



**Phylogeny and Habitat Affinities of
Tiger Beetles (Genus *Cicindela*) of
Sri Lanka**

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Abstract

Diversity of insects in Sri Lanka is very poorly documented and continues to remain so due to the very small numbers of entomologists specializing in taxonomy and ecology in the country. This situation is highlighted by the fact that not a single species of Coleoptera, which is the largest group of invertebrates is included in the official document that sets out priorities for biodiversity conservation in Sri Lanka. Limitations which are inherent to morphology-based identification systems make it even more difficult to carry out systematic biodiversity surveys of insects.

This status therefore signals the need for a new approach for taxon recognition using newer approaches that have been applied elsewhere in the world. This study was carried out to investigate the phylogeny and ecology of a group of Coleopterans using both conventional methods of field surveys with morphological taxonomy and genomic approaches based on the diversity of mtDNA sequences. A taxonomic revision of *Cicindela sensu lato* (Coleoptera, Cicindelidae) of Sri Lanka was carried out using both the aforesaid approaches simultaneously with a study of its ecological distribution. Mitochondrial DNA sequence analyses of the taxon was used to address the phylogeny of *Cicindela sensu lato* of Sri Lanka with reference to its habitats and habitat affinities that were elucidated from the ecological studies.

The existing literature on the Family Cicindelidae of Sri Lanka which documents 7-30 species of *Cicindela* from the island, was compiled and maps of the locations of occurrence for every species recorded during this study were created in order to provide background knowledge for field studies. Based on this information ninety-four locations of the wet zone, dry zone and intermediate zone of Sri Lanka were surveyed and recorded for the presence or absence of *Cicindela*. Twenty variables of climate and soil of each location were recorded using standard methods in the published literature on tiger beetles of the world.

Habitat types, habitat affinities and habitat variables that predict the occurrence of *Cicindela* were examined. Ninety-six specimens were examined for mtDNA sequence divergence in a 1865bp region of three mitochondrial genes, CO1, Cytb and 16SrRNA, that were combined. Using this information, species identification by morphological taxonomy was confirmed and phylogenetic relationships between the *Cicindela* of Sri Lanka and that of India and other countries were considered. The origin of *Cicindela sensu lato* of Sri Lanka, with estimated time frame of origin was addressed in association with the possible routes of dispersal.

The major findings of the study were as follows: a) *Cicindela sensu lato* of Sri Lanka occupies four main habitat types – coastal, tank, riparian and urban – that are distinguishable by their climatic and soil characteristics. b) They were found to occur in thirty-eight locations in which a majority of species are found in riparian habitats. c) Most of the cicindelid species of Sri Lanka displays habitat specificity or are restricted to a majority of locations that represent a particular habitat type. d) Presence or absence of

Cicindela in a particular location is largely determined by the environmental temperature, soil hue and soil pH of the habitat. e) At present eleven species of *Cicindela* [*Cicindela* (*Oligoma*) *paradoxa*, *Cicindela* (*Oligoma*) *lacunosa*, *Cicindela* (*Hypaetha*) *biramosa*, *Cicindela* (*Hypaetha*) *quadrilineata*, *Cicindela* (*Monelica*) *fastidiosa*, *Cicindela* (*Lophyridia*) *angulata*, *Cicindela* (*Lophyridia*) *cardoni*, *Cicindela* (*Ifasina*) *labioaenea*, *Cicindela* (*Ifasina*) *waterhousei*, *Cicindela* (*Ifasina*) *willeyi*, *Cicindela* (*Lophyra*) *catena*] representing six subgenera are found in Sri Lanka. f) Two endemic species, *Cicindela* (*Ifasina*) *waterhousei* and *Cicindela* (*Ifasina*) *willeyi* are found restricted to localized areas of the lowland wet zone of Sri Lanka. g) The *Cicindela* of Sri Lanka may have originated 8.64 to 3.68 mya during the late Miocene or early Pliocene of the Tertiary period. h) All the cicindelid species of Sri Lanka that were recorded during the study shows a strong phylogenetic affinity to tiger beetle species of India suggesting that the mainland may have acted as a secondary center of origin for *Cicindela* of Sri Lanka. i) However, estimates of pairwise divergences for certain species indicates the possibility of some taxa being separate phylogenetic species. j) The monophyly of *Cicindela sensu lato* of Sri Lanka is strongly supported.

In conclusion, the study through the revision, elucidated the taxonomic status of the genus *Cicindela sensu lato* according to morphological taxonomy and molecular phylogenetic analyses with reference to the ecology of species. DNA barcodes were obtained for every species encountered during the study providing a foundation for future investigations of this genus. The study is the first molecular phylogenetic analyses of an insect group of Sri Lanka involving high resolution data of three mitochondrial genes coupled with field surveys that established exact localities of occurrence and specific habitat variables.