 36.7 | 6.2 - 45.2 | 1162.3 |
| ***Cicindela tranquebarica tranquebarica*** | | | | |
| BL | 15 | 15 ± 1.4 | 18 | 18 ± 130.5 |
| | 7 - 80 | 35.3 | 7.1 - 98.9 | 469.3 |

JHE = Joint Hypergeometric Estimator
MC Sim Est. = Monte Carlo Simulation Estimator
Pop. Est. = Population Estimate
CI = Confidence Interval

## Discussion

There were two purposes for this study. First, tiger beetle species richness was to be identified at different habitat sites on BNL property. Second, once these individuals were captured a population study based on mark and release techniques was to be employed. The results in Table 1 indicate that indeed there is biodiversity of tiger beetles at BNL. Five species were identified: *C. formosa generos, C. punctulata punctulata, C. scutellaris rugifrons, C. sexguttata and C. tranquebarica tranquebarica* and at least one of those species occurred at 7 sites. The most favorable habitats were BL, FB and FBB because they are open and have sandy substrate. One can see that out of the 78 individuals captured and released, 46 (58.9%) were *C. punctulata punctulata*. This species is a summer species while the other 4 are spring/fall species. Although we saw the other species, they were not prevalent.

Populations of tiger beetles were calculated using the program NOREMARK. The program could not estimate populations based on extremely small captures or no recaptures, therefore our estimations were limited to four species at their most prevalent sites (Table 3). One can see that *C. punctulata punctulata* has the largest population estimates at all 3 sites (BL=148, FB=31 and FBB=47) in a closed population and 178, 36, 70 respectively in an open population. Twelve out of the 78 marked individuals (15.3%) (Table 2) were recaptured at least once at their original location which leads us to believe tiger beetles tend not to immigrate or emigrate. BL numbers are larger because there were less recaptures whereas the most recaptures occurred at FB.

*C. sexguttata, C. tranquebarica tranquebarica and C. scutellaris rugifrons* populations were estimated in the teens (in both open and closed models) which validate their spring/fall life cycle. Although all models were set at a 95% confidence interval, one would need to visit each site at least 50 hours to reliably determine species numbers [6] and visit the sites during peak season of each species life cycle.

## Conclusion

BNL has a diverse population of spring/fall and summer species of tiger beetles which may be used in conservation studies. These species are able to be captured, identified, marked, released and recaptured by way of pitfall traps or netting. Populations may be estimated from this mark and recapture technique.

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