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Distribution and habitat preferences of tiger beetles (Coleoptera: Cicindelidae) of the riverine ecosystems of Sri Lanka

Chandima D. Dangalle [1], Nirmalie Pallewatta [2] & Alfried P. Vogler [3]

[1,2] Department of Zoology, Faculty of Science, University of Colombo, Cumaratunga Munidasa Mawatha, Colombo 03, P.O. Box 00300, Sri Lanka
[3] Department of Entomology, The Natural History Museum, Cromwell Road, London, SW7 5BD, United Kingdom
[1] cddangalle@gmail.com (corresponding author), [2] nirmalip@yahoo.com, [3] a.vogler@nhm.ac.uk

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Abstract: Tiger beetles have been observed in many riverine ecosystems of Sri Lanka. However, current locations, species, distribution of species, habitat preferences and possible interactions between species are unknown. The present study intends to investigate these details and provide information that can be used in further studies. Tiger beetles are sampled from 15 riverine locations and examined for identification, body weight and body length. The riverine locations are analysed for locational, climatic and soil parameters and microhabitat details are recorded. Statistical analysis using One-Way Analysis of Variance and Tukey's pair comparison method of Minitab 16.0 statistical software package is conducted to compare the body sizes of species. Further, a statistical comparison between the climatic and soil parameters of the locations of *Cylindera* (*Ifasina*) *labioaenea* and that of other species are carried out. The study reveals five tiger beetle species *Cylindera* (*Ifasina*) *labioaenea* Horn, *Cylindera* (*Ifasina*) *willeyi* Horn, *Cylindera* (*Ifasina*) *waterhousei* Horn, *Calomera cardoni* Fleutiaux, *Calomera angulata* Fabricius, from the riverine ecosystems of Sri Lanka. *Cylindera labioaenea* is the most common species; *C. willeyi* and *C. waterhousei* are endemic to Sri Lanka. *Cylindera labioaenea*, *C. willeyi* and *C. waterhousei* are small, while *Calomera cardoni* and *Calomera angulata* are medium in size. *Cylindera labioaenea* is significantly smaller than *C. willeyi* and *C. waterhousei*, and resides in locations with significantly higher air temperatures, solar radiations and significantly lower relative humidity than the other two species. An optimal temperature range for the riverine tiger beetles is suggested and their preferences to soil moisture, soil temperature, soil colour and soil salinity are discussed. The occurrence of *C. labioaenea* as a single species population while the fact that other species co-exist may be due to a defensive strategy.

Keywords: Body size, Cicindelidae, climatic and soil preferences, riverine ecosystems, tiger beetles.

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Author Details: Dr. Chandima Dangalle is a senior lecturer in Zoology. Her expertise lies in the fields of entomology and molecular biology. Her research focuses on collecting baseline data on the distribution and habitat preferences of tiger beetles in Sri Lanka and in evolution and phylogeny of the species. Dr. Dangalle conducted her PhD in the Department of Zoology, University of Colombo, Sri Lanka and Department of Entomology, Natural History Museum, London, United Kingdom. Dr. Nirmalie Pallewatta is a senior lecturer and the current head of the Department of Zoology, University of Colombo, Sri Lanka. A zoologist by training, Pallewatta received her PhD in 1986 from the Imperial College of Science, Technology and Medicine at the University of London, United Kingdom. Prof. Alfried Vogler works on the molecular systematics of Coleoptera. He has a joint position at the Natural History Museum and at Imperial College, London, United Kingdom. Together with PhD students and postdocs, he is currently working on the insect fauna of Madagascar, to establish the causes of endemicity and diversity, based on large-scale DNA sequencing of entire communities.

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INTRODUCTION

Tiger beetles (Coleoptera: Cicindelidae) are colourful insects that are distributed worldwide. They have been studied intensively in many countries and are among the few insect groups for which endangered species are declared and placed on national Red Lists (Pearson 2011).

Fifty-nine species of tiger beetles have been recorded from Sri Lanka, of which 39 are endemic (Dangalle et al. 2012a). The genera *Collyris*, *Neocollyris*, *Tricondyla* and *Derocrania* consists of arboreal species, while the majority of species are included in the genus *Cicindela* (currently split into a large number of genera, according to Pearson et al. 2006) which is terrestrial (Dangalle et al. 2011a). The terrestrial species are found in a variety of sandy, open environments of which most tend to prefer the riverine habitat because of close proximity to water and food resources and safety from predators (Bhargav & Uniyal 2008; Dangalle et al. 2012a). Only nine species of tiger beetles are so far known from the riverine ecosystems of the island amongst vegetation and on sandy banks along small to large rivers (Table 1).

Currently, riverine ecosystems of many countries are facing threats from land development and agricultural practices that lead to loss of riverine invertebrates (Hudgins et al. 2011). Off-road vehicles and human traffic along Genesee River, New York has caused local extinctions of Cobblestone tiger beetles (*Cicindela marginipennis*) (Hudgins et al. 2011), while toxic chemicals and other water-borne pollutants in the Red River, China has threatened the survival of several tiger beetles (Shook & Xiao-Qiang 2006). In Sri Lanka, the endemic species *Cylindera* (*Ifasina*) *willeyi* has become locally extinct from its historical riverine locations in the Central Province and Labugama, Western Province due to unsuitability and loss of these former habitats (Dangalle et al. 2011). However, records on tiger beetles of the riverine ecosystems of Sri Lanka are few, and specific habitat requirements and distribution of species are poorly understood. The increase in the island's population, accompanied by expansion of the land area under urban, agricultural and industrial development have contributed to the loss and reduction of extents of natural ecosystems their inherent species as well as genetic diversity. Therefore, it is imperative that the tiger beetles inhabiting the riverine ecosystems of Sri Lanka be recorded and investigated. The present study intends to record the tiger beetles of riverine ecosystems of Sri Lanka, investigate their current locations and distribution and record habitat preferences. The study will provide preliminary information that can be used in future studies for assessing their conservation status.

MATERIALS AND METHODS

Study Area

Forty-two riverine locations of Sri Lanka were investigated for the occurrence of tiger beetles from June 2003 to October 2006 and May 2013 to May 2014. These locations were situated in Colombo, Gampaha and Kalutara districts of the Western Province; Ratnapura and Kegalle districts of the Sabaragamuwa Province; Puttalam and Kurunegala districts of the North-Western Province; Anuradhapura District of the North-Central Province; Nuwara, Nuwara Eliya and Matale districts of the Central Province, and Hambantota District of the

Table 1. Tiger beetle species known from the riverine ecosystems of Sri Lanka (* denotes endemic species)

	Species	Habitat	Location
1	*Lophyra* (*Lophyra*) *cancellata* Dejean, 1825	Dry upper sandy banks along medium to large rivers.	Kurunegala (1979, 1981, 1983), Mahaweli Ganga (1981), Kala Oya (1981, 1983)
2	*Calomera cardoni* Fleutiaux, 1890	Wet sandy banks of small to large rivers.	Kurunegala (1983), Mahaweli Ganga (1981)
3	*Calomera angulata* Fabricius, 1798	Moist, sandy river banks.	Locations unknown.
4	*Cylindera* (*Ifasina*) *waterhousei* Horn, 1900 *	Vegetation and wet rocks along water courses within dark, moist forests.	Labugama (1979), Karawanella (1979)
5	*Cylindera* (*Eugrapha*) *singalensis* (Horn, 1911)	Along major rivers.	Hambantota (1921)
6	*Myriochila* (*Myriochila*) *undulata* (Dejean, 1825)	Edges of small rivers.	Tissamaharama (1983)
7	*Myriochila* (*Myriochila*) *distinguenda* (Dejean, 1825)	Along river edges.	Puttalam (1981), Padaviya (1970), Kilinochchi (1970), Mannar (1976)
8	*Hypaetha quadrilineata* (Fabricius, 1781)	Along rivers.	Locations unknown.
9	*Callytron limosum* (Saunders, 1834)	Along major rivers.	Chilaw (1979)

Source: Acciavatti & Pearson 1989

Southern Province. The locations consisted of major rivers, streams, water canals, ferrys and waterfalls. Each location was visited twice during the study period and river banks, sand bars, moist rocks and shrub areas were searched for beetles between 9.00 and 17.00 hr.

Collection and Identification

Tiger beetles were collected using a standard insect net and preserved in 70% alcohol. Permission to make collections was obtained through a permit issued by the Department of Wildlife Conservation, Ministry of Environment and Natural Resources of Sri Lanka.

Species identification was carried out according to the taxonomic keys of the *Cicindela* of the Indian Subcontinent by Acciavatti & Pearson (1989), and descriptions of Horn (1904) and Fowler (1912). Nomenclature is based upon Wiesner (1992) except for the use of *Calomera* instead of *Lophyridia*, based upon Lorenz (1998).

Measurement of body weight and body length

Body weight and body length were estimated for 42 tiger beetles, viz: 21 specimens of *Cylindera* (*Ifasina*) *labioaenea*, eight specimens of *Cylindera* (*Ifasina*) *willeyi*, seven specimens of *Cylindera* (*Ifasina*) *waterhousei*, three specimens of *Calomera cardoni* and three specimens of *Calomera angulata*.

Body weight of the alcohol fixed beetles was determined to the nearest mg using an analytical balance (Chyo JL180, Chyo Balance Corp., Japan).

Body length was estimated by measuring the distance from the frons of the head to the elytral apex when the head was in the normal feeding position. Caudal spines on the elytral apex were disregarded. Based on the references of Acciavatti & Pearson (1989), McCairns et al. (1997) and Zerm & Adis (2001), body length of beetles were categorized as follows: less than 8mm - very small, 8–10 mm - small, 10–15 mm - medium, 15–20 mm - large, more than 20mm - very large.

Measurements of body length were taken using a dissecting microscope (Nikon Corporation SE, Japan) with an ocular micrometer (Nikon, Tokyo, Japan) that was calibrated by a stage micrometer (Olympus, Japan).

Measurement of Habitat Parameters

Climatic and soil parameters of the riverine locations of tiger beetles were recorded in each visit using standard methods. The air temperature, solar radiation, relative humidity and wind speed were measured using a portable integrated weather station (Health Enviro-Monitor, Davis Instrument Corp., Hayward, USA). The soil temperature (using Insert soil thermometer SG 680-10), soil pH (using portable soil pH meter Westminister No.259), soil salinity (using an YSI model 30 hand-held salinity meter) and soil colour (measured by comparison with a Munsell soil colour chart (Year 2000 revised washable edition) were estimated in each selected habitat. Soil moisture was detected using a gravimetric method (determined by selecting five random spots of a given site, collecting samples to a depth of 10 cm and estimating the difference in weight before and after oven drying to 107–120 ^{0}C in the laboratory).

Statistical Analysis

The body weights and body lengths of the five species were statistically compared. The climatic and soil parameters of the 10 locations of *Cylindera* (*Ifasina*) *labioaenea* were compared with the five locations of other species *willeyi*, *waterhousei*, *cardoni*, and *angulata*). Statistical comparisons were done using One-Way Analysis of Variance and Tukey's pair comparison method of the Minitab 16.0 statistical software package.

RESULTS

Locations of tiger beetles

Tiger beetles were encountered in 15 riverine locations of 42 locations investigated. They were recorded in the districts of Colombo, Gampaha, Kalutara of the Western Province; Ratnapura and Kegalle districts of the Sabaragamuwa Province and Puttalam, Kurunegala of the North-Western Province of Sri Lanka (Fig. 1 and Table 2). Beetles were found inhabiting river banks, amongst shrubs and grasses near the river and on moist rocks (Table 2).

Recorded Species

Five species *Cylindera* (*Ifasina*) *labioaenea*, *Cylindera* (*Ifasina*) *willeyi*, *Cylindera* (*Ifasina*) *waterhousei*, *Calomera cardoni*, *Calomera angulata*, were recorded from riverine locations of Sri Lanka (Image 1). *C. labioaenea* was the most common species and dominated the other species in terms of occurrence (Fig. 2). *C. willeyi* and *C. waterhousei* are endemic to Sri Lanka.

Body Size

Small and medium sized tiger beetles were recorded from riverine locations. *Cylindera labioaenea*, *C. willeyi* and *C. waterhousei* were categorized as small tiger beetles and *Calomera angulata* and *C. cardoni* were categorized

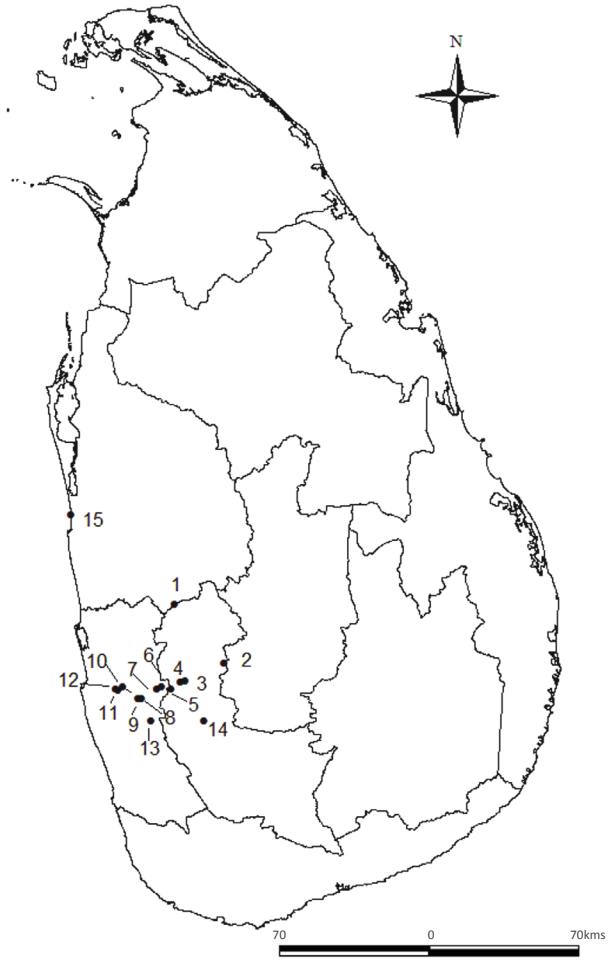

Figure 1. Sampling locations of tiger beetles

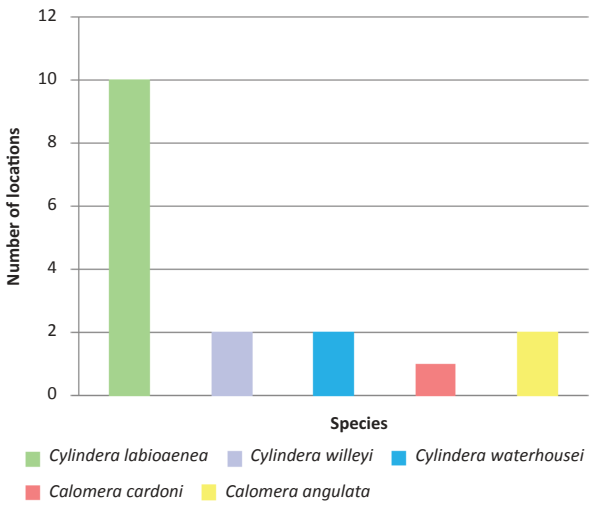

Figure 2. Occurrence of Tiger Beetle species in riverine locations of Sri Lanka

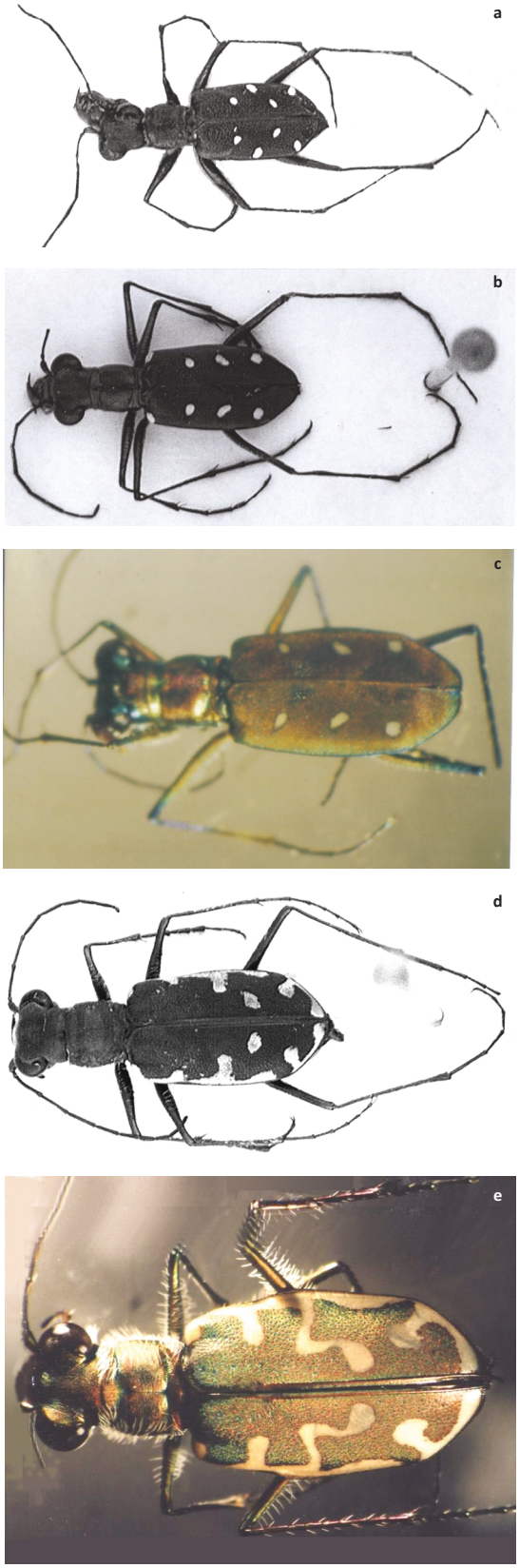

Image 1. Tiger beetle species of the riverine ecosystems of Sri Lanka. a - *Cylindera* (*Ifasina*) *labioaenea*; b - *Cylindera* (*Ifasina*) *willeyi*; c - *Cylindera* (*Ifasina*) *waterhousei*; d - *Calomera cardoni*; e - *Calomera angulata*. © Chandima Dangalle

Table 2. Riverine locations of tiger beetles recorded during the study (Location number coincides with the numbers given in Figure 1. Each location was surveyed twice during the month denoted in the Survey Date).

	Location	Spatial coordinates and elevation	Habitat and microhabitat	Survey date	Recorded species	No. of specimens collected
1	Ma Oya, Alawwa, Kurunegala District, North-Western Province	7°17'40N & 80°14'20E; 45.1m	Stream Stream bank	July 2004	*Calomera cardoni* *Calomera angulata*	03 01
2	We Oya, Yatiyantota, Kegalle District, Sabaragamuwa Province	7°01'27N & 80°18'02E; 31.0m	Stream Amongst shrubs of river bank.	March 2005	*Cylindera* (*Ifasina*) *labioaenea*	03
3	Maha Oya Falls, Dehi Owita, Colombo Distict, Kegalle District, Sabaragamuwa Province	6°58'03N & 80°16'56E; 39.3m	Waterfall Moist rocks	August 2003	*Cylindera* (*Ifasina*) *labioaenea*	03
4	Maha Oya, Dehi Owita, Kegalle District, Sabaragamuwa Province	6°57'91N & 80°16'44E; 6.7m	Stream Among shrubs of river bank.	August 2003	*Cylindera* (*Ifasina*) *willeyi*	07
5	Seethavaka River, Thalduwa, Colombo District, Western Province	6°54'21N & 80°07'40E; 18.3m	Major river River bank	August 2003	*Cylindera* (*Ifasina*) *labioaenea*	01
6	Asvathu Oya, Awissawella, Colombo District, Western Province	6°56'66N & 80°10'66E; 16.5m	Stream River bank	July 2003	*Cylindera* (*Ifasina*) *labioaenea*	04
7	Water canal, Puvakpitiya, Colombo District, Western Province	6°15'58N & 80°11'14E; 16.0m	Water canal Amongst shrubs of river bank.	June 2003	*Cylindera* (*Ifasina*) *labioaenea*	01
8	Heen Ela, Waga, Colombo District, Western Province	6°54'21N & 80°07'40E; 18.3m	Water canal River bank	August 2003	*Cylindera* (*Ifasina*) *labioaenea*	01
9	Siriniwasa Stream, Waga, Colombo District, Western Province	6°50'11N & 80°07'02E; 12.9m	Stream Rocks	May 2013	*Cylindera* (*Ifasina*) *labioaenea*	01
10	Kelani River, Malwana, Gampaha District, Western Province	6°56'84N & 80°00'75E; 23.2 m	Major river River bank	August 2003	*Cylindera* (*Ifasina*) *labioaenea*	03
11	Kelani River, Kirielamulla, Gampaha District, Western Province	6°56'86N & 80°00'66E; 12.8m	Major river Amongst grasses of river bank.	August 2003	*Cylindera* (*Ifasina*) *labioaenea*	02
12	Kelani River, Kaduwela, Colombo District, Western Province	6°56'13N & 79°59'07E; 22.9m	Major river Moist rocks	August 2003	*Cylindera* (*Ifasina*) *labioaenea*	02
13	Water canal, Handapangoda, Kalutara District, Western Province	6°47'05N & 80°08'03E; 23.0m	Water canal Moist rocks	July 2003	*Cylindera* (*Ifasina*) *willeyi* *Cylindera* (*Ifasina*) *waterhousei*	01 02
14	Bopath Falls, Kuruwita, Ratnapura District, Sabaragamuwa Province	6°48'06N & 80°22'04E; 16.5m	Waterfall River bank	August 2003	*Cylindera* (*Ifasina*) *waterhousei*	05
15	Deduru Oya, Halawatha, Puttalam District, North-Western Province	7°60'28N & 79°81'18E; 81.43m	River River banks	May 2014	*Calomera angulata*	02

as medium sized tiger beetles. When considering the body length, *labioaenea* was significantly smaller than *willeyi* and *waterhousei*, and *angulata* was significantly smaller than *cardoni*. However, significant differences were only evident between small and medium sized beetles according to body weight (Table 3).

Habitat Parameters

The climatic and soil parameters for the riverine locations of tiger beetles is given in Table 4. When considering the comparison between habitat parameters of the locations of *labioaenea* and locations of other species, significant differences were evident. Air temperature and solar radiation was high ($p<0.05$) in the locations of *labioaenea* than of the other species, while relative humidity was significantly low (Table 5).

DISCUSSION

Cylindera (*Ifasina*) *labioaenea* was the most common tiger beetle species and occurred as a single species population in all its locations. *Calomera cardoni* co-occurred with *Calomera angulata* at Ma Oya, while *willeyi* co-occurred with *waterhousei* at the stream in Handapangoda.

When examining the body size of species, *labioaenea* was the smallest species with a significantly lower body

Table 3. Average values (± standard error of mean) and the range (within brackets) of body weight and body length of tiger beetle species of riverine locations.

Species	Number of Specimens	Average Body Weight (mg)	Body Length (mm)
Cylindera (*Ifasina*) *labioaenea*	21	18.20^{a} ± 0.96 (9.20 – 28.80)	7.85^{a} ± 0.12 (7.05 – 8.90)
Cylindera (*Ifasina*) *willeyi*	08	27.45^{a} ± 1.32 (23.10 – 32.30)	9.19^{b} ± 0.11 (8.68 – 9.60)
Cylindera (*Ifasina*) *waterhousei*	07	24.76^{a} ± 2.10 (16.30 – 34.10)	8.80^{b} ± 0.27 (7.55 – 9.08)
Calomera cardoni	03	78.37^{b} ± 12.99 (55.40 – 100.30)	13.18^{c} ± 0.74 (11.70 – 14.00)
Calomera angulata	03	66.73^{b} ± 11.96 (44.40 – 85.30)	10.72^{d} ± 0.10 (10.55 – 10.89)

Means sharing a common letter (s) within the same column are not significantly different according to Tukey's multiple comparison test.

Table 4. Climatic and soil parameters of the riverine locations at which tiger beetles were recorded.

Habitat Parameter	Average value ± Std. Error	Range
Air temperature (^{0}C) (n = 30)	35.13±0.53	31.00–41.00
Solar radiation (w/m^{2}) (n = 30)	385.93±46.38	92.00–949.00
Relative humidity (%) (n =30)	59.87±1.18	47.00–69.00
Wind speed (MPH) (n = 30)	0.67±0.27	0.00–5.00
Soil temperature (^{0}C) (n = 24)	31.54±0.62	26.00–39.00
Soil pH (n = 24)	6.01±0.22	4.20–7.20
Soil salinity (ppt) (n = 24)	0.00	-
Soil colour (n = 24)	Yellow to Dark brown	-
Soil moisture (%) (n = 22)	16.31±3.68	1.64–52.92

weight and body length. In turn, the habitats of the species had a significantly high air temperature and solar radiation, and a low relative humidity reflecting comparatively warm, dry environments. In terrestrial arthropods the body size of ants has been shown to decrease with temperature whereas bees, butterflies and moths show a variety of body size-climate patterns (Entling et al. 2010). In tiger beetles large body size has been associated with coastal and reservoir habitats with high wind speed, low soil moisture and high soil pH, while species with small body have been associated with riverine habitats with low wind speed, high soil moisture and low soil pH (Dangalle et al. 2013). The interspecific mechanism, starvation resistance predicts an increase in body size towards cold environments (Greenberg 1979; Entling et al. 2010), while accelerated maturation leads to smaller adult size at high temperatures (Entling et al. 2010). Increased temperature is known to increase development and growth rates, shortening development time resulting in reduced adult size (Kingsolver & Huey 2008). Thus, in light of these conditions smaller tiger beetles can be expected in warmer riverine ecosystems while comparatively larger species may occur in more moist, cold riverine habitats.

We further observed that *C. labioaenea* occurs as a single species population in all its locations while the other species co-exist. Hoback et al. (2001) has shown that in sympatric tiger beetles, larger species may act as intraguild predators on smaller species. In the present study, *C. willeyi* and *C. waterhousei* that co-existed at Handapangoda were statistically similar in size (body lengths 9.19±0.11 and 8.80±0.27 respectively), while the sympatric *Calomera cardoni* and *C. angulata* were both in the medium size range (body lengths 13.18±0.74 and 10.72±0.10 respectively). According to Hoback et al. (2001), smaller species compensate for predation risk by defensive behaviours including a shift in habitat use and a change in foraging activity in the presence of the larger species. However, the present study indicates that the smallest species, *C. labioaenea*, may have completely avoided the habitats of the larger species as a defensive strategy after experiencing predatory encounters. More investigations and more sampling in riverine locations are required to provide more evidence to this fact.

When considering the habitat preferences tiger beetles, were found foraging at air temperatures of 35.13±0.53 ^{0}C. Tiger beetle activity is highly dependent on air temperature and many species display maximum activity at an optimal temperature range that is decided by thermoregulatory mechanisms, desiccation and prey availability (Dreisig 1980; Schultz & Hadley 1987). Our data suggests that the optimal temperature range of the riverine tiger beetles lies between 31.00–41.00 ^{0}C.

Tiger beetles are also sensitive to soil moisture, soil salinity and soil temperature of locations due to preferences in oviposition and larval development (Romey & Knisley 2002; Cornelisse & Hafernik 2009). When considering soil moisture, high percentages are found in riverine ecosystems (16.31±3.68) when comparing with the reservoir ecosystems (4.25±0.67) (Dangalle et al. 2012) and coastal ecosystems (4.60±1.41) (Dangalle et al. 2013b) of tiger beetles. As *C. labioaenea*, *C. willeyi*, *C. waterhousei* and *Calomera cardoni* were restricted to riverine ecosystems and not observed in other habitat types, it is possible that soil moisture is a key factor contributing to the habitat preference

Table 5. Comparison of the habitat parameters of the riverine locations of *Cylindera labioaenea* and other tiger beetle species ("n" denotes the number of times from which habitat parameters were recorded from locations. Values are given as average ± standard error and range is given within brackets)

Species	Air temp. (°C)	Incident Solar Radiation (w/m²)	Relative Humidity (%)	Wind Speed (MPH)	Soil temp. (°C)	Soil pH	Soil colour	Soil salinity (ppt)	Soil moisture (%)
Cylindera labioaenea (n = 20)	35.80^{a} ± 0.59 (32.00 – 41.00)	469.90^{a} ± 57.42 (92.00 – 949.00)	56.80^{a} ± 1.28 (47.00 – 67.00)	0.80^{a} ± 0.38 (0.00 – 5.00)	32.57^{a} ± 0.69 (30.00 – 39.00) (n = 14)	5.60^{a} ± 0.30 (4.20 – 7.00) (n = 14)	Yellow to Dark reddish-brown	0.00^{a}	23.02^{a} ± 5.89 (3.12 – 52.92) (n = 12)
All other species (n = 10)	33.80^{b} ± 0.98 (31.00 – 41.00)	218.00^{b} ± 46.59 (104.00 – 481.00)	66.00^{b} ± 0.59 (64.00 – 69.00)	0.40^{a} ± 0.31 (0.00 – 3.00)	30.10^{a} ± 0.99 (26.00 – 35.00)	6.58^{a} ± 0.21 (5.00 – 7.20)	Yellowish brown to Dark yellowish-brown	0.00^{a}	8.25^{a} ± 2.27 (1.64 – 18.82)

Means sharing a common letter (s) within the same column are not significantly different according to Tukey's multiple comparison test.

of species. Soil temperature in riverine ecosystems is low (31.54±0.62 °C) when comparing with reservoir ecosystems (33.64±2.11 °C) (Dangalle et al. 2012) and coastal ecosystems (34.71±0.95 °C) (Dangalle et al. 2013b) suggesting that this factor may also contribute to the habitat preferences of riverine tiger beetles. When considering soil colour, tiger beetles are known to occur in soils which match their structural colouration. Blending of structural colouration with the colour of the surrounding soil enables tiger beetles to evade attack from natural enemies such as birds, bats and robberflies (Seago et al. 2009). As tiger beetles collected from riverine habitats were mainly dark brown and bronze with light yellow elytral maculations and spots, their preference to soils of yellow to dark brown is apparent. Further, we observed that tiger beetles of riverine ecosystems prefer soils with non-saline conditions.

Calomera angulata which is common to reservoir habitats of Sri Lanka (Dangalle et al. 2012) was also observed in riverine ecosystems. However, as they were discovered in only two locations, the preference of the species for riverine habitats needs to be further investigated.

As the riverine ecosystems provide refugia to two endemic tiger beetle species of the country as well as other tiger beetles better decisions regarding the design, planning and implementation of conservation strategies of these ecosystems are required.

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Appendix A. Raw habitat data of sampling locations of tiger beetles.

Location	Air Temp. (°C)	Incident Solar Radiation (w/m²)	Relative Humidity (%)	Wind Speed (MPH)	Soil Temp. (°C)	Soil pH	Soil Colour	Soil Salinity (ppt)	Soil Moisture (%)
Ma Oya, Alawwa	32, 32	246, 250	64, 68	3, 1	28, 30	7.0, 7.2	Yellowish-brown	0.0, 0.0	1.64, 1.70
We Oya, Yatiyantota	38, 39.2	221, 223	52, 54	0, 0	35, 39	7.0, 7.0	Strong brown	0.0, 0.0	8.50, 8.52
Maha Oya Falls, Dehi Owita	33, 35	231, 233	58, 60	0, 0	Found on moist rocks with no soil.				
Maha Oya, Dehi Owita	31, 33	131, 133	65, 65	0, 0	27.5, 28.5	6.7, 6.9	Yellowish-brown	0.0, 0.0	2.88, 2.90
Seethavaka River, Thalduwa	35, 37	945, 949	57, 59	0, 0	32, 33	6.3, 6.5	Dark yellowish-brown	0.0, 0.0	12.06, 12.10
Asvathu Oya, Awissawella	32, 34	712, 716	65, 67	3, 5	30, 32	6.3, 6.5	Yellowish-brown	0.0, 0.0	3.12, 3.28
Water Canal, Puvakpitiya	32, 34	261, 263	64, 66	0, 0	30, 32	6.1, 6.3	Yellow	0.0, 0.0	-
Heen Ela, Waga	36, 36.8	492, 498	47, 51	0, 0	30, 36	4.4, 4.8	Strong brown	0.0, 0.0	12.00, 15.90
Siriniwasa Stream, Waga	33, 33	92, 94	56, 62	0, 0	Found on rocks with no soil.				
Kelani River, Malwana	38, 38	576, 580	51, 55	0, 0	30, 32	4.2, 4.6	Dark brown	0.0, 0.0	51.50, 52.92
Kelani River, Kirielamulla	36, 40	572, 584	53, 53	4, 4	32, 33	4.2, 4.2	Dark reddish-brown	0.0, 0.0	47, 49.38
Kelani River, Kaduwela	35, 41	571, 585	50, 56	0, 0	Found on rocks with no soil.				
Water Canal, Handapangoda	32, 32	125, 127	65, 65	0, 0	26, 28	5.0, 7.0	Dark yellowish-brown	0.0, 0.0	17.10, 18.82
Bopath Falls, Kuruwita	33, 35	104, 106	65, 65	0, 0	31, 32	6.0, 6.2	Dark yellowish-brown	0.0, 0.0	3.75, 3.91
Deduru Oya, Halawatha	37, 41	477, 481	69, 69	0,0	35, 35	6.8, 7.0	Brownish-yellow	0.0, 0.0	14.65, 15.16

Appendix B. Raw morphometric data for tiger beetles.

Species	Number of specimens measured	Body weight (mg)	Body length (mm)
Cylindera (*Ifasina*) *labioaenea*	21	14.80, 22.80, 14.20, 16.30, 17.10, 14.60, 17.10, 17.70, 16.90, 21.80, 28.80, 17.20, 20.70, 18.80, 17.20, 20.70, 15.50, 27.30, 17.60, 9.20, 15.9	7.05, 8.00, 7.73, 7.28, 8.30, 7.30, 7.70, 8.00, 7.83, 7.65, 8.90, 8.60, 8.50, 8.70, 8.28, 8.00, 8.00, 7.28, 7.10, 7.30, 7.39
Cylindera (*Ifasina*) *willeyi*	08	32.30, 25.80, 23.40, 27.80, 31.20, 23.10, 31.30, 24.70	9.45, 8.88, 8.68, 9.20, 9.35, 9.40, 9.00, 9.60
Cylindera (*Ifasina*) *waterhousei*	07	28.30, 34.10, 16.30, 24.80, 21.80, 22.60, 25.40	7.55, 9.90, 8.53, 8.75, 9.08, 8.78, 9.00
Calomera cardoni	03	79.4, 55.4, 100.3	13.85, 11.70, 14.00
Calomera angulata	03	44.4, 70.50, 85.30	10.55, 10.71, 10.89