

9-12-2013

Status of the tiger beetle *Cicindela hirticollis* Say (Coleoptera: Cicindelidae) in New York City and on Long Island, New York, USA

Jonathan R. Mawdsley

The H. John Heinz III Center for Science, Economics and the Environment, mawdsley@heinzctr.org

Matthew D. Schlesinger

New York Natural Heritage Program, Albany, NY, schlesinger@nynhp.org

Tim Simmons

Natural Heritage & Endangered Species Program, West Boylston MA, tim.simmons@state.ma.us

Orland J. Blanchard

Florida State Collection of Arthropods, oblancha@liu.edu

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Mawdsley, Jonathan R.; Schlesinger, Matthew D.; Simmons, Tim; and Blanchard, Orland J., "Status of the tiger beetle *Cicindela hirticollis* Say (Coleoptera: Cicindelidae) in New York City and on Long Island, New York, USA" (2013). *Insecta Mundi*. 822.
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INSECTA MUNDI

A Journal of World Insect Systematics

0317

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Jonathan R. Mawdsley

The H. John Heinz III Center for Science, Economics and the Environment
900 17th St. NW, Suite 700
Washington, DC 20006 USA

Matthew D. Schlesinger

New York Natural Heritage Program
625 Broadway, 5th Floor
Albany, NY 12233-4757 USA

Tim Simmons

Division of Fisheries & Wildlife
Natural Heritage & Endangered Species Program
100 Hartwell Street, Suite 230
West Boylston MA 01583 USA

Orland J. Blanchard

Florida State Collection of Arthropods
Division of Plant Industry
Florida Department of Agriculture and Consumer Services
PO Box 147100
Gainesville, FL 32614-7100 USA

Date of Issue: September 12, 2013

Jonathan R. Mawdsley, Matthew D. Schlesinger, Tim Simmons, and Orland J. Blanchard

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Insecta Mundi 0317: 1-7

ZooBank Registered: urn:lsid:zoobank.org:pub:72AF589B-AD35-4C1B-AEEA-802DD090B8DF

Published in 2013 by

Center for Systematic Entomology, Inc.
P. O. Box 141874
Gainesville, FL 32614-1874 USA
<http://www.centerforsystematicentomology.org/>

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Status of the tiger beetle *Cicindela hirticollis* Say (Coleoptera: Cicindelidae) in New York City and on Long Island, New York, USA

Jonathan R. Mawdsley

The H. John Heinz III Center for Science, Economics and the Environment
900 17th St. NW, Suite 700
Washington, DC 20006 USA
mawdsley@heinzcenter.org

Matthew D. Schlesinger

New York Natural Heritage Program
625 Broadway, 5th Floor
Albany, NY 12233-4757 USA
schlesinger@nynhp.org

Tim Simmons

Division of Fisheries & Wildlife
Natural Heritage & Endangered Species Program
100 Hartwell Street, Suite 230
West Boylston MA 01583 USA
tim.simmons@state.ma.us

Orland J. Blanchard

Florida State Collection of Arthropods
Division of Plant Industry
Florida Department of Agriculture and Consumer Services
PO Box 147100
Gainesville, FL 32614-7100 USA
oblancha@liu.edu

Abstract. Coastal species are under considerable threat from recreational activities and climate change. The tiger beetle *Cicindela hirticollis* Say (Coleoptera: Cicindelidae) was recorded historically from 30 locations along the shores of New York City and Long Island, New York. We conducted surveys for extant populations of this species at 40 sites from 1989 to 2010. Adults of *C. hirticollis* were found at 13 beaches. Only four sites had 40 or more adults of *C. hirticollis* active at the time the beach was surveyed. No beetles were detected on the large coastal beaches that were formerly occupied by this species. Many coastal beaches of New York receive heavy human foot and vehicle traffic and are therefore unlikely to provide suitable habitat for *C. hirticollis* without a shift in beach management that recognizes the potential of some beaches as wilderness systems capable of supporting the full array of beach-dependent species.

Introduction

Tiger beetles (Coleoptera: Cicindelidae) have long been one of the most popular groups of insects with both amateur collectors and professional entomologists (Knisley and Schultz 1997; Pearson and Vogler 2001; Pearson et al. 2006). Because of this popularity, the taxonomy of the family is reasonably well resolved and many aspects of the biology, life history, and habitat requirements of individual tiger beetle species have been investigated (Knisley and Schultz 1997). In the northeastern United States, tiger beetles have been collected with some regularity since the early 19th century (Harris 1828, 1852; Gould 1834; LeConte 1860). In the 20th century, there have been many collectors and scientists who focused specifically on the northeastern tiger beetle fauna (Harris 1911; Boyd 1973, 1978; Dunn 1981, 1986; Leonard and Bell 1999).

In the 1970s, tiger beetle enthusiasts in the United States began noticing that a number of cicindelid species were disappearing from sites where these beetles had once been common (Wilson 1970; Stamatov

1972; Boyd 1978; Nagano 1980; Satoh et al. 2004; Arndt et al. 2005). These observations came at an opportune time, coinciding with a more general awareness of endangered species conservation and the passage of the U. S. Endangered Species Act in 1973. The suite of tiger beetle species associated with coastal beaches was quickly recognized as a guild that was being disproportionately affected by human activities, a phenomenon occurring on ocean beaches around the world (Wilson 1970; Stamatov 1972; Nagano 1980). Larvae of these beetles live in narrow burrows that they dig in beach sand (Knisley and Schultz 1997). The larvae can be killed when heavy foot traffic or vehicular traffic on the beach compresses the sand and crushes the burrows (Hill and Knisley 1993). Beach tiger beetle larvae are also potentially sensitive to chemical and oil spills (Nagano 1980).

In the northeastern United States, population declines have been studied most extensively in *Cicindela dorsalis dorsalis* Say, a subspecies that formerly occurred in “great swarms” on coastal sea beaches from New Jersey to southern Massachusetts, with disjunct populations along the shores of the Chesapeake Bay (Boyd 1975, 1978). Declines in populations of this species at beaches with heavy human use were noted early on: W. T. Davis was quoted in Leonard (1928: 207) saying that *C. d. dorsalis* was “formerly found also on S.[taten] I.[sland], but probably exterminated about 1895 by commercial use of beaches.” By 1972 it was clear that precipitous declines had occurred in many of the Atlantic coast beach populations of this species (Stamatov 1972). Surveys conducted in the late 1980s and early 1990s found just two small surviving populations of this tiger beetle along the Atlantic coast, with a larger number of extant populations along the shores of Chesapeake Bay (Knisley et al. 1987; Hill and Knisley 1993). Knisley et al. (1987) attributed this decline to extensive human recreational use of the beaches and associated trampling of the larval beetles. On the basis of this evidence, *C. d. dorsalis* Say was formally listed under the U. S. Endangered Species Act as a Threatened species in 1990. This listing has led to the implementation of a variety of conservation measures for this tiger beetle, including habitat protection activities and translocation of adults and larvae (Knisley and Schultz 1997; Knisley et al. 2005).

The conservation status of other cicindelid species associated with coastal beaches in the northeastern United States has been less thoroughly investigated, but significant concerns exist (Leonard and Bell 1999). One species that is of potential conservation concern throughout the region is *C. hirticollis* Say, a species that formerly co-occurred with *C. d. dorsalis* on coastal sea beaches in the northeastern United States (Boyd 1978; Leonard and Bell 1999). Originally described from specimens collected in Pennsylvania, *C. hirticollis* has since been recorded from much of the United States and southernmost Canada (Freitag 1999). *Cicindela hirticollis* is divided into 10 subspecies, of which two (the nominate *C. h. hirticollis* Say and *C. h. rhodensis* Calder) have been recorded from coastal beaches in the northeastern United States (Graves et al. 1988). Both of these subspecies, as well as intermediate or intergrade forms, have been reported from sites on Long Island (Leonard 1928; Graves et al. 1988; Pearson et al. 2006).

Like *C. d. dorsalis*, *C. hirticollis* appears to be sensitive to anthropogenic disturbances, particularly human use of the beaches or riverine sandbars where the larval beetles have their burrows. Recent declines or extirpations of this tiger beetle have been reported from Arizona (Pearson et al. 2006), California (Nagano 1980; Knisley and Fenster 2005), New Hampshire (Leonard and Bell 1999), New Jersey (Boyd 1978), Ohio (Graves and Brzoska 1991), western Vermont (Kart et al. 2005), Virginia (Acciavatti et al. 1992), and most recently New York (Schlesinger and Novak 2011).

Given the almost complete extirpation of *C. d. dorsalis* from coastal beaches in the northeastern United States (Knisley et al. 1987; Hill and Knisley 1993), a conservation assessment of sympatric populations of *C. hirticollis* seems long overdue. In this paper, we expand upon the information provided in Schlesinger and Novak (2011) by documenting our recent surveys of historical sites for this species in New York City, on Long Island, and on nearby smaller islands (e.g., Shelter Island, Plum Island) and with a fuller treatment of site conditions and causes of population changes. By compiling and publishing our findings, we hope to bring this species to the attention of the conservation agencies and public decision-makers whose policies will ultimately decide the future of these populations.

Methods

We developed a list of the historical collecting localities for *C. hirticollis* in New York State by consulting the annotated checklist of Leonard (1928), an unpublished Master’s thesis on New York Cicindelidae (Gordon 1939), and historical specimens from major regional collections, including the American Mu-

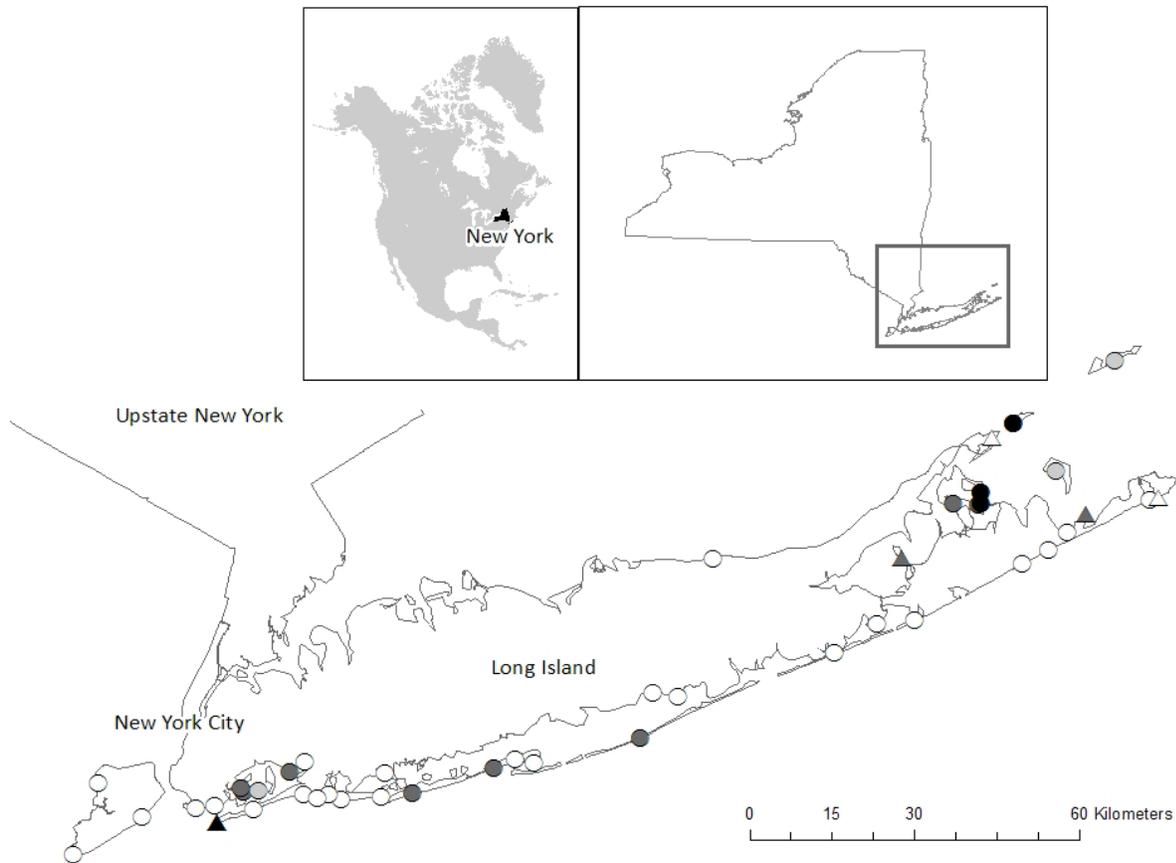


Figure 1. Historical (circles) and *de novo* (triangles) survey sites for the tiger beetle *Cicindela hirticollis* Say in New York City and on Long Island, New York. Open symbols indicate no detection, light gray circles indicate sites not surveyed, and dark gray symbols indicate that at least one adult was detected. Symbols in black indicate large populations (> 40 individuals detected).

seum of Natural History, the Cornell University Insect Collection, the Museum of Comparative Zoology (Harvard University), the National Museum of Natural History (Smithsonian Institution), and the New York State Museum. We identified 30 historical sites from these sources (Fig. 1). This number should be considered approximate because of the vagueness of some historical locality descriptions (e.g., those at the level of town, county, or even state).

We used GIS and Google Maps (<http://maps.google.com>) to examine the present-day setting of historical locations, following methods developed by Mawdsley (2008). Extant beach areas near to the historical localities for *C. hirticollis* were identified as potential survey locations. Several sites had no nearby extant beaches and were considered no longer occupied by beach tiger beetles. In addition, we surveyed five “*de novo*” sites without prior records of *C. hirticollis* based on the apparent presence of suitable habitat. We ended up with 43 survey sites, of which we were able to visit 40 (Fig. 1). These sites were visited by one or more of the authors from June to September, 1989 to 2010 (although the majority of surveys occurred from 2007 to 2010), within the historical window of seasonal activity for New York populations of *C. hirticollis* (Leonard 1928). Each survey site was visited at optimal or near-optimal conditions for adult tiger beetle activity (for beach tiger beetles, sunny with temperature above 70° F, as described by Knisley and Schultz 1997). When possible, a 1-mile (1.6-km) stretch of beach was selected for detailed survey work. Because human disturbance is known to be disruptive to beach tiger beetles, we

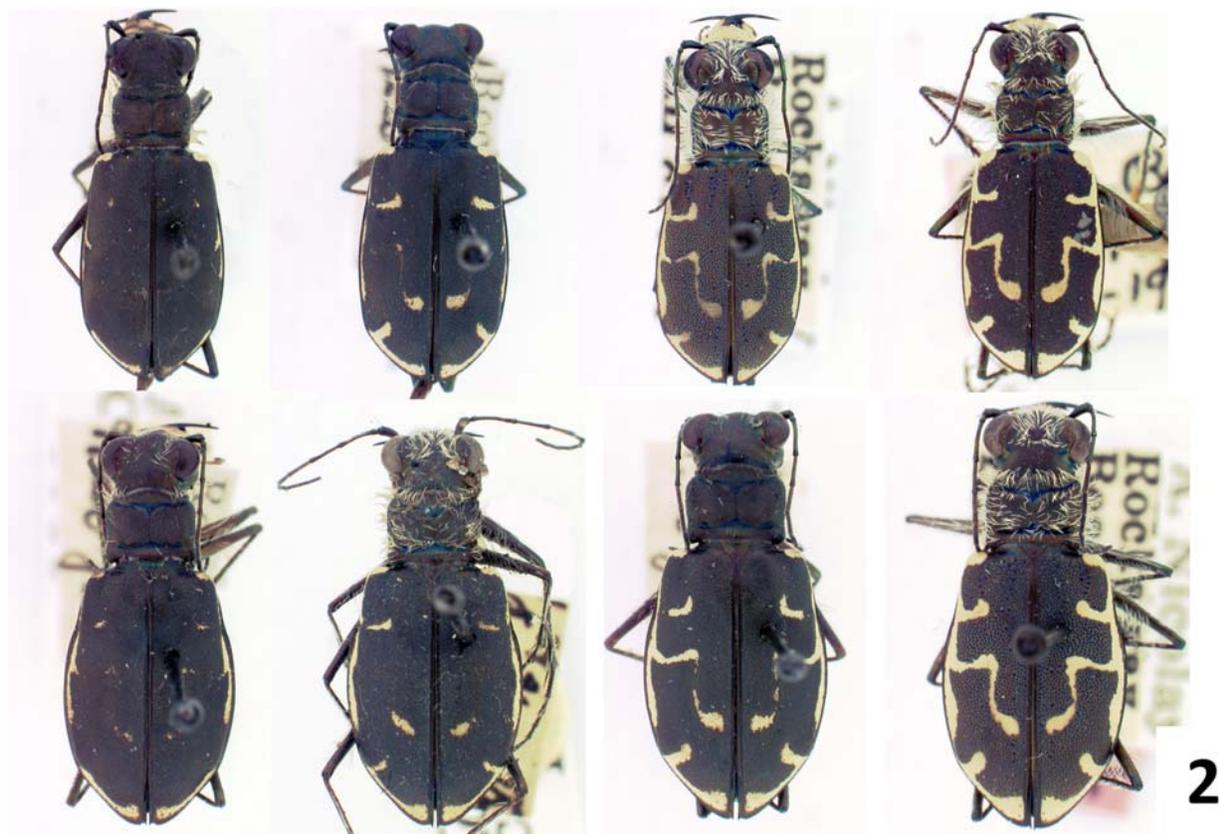


Figure 2. Adult specimens of *Cicindela hirticollis* Say collected at Rockaway Beach on Long Island between 1909 and 1932, showing variability in elytral color pattern ranging from the form described as *C. h. hirticollis* Say (right) to the form described as *C. h. rhodensis* Calder (left). Specimens in top row are males; specimens in bottom row are females.

deliberately chose to survey stretches of the larger beaches that showed the fewest signs of human disturbance.

In conducting these surveys, we followed a simple survey protocol published by Knisley and Schultz (1997) for tiger beetles associated with linear features such as beaches, trails, or sand roads. Surveyors simply walked slowly along a given stretch of beach and counted the number of active beetles that were seen. Because not all beetles present are detected, the number of beetles counted is actually an index of abundance rather than a direct measure of population size. Knisley and Schultz (1997) report that this survey method will underestimate actual abundance by 50%-80%. Sources of error include failure to detect beetles that are present but are not noticed by the surveyor, double-counting of beetles that are disturbed by the surveyor and fly into an area that has not yet been surveyed, beetles that are burrowed below the surface, and the fact that individuals emerge over a period of several days and may not be available on the day the survey is conducted (Knisley and Schultz 1997). In our surveys we tried to walk twice along each beach, especially in situations where no tiger beetles were detected during the first pass.

Voucher specimens of tiger beetles were collected at sites when permitted by law and by local property owners. Vouchers have been deposited in the collections of the New York State Museum and the National Museum of Natural History, Smithsonian Institution.

Results

We detected adults of *C. hirticollis* at 13 of the 40 beach sites surveyed, including 10 of 35 historical sites and 3 of 5 *de novo* sites (Fig. 1). At least three of these sites are marginal and may not support active populations of *C. hirticollis*. Only four sites were large and appeared to support robust populations

of this species, with 40 or more individuals detected (Fig. 1); however, these sites were all surveyed from mid-August through early September and sites surveyed earlier in summer may have been visited during periods of low abundance. Most sites with beetles were within protective or restrictive state or federal ownership.

Most of the 27 sites where *C. hirticollis* was not detected were large coastal beaches open to the general public for recreational activities. Human modifications (sand supplementation, beach grooming, extensive foot traffic, and/or vehicle tire tracks) were observed at all of these beaches. The only tiger beetles observed at these sites were *C. repanda* Dejean, a tiger beetle with remarkably broad habitat tolerances (Boyd 1978), and in one case *C. limbalis* Klug on the clay bank adjacent to one beach site.

From a taxonomic perspective, the populations of *C. hirticollis* on Long Island are of considerable interest, as they include individuals with markings characteristic of the nominate subspecies *C. h. hirticollis* as well as individuals with markings characteristic of the northeastern subspecies *C. h. rhodensis* (Leonard 1928; Pearson et al. 2006; Fig. 2). We found individuals with both types of markings, as well as individuals with intermediate or intergrade markings, at the two sites on Shelter Island as well as the large site at Plum Island. The individuals that we found at Gateway National Recreation Area had markings characteristic of *C. h. hirticollis*, although individuals with markings characteristic of *C. h. rhodensis* are also known historically from this area.

Discussion

Populations of *C. hirticollis* in New York have unquestionably declined, as measured in terms of the number of occupied sites, relative to the historical levels documented by Leonard (1928) and Gordon (1939). The pattern of decline appears to parallel that of *C. d. dorsalis*, with the loss of populations associated with large coastal beaches that are being used for human recreational activities.

Although *C. hirticollis* can still be found at a number of sites on and around Long Island, the species' future in the southern portion of New York State is still very much an open question. Only a few of the sites occupied by this species appear to support large populations, and the site with the largest number of beetles (Plum Island) has been recently proposed for public sale and private re-development. The beach at Plum Island currently receives very little human traffic of any kind, and any form of re-development that would increase human foot traffic could potentially affect populations of *C. hirticollis*.

Given the intensity of human use observed at the large coastal beaches, and the substantial modifications observed at smaller beaches, it is unlikely that populations of *C. hirticollis* will re-establish at these sites, even though there may be small remnant populations in the vicinity of these sites that could potentially serve as source populations for natural recolonization. Translocation and reintroduction of beach tiger beetles has been attempted in the case of *C. d. dorsalis* (Knisley et al. 2005) with mixed results; similar methods could be attempted for *C. hirticollis*. One population of *C. d. dorsalis* that was established by translocating 65 individuals over a three-year period now numbers over 1000 individuals (T. Simmons and N. Kapitulik, unpublished data).

Given that *C. hirticollis* appears to persist at a small number of sites in New York City and on Long Island, it is possible that the remnant populations may be vulnerable to rare storm events which have the potential to significantly alter beach structure and composition at particular sites. There is at least one historical parallel worth considering: the beach tiger beetle *C. chlorocephala smythi* Harris was apparently extirpated from the beaches of southern Texas by a series of intense hurricanes in the early 20th century (Pearson et al. 2006). Further, intense hurricanes are expected to increase in frequency this century due to anthropogenic warming (Bender et al. 2010).

Based on our recent experiences with *C. hirticollis*, we suggest that conservation measures be implemented for the Long Island populations of this species. At a minimum, such measures should include the continued monitoring of beetles at sites where adults were detected during this study. In addition to counting the number of active beetles, future surveys should attempt to identify and locate larval burrows, in order to develop a more robust estimate of population size at each of the occupied sites and identify the areas most important to larval survival. New surveys at sites away from the large recreational beaches are also needed, particularly in Gateway National Recreation Area where there are a number of smaller beaches that have limited or no public access. Other promising sites include the series of small "back bay" beaches which are generally located on the landward side of the barrier islands along

the southern shore of Long Island. Many of these beaches receive less human activity than the much larger Atlantic coastal beaches. There are also several islands toward the eastern end of Long Island that are currently in private ownership and have beaches that may support populations of *C. hirticollis*.

Changes in management of recreation and other vehicle traffic at sites that are structurally suitable for *C. hirticollis* could have the greatest impact on this species' ability to colonize or recolonize additional sites, as pervasive vehicle traffic on beaches is likely prohibiting their occurrence on some otherwise suitable beaches. Driving on beaches is permitted in many of New York's state parks, for example. A shift in management that recognizes some beaches as wilderness, and an attempt to eliminate or at least reroute vehicles on some stretches of beach, would go a long way toward ensuring the persistence of this species, as has been recommended for other beach invertebrates (e.g., Schlacher and Thompson 2012).

Given the clear declines in the number of sites occupied by *C. hirticollis* in New York City and on Long Island, the species is also potentially a candidate for listing under New York's endangered species law. Formal protection of any species should not be considered lightly, but in the case of *C. hirticollis* there are several arguments that could be advanced in support of such a listing. A formal listing would help to ensure that *C. hirticollis* and its habitat requirements are considered in a variety of public decision-making activities, including beach management, beachfront development, and the disposition of Plum Island. A formal listing could also help to identify resources for continued surveys and monitoring of the extant populations of this species. And listing could also serve as an impetus for the development of a robust conservation strategy for the remaining populations of *C. hirticollis*, as has already happened with *C. d. dorsalis* (Hill and Knisley 1993).

Acknowledgments

Funding for this project was provided through New York State Department of Environmental Conservation New York State Wildlife Grant T-2, Project 1, Job 27 in cooperation with the U.S. Fish and Wildlife Service Division of Wildlife and Sport Fish Restoration, facilitated by P. Novak. We thank D. Pearson and B. Knisley for their helpful reviews of the manuscript and M. SurrIDGE for other assistance. For assistance with the 2009 field work, we would especially like to thank T. Green of Brookhaven National Laboratory.

Literature Cited

- Acciavatti, R. T., T. T. Allen, and C. Stuart. 1992.** The West Virginia tiger beetles (Coleoptera: Cicindelidae). *Cicindela* 24: 45-78.
- Arndt, E., N. Aydın, and G. Aydın, 2005.** Tourism impairs tiger beetle (Cicindelidae) populations—a case study in a Mediterranean beach habitat. *Journal of Insect Conservation* 9: 201-206.
- Bender, M. A., T. R. Knutson, R. E. Tuleya, J. J. Sirutis, G. A. Vecchi, S. T. Garner, and I. M. Held. 2010.** Modeled impact of anthropogenic warming on the frequency of intense Atlantic hurricanes. *Science* 327: 454-458.
- Boyd, H. P. 1973.** Collecting tiger beetles in the Pine Barrens of New Jersey. *Cicindela* 5: 1-12.
- Boyd, H. P. 1975.** The overlapping ranges of *Cicindela dorsalis* and *C. d. media* with notes on the Calvert Cliffs area, Maryland. *Cicindela* 7: 55-59.
- Boyd, H. P. 1978.** The tiger beetles (Coleoptera: Cicindelidae) of New Jersey with special reference to their ecological relationships. *Transactions of the American Entomological Society* 104:191-242.
- Dunn, G. A. 1981.** Tiger beetles of New Hampshire. *Cicindela* 13: 1-28.
- Dunn, G. 1986.** Tiger beetles of New England (Coleoptera: Cicindelidae). *Entomological Society Quarterly* 3:27-41.
- Freitag, R. 1999.** Catalogue of the tiger beetles of Canada and the United States. National Research Council Canada; Ottawa, Ontario. 195 p.
- Gordon, W. M. 1939.** The Cicindelidae of New York with reference to their ecology. Cornell University; Ithaca, NY. 136 p.
- Gould, A. A. 1834.** On the Cicindelae of Massachusetts. *Boston Journal of Natural History* 1: 41-54.
- Graves, R. C., and D. W. Brzoska. 1991.** The tiger beetles of Ohio (Coleoptera: Cicindelidae). *Ohio Biological Survey Bulletin, New Series*, 8(4): 1-42.

- Graves, R. C., M. E. Krejci, and A. C. F. Graves. 1988.** Geographic variation in the North American tiger beetle, *Cicindela hirticollis* Say, with a description of five new subspecies (Coleoptera: Cicindelidae). *The Canadian Entomologist* 120: 647-678.
- Harris, T. W. 1828.** Contributions of entomology: Cicindelidae. *New England Farmer* 7: 90-91.
- Harris, T. W. 1852.** The *Cicindela* or tiger beetles. *The Family Visitor* 2: 305.
- Harris, E. D. 1911.** List of North American Cicindelidae in the Harris Collection. Truan Press; Yonkers, NY. 68 p.
- Hill, J. M., and C. B. Knisley. 1993.** Northeastern beach tiger beetle (*Cicindela dorsalis dorsalis* Say) recovery plan. U.S. Fish and Wildlife Service; Hadley, MA. 45 p.
- Kart, J., R. Regan, S. Darling, C. Alexander, K. Cox, M. Ferguson, S. Parren, K. Royar, and B. Popp. 2005.** Vermont's wildlife action plan. Vermont Fish and Wildlife Department, Waterbury, VT. www.vtfishandwildlife.com.
- Knisley, C. B., J. I. Luebke, and D. R. Beatty. 1987.** Natural history and population decline of the coastal tiger beetle, *Cicindela dorsalis dorsalis* Say (Coleoptera: Cicindelidae). *Virginia Journal of Science* 38: 293-303.
- Knisley, C. B., and T. D. Schultz. 1997.** The biology of tiger beetles and a guide to the species of the South Atlantic states. Virginia Museum of Natural History; Martinsville, VA. 210 p.
- Knisley, C. B., and M. S. Fenster. 2005.** Apparent extinction of the tiger beetle, *Cicindela hirticollis abrupta* (Coleoptera: Carabidae: Cicindelinae). *The Coleopterists Bulletin* 59: 451-458.
- Knisley, C. B., J. M. Hill, and A. M. Scherer. 2005.** Translocation of threatened tiger beetle *Cicindela dorsalis dorsalis* (Coleoptera: Cicindelidae) to Sandy Hook, New Jersey. *Annals of the Entomological Society of America* 98: 552-557.
- LeConte, J. L. 1860.** Revision of the Cicindelae of the United States. *Transactions of the American Philosophical Society* 11: 27-63.
- Leonard, J. G., and R. T. Bell. 1999.** Northeastern tiger beetles: a field guide to the tiger beetles of New England and Eastern Canada. CRC Press; Boca Raton, FL. 179 p.
- Leonard, M. D. 1928.** A list of the insects of New York. Cornell University; Ithaca, NY. 1121 p.
- Mawdsley, J. R. 2008.** Use of simple remote sensing tools to expedite surveys for rare tiger beetles (Insecta: Coleoptera: Cicindelidae). *Journal of Insect Conservation* 12: 689-693.
- Nagano, C. D. 1980.** Population status of the tiger beetles of the genus *Cicindela* (Coleoptera: Cicindelidae) inhabiting the marine shoreline of southern California. *Atala* 8: 33-42.
- Pearson, D. L., and A. P. Vogler. 2001.** Tiger beetles: the evolution, ecology and diversity of the cicindelids. Cornell University Press; Ithaca, NY. 341 p.
- Pearson, D. L., C. B. Knisley, and C. J. Kazilek. 2006.** A field guide to the tiger beetles of the United States and Canada. Oxford University Press; New York, NY. 264 p.
- Satoh, A., T. Sota, T. Ueda, Y. Enokido, J. C. Paik, and M. Hori. 2004.** Evolutionary history of coastal tiger beetles in Japan based on a comparative phylogeography of four species. *Molecular Ecology* 13: 3057-3069.
- Schlacher, T. A., and L. Thompson. 2012.** Beach recreation impacts benthic invertebrates on ocean-exposed sandy shores. *Biological Conservation* 147: 123-132.
- Schlesinger, M. D., and P. G. Novak. 2011.** Status and conservation of an imperiled tiger beetle fauna in New York State, USA. *Journal of Insect Conservation* 15: 839-852.
- Stamatov, J. 1972.** *Cicindela dorsalis* Say endangered on northern Atlantic Coast. *Cicindela* 4: 78.
- Wilson, D. A. 1970.** Three subspecies of cicindelids threatened with extermination. *Cicindela* 2: 18-20.

Received July 12, 2013; Accepted August 4, 2013.

