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The Association between Body-size and Habitat-type in Tiger Beetles (Coleoptera, Cicindelidae) of Sri Lanka

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ABSTRACT

Body size is an important feature of an animal that is linked with its life history, morphology, physiology and ecology. Understanding the association between body size and habitat type of an animal and the underlying causes for this are important for determining their distribution. The present study examines the association between body size and habitat types of tiger beetles in Sri Lanka and the environmental correlations for these associations. Morphometric parameters of tiger beetles and environmental parameters (air temperature, solar radiation, relative humidity, wind speed and, the colour, temperature, moisture content, pH and salinity of soil) in each habitat were recorded. Ten tiger beetle species were found from 37 locations which included coastal, riverine, urban and reservoir habitats. Species with larger body and mandible sizes prefer coastal and reservoir habitats with high wind speed, low soil moisture and high soil pH, whereas species with smaller body and mandible sizes prefer riverine habitats with low wind speed, high soil moisture and low soil pH. Species with smaller body size may also prefer urban habitats which may be due to similarity of environmental conditions that prevails in these two sites. These findings will assist in predicting the distribution of tiger beetles within various habitat types of Sri Lanka.

Key words: body length, mandible length, climatic parameters, soil parameters

INTRODUCTION

Body size is a well-known feature of an animal that influences its energy requirements, potential resource exploitation and susceptibility to predation (Cohen *et al.*, 1993; Principe, 2008). Another aspect of body size that has been widely discussed is its relationship with habitat type, habitat succession, habitat degradation level and environmental quality (Linzmeier and Ribeiro-Costa, 2011). A positive relationship between body size and home range has been identified in many taxonomic groups of animals (Pyron, 1999). Small-bodied species are expected to be more specialized for habitat type than large-bodied species and, tend to occur in less-open habitats and appears as less social than larger species (Pyron, 1999; Perry and Garland, 2002; Tershy, 1992). For instance, ground-dwelling monitor lizards have larger body sizes, rock-dwellers have smaller body sizes while arboreal forms possess an intermediate body size (Collar *et al.*, 2011). Crocodylian species that are larger in size are common in water bodies with steep sloping banks which lack a mat cover of heavy floating grass, while smaller species occur in small streams that flow through dense tropical forests (Farlow and Pianka, 2002).

Among insects, chrysomelid beetles show a decrease in their body size, from areas of early successional stages to late successional stages but coleopteran predators with large body sizes are more numerous in forest edge areas with sparse vegetation at early successional stages (Linzmeier and Ribeiro-Costa, 2011). Further, increased human-induced disturbances alter the distribution of coleopterans towards a prevalence of small-sized species in highly disturbed habitats, a hypothesis which however cannot be generalized (Ulrich *et al.*, 2007). Body size of aquatic insect larvae is known to be associated with flow velocity and large individuals are more numerous in habitats with high flow velocity conditions (Sagnes *et al.*, 2008).

Tiger beetles (Coleoptera, Cicindelidae) are highly habitat specific (Adis *et al.*, 1998; Cardoso and Vogler, 2005; Dangalle *et al.*, 2012a; Knisley and Hill, 1992; Morgan *et al.*, 2000; Satoh *et al.*, 2006; Pearson and Cassola, 2007; Rafi *et al.*,

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2010). Each species tends to be restricted to a narrow and unique habitat such as coastal sand dunes (Morgan *et al.*, 2000; Satoh *et al.*, 2004; Neil and Majka, 2008; Dangalle *et al.*, 2012a), riverine habitats (Ganeshaiah and Belavadi, 1986; Satoh *et al.*, 2006; Dangalle *et al.*, 2011a; Dangalle *et al.*, 2011b), reservoirs (Dangalle *et al.*, 2012b), forests (Adis *et al.*, 1998), agro-ecosystems (French *et al.*, 2004; Sinu *et al.*, 2006), parks, areas with human disturbances (Bhardwaj *et al.*, 2008; Mosley, 2009), open areas with sparse vegetation (Schiefer, 2004) and grasslands (Acorn, 2004). The association of tiger beetle species with habitat has been related to their preferences for mating and oviposition sites, food availability, seasonality, vegetation cover and physical, chemical and climatic qualities of the habitat (Pearson *et al.*, 2006). However, the association between the body sizes of tiger beetles and habitat type has not been studied, though body size has been estimated for many other species for various habitats. The present study intends to, (1) analyse the association of body size with habitat type of tiger beetles of Sri Lanka, and (2) determine the climatic and soil parameters of the habitat that may influence body size – habitat type association.

MATERIALS AND METHODS

Surveying and collection of tiger beetles

Ninety four locations in Sri Lanka were surveyed for tiger beetles from May 2002 to December 2006. When beetles were encountered, a sample of three to five beetles was collected using an insect net and preserved in 70% alcohol. Permission to make collections of tiger beetles was obtained from the Department of Wildlife Conservation, Sri Lanka.

Identification of tiger beetles

Tiger beetles were identified using keys for *Cicindela* of the Indian subcontinent (Acciavatti and Pearson, 1989) and descriptions of Horn (1904), Fowler (1912) and Naviaux (1984). Identifications were confirmed by comparing the specimens with type specimens available in the National Museum of Colombo, Sri Lanka and British Natural History Museum of London, United Kingdom. Nomenclature is based upon Wiesner (1992) except for the use of *Calomera* instead of *Lophyridia*, based upon Lorenz (1998).

Measurement of morphological parameters of tiger beetles

Body lengths and mandible lengths were measured and recorded for all tiger beetle specimens. 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 and Pearson (1989), McCairns *et al.* (1997) and Zerm and Adis (2001), the body length of beetles was categorized as follows:

Less than 8 mm – very small
8 to 10 mm – small
10 to 15 mm – medium
15 to 20 mm – large
More than 20 mm – very large

Mandible length was estimated by measuring the distance from the articulation point to the tip of the left mandible. Broken and worn out mandibles were disregarded. Based on Pearson and Juliano (1993) and, Satoh and Hori (2004) mandibles of beetles were categorized according to the following size groups.

< 2 mm – small
2 to 3 mm – medium
> 3 mm – large

Measurements of both body length and mandible length were taken using a dissecting microscope (Nikon Corporation SE, Japan) with an eyepiece graticule (Nikon, Tokyo, Japan) which has calibrated by an objective micrometer (Olympus, Japan).

Measurements of habitat variables

Habitat parameters were collected in locations where tiger beetles were recorded during the period from 10:00 h to 15:00 h. 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). In addition, the habitat type and vegetation distribution in each location were recorded.The soil temperature [using a soil thermometer SG 680-10], soil pH [using portable soil pH meter Westminister No.259], soil salinity [using a YSI model 30 hand-held salinity meter] and soil colour [measured by comparison with a Munsell soil colour chart (Year 2000 revised edition)] were estimated in each selected habitat. Soil moisture content was detected using the gravimetric method [determined by collecting five random samples to a depth of 10 cm and estimating the difference in fresh weight upon oven drying to 107-120 °C in the laboratory].

Statistical Analyses

The body length and mandible length of tiger beetles of different habitats and habitat parameters were compared using One-Way Analysis of Variance and Tukey's multiple comparison method using the Minitab 16.0 statistical software package. Habitat parameters of urban habitats were not included in the statistical analyses as tiger beetles were found only in two urban locations.

The correlations (Pearson's correlation coefficient) between body length of beetles and selected habitat parameters (which showed significant differences among habitat types) were investigated using Minitab 16.0 statistical package.

RESULTS

Locations and habitat types of tiger beetles

Tiger beetles were recorded from thirty seven locations in Sri Lanka in four different habitat types, namely; coastal, riverine, urban and reservoir (Figure 1; Table 1 in the Appendix I). The majority of the beetles were found from coastal, riverine and reservoir habitats. However, tiger beetles were found only from two urban habitat locations. A total of ten species were collected from the 37 locations, of which five were found in riverine habitats; four in reservoir habitats; three in coastal habitats and three in urban habitats. Four species were found in more than one habitat type (Tables 1 and 2 in the Appendix I).

The ten coastal habitats where tiger beetles inhabited were characterized by broad beaches with sparse vegetation cover. Such sites were exposed to sunlight or strong wind conditions. However, these beaches were fringed with *Ipomoea* spp., *Pandanus* spp., *Mimosa* spp., grasses and coconut trees (*Cocos nucifera*).

The fourteen riverine habitats where tiger beetles were found, consisted of large trees such as *Artocarpus* sp., *Areca* sp., *Mangifera indica*, *Hevea* sp. and bamboo sp. bordering the river bank. Moreover, ferns, *Colocasia* sp., *Mimosa* sp. and tall grasses in such sites provided a thick undergrowth. Moist rocks were also found in most of the riverine habitats.

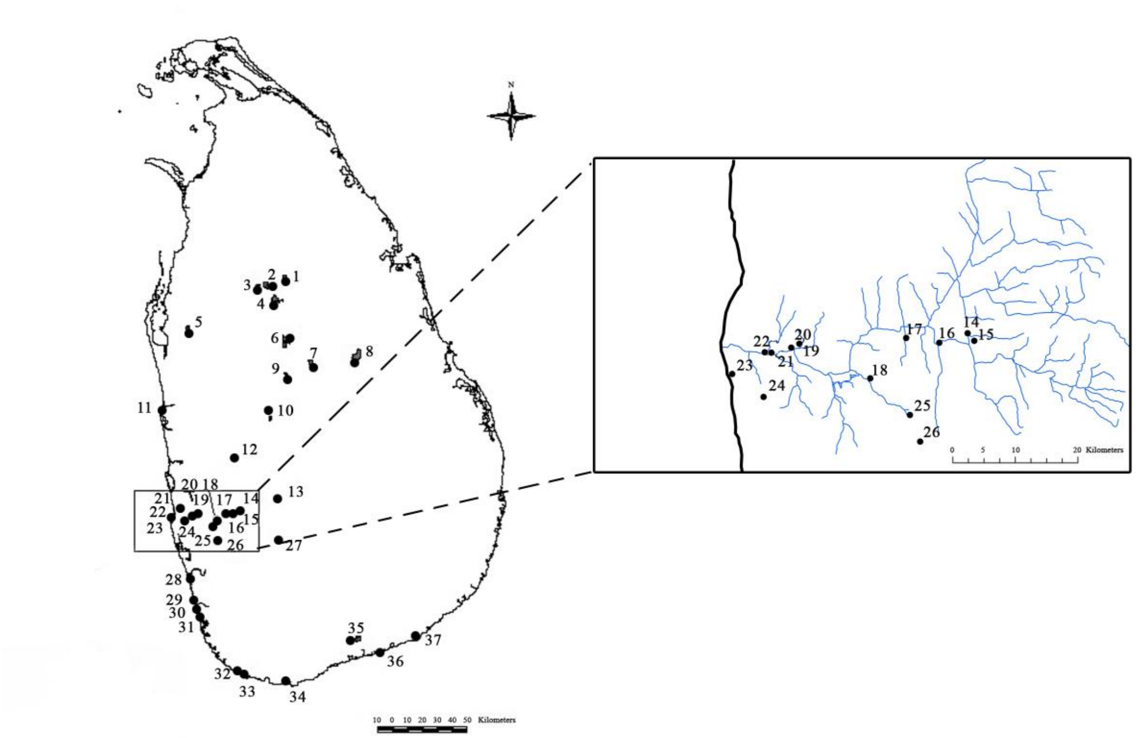

Figure 1. Sampling locations of tiger beetles (See the Table 1 in appendix I).

The urban habitats of tiger beetles included landscaped gardens with ornamental plants that provided sufficient shade as well as moisture. The reservoir habitats consisted of sparsely vegetated sandy banks covered with *Mimosa* sp., *Desmodium* sp. and grasses with scattered *Azadirachta indica* and *Limonia acidissima* trees.

Morphological parameters of tiger beetles

According to the body lengths, the beetles of coastal and reservoir habitats were medium in size (coastal 10.475–13.625 mm; reservoir 8.1–12.6 mm). In contrast, most of the beetles in riverine and urban habitats were smaller (riverine 7.05 – 14.0 mm; urban 7.375–11.9 mm) (Figure 2a and Table 2 in Appendix I). Mandibles of beetles in coastal and reservoir habitats were significantly larger than those in riverine and urban habitats ($p<0.01$) (Figure 2 b and Table 2 in Appendix I). Medium sized mandibles were found in beetles of coastal and reservoir habitats (coastal 1.500–2.575 mm; reservoir 1.750–2.825 mm), while beetles of riverine and urban habitats were found to be having smaller mandibles (riverine 1.075–2.500 mm; urban 1.275–2.550 mm).

(a)

(b)

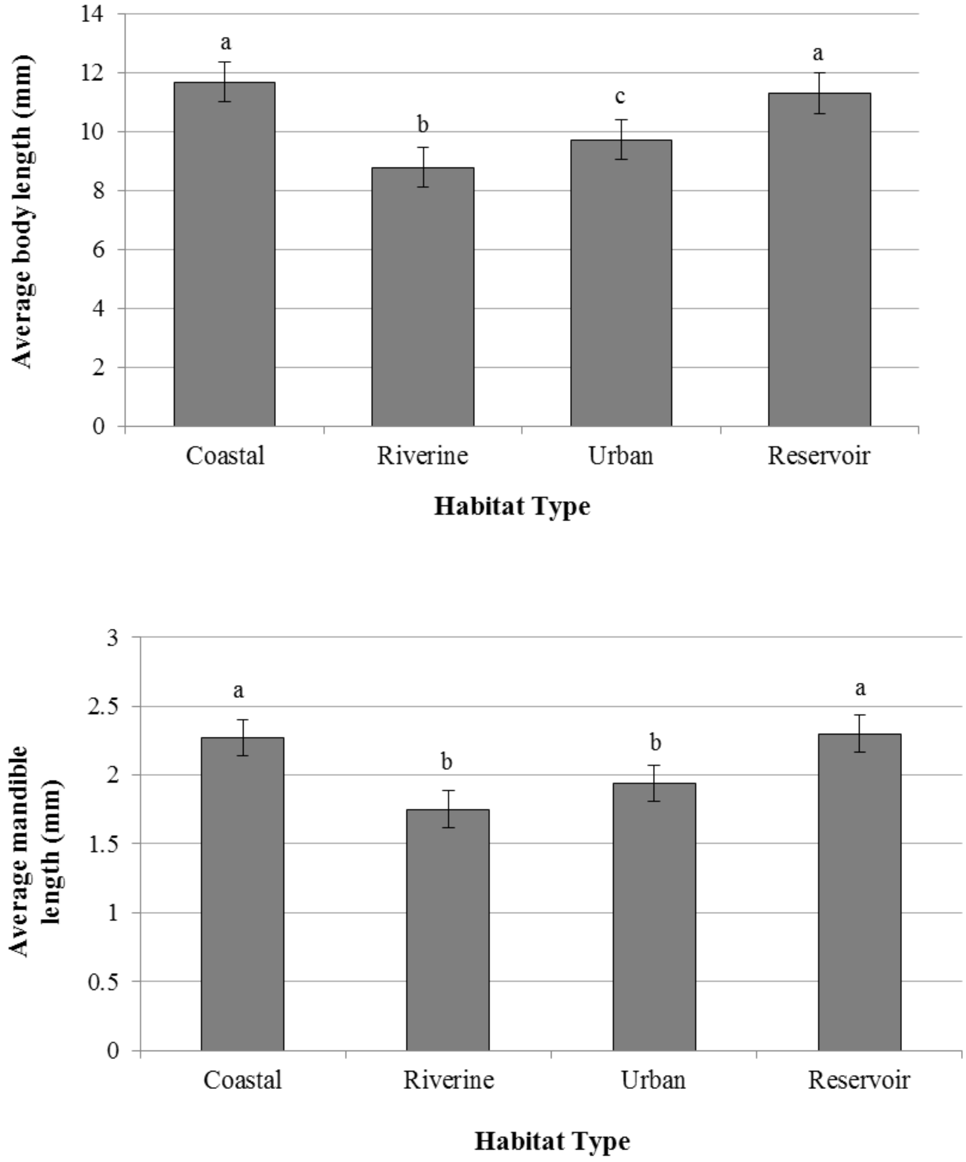

Figure 2. Average (a) body and (b) mandible lengths of tiger beetles in different habitat types of Sri Lanka

Habitat variables

The wind speed, soil moisture and soil pH of coastal and reservoir habitats were significantly different from that of riverine habitats (Table 1). In contrast, the temperature, solar radiation, relative humidity, soil temperature and soil colour of coastal, riverine and reservoir habitats did not vary significantly from each other.

Wind speed was significantly high in coastal and reservoir habitats than that in riverine habitats ($p<0.01$) (Table 1). Median wind speed was the highest for reservoir habitats (7.0) and the lowest for riverine habitat types (0). Coastal habitats also exhibited a high median wind speed (3.5) but had the greatest variability, with an interquartile range of 11.5. Riverine habitats demonstrated the least variability, with an interquartile range of only 0.5.

Soil moisture was significantly varied among coastal, riverine and reservoir habitats ($p<0.05$) (Table 1). Median soil moisture was the highest for riverine habitats (10.29), though it demonstrated the greatest variability (interquartile range of 22-39). Coastal and reservoir habitats had similar soil moisture levels (median = 3.5 and 2.92, respectively) with somewhat high variabilities (interquartile ranges being 8.3695 and 8.0965, respectively).

Soil pH was also significantly high in coastal and reservoir habitats than that in riverine habitats ($p<0.01$) (Table 1). Median soil pH was the highest in coastal habitats (7.5) and the lowest in riverine habitats (6.2). Reservoir habitats also exhibited a high median soil pH (7.0) and had the lowest variability (interquartile range of 0.3). Riverine habitats demonstrated the highest variability, with an interquartile range of 2.2.

Soil salinity was significantly high in coastal habitats when compared with riverine and reservoir habitats ($p<0.01$) (Table 1).

Wind speed and soil pH of urban habitats was very similar to that of riverine habitats. However, soil moisture of urban habitats resembled that of coastal and reservoir habitats (Table 1). Further collections of tiger beetles from urban sampling locations were required to understand the relationship between habitat variables of urban and other studied habitat types.

Correlation between body size and habitat variables

A moderately positive correlation was observed between wind speed of the habitats and body length of tiger beetles at the 0.01 level of significance (Figure 3a). Similarly, the mandible length positively correlated with the wind speed of the habitats (Figure 3b). The soil pH of habitats also positively correlated with body and mandible lengths of tiger beetles at 0.01 level of significance (Figures 3c and d).

A negative but weak correlation was observed between soil moisture of habitats and body length of tiger beetles (Figure 3e). Mandible length too showed a week negative correlation with soil moisture at 0.05 level of significance (Figure 3f).

DISCUSSION

Results revealed that the tiger beetles occupying open habitats with sparse vegetation (e.g. coastal areas and the reservoir banks) may have larger body sizes than most species occupying riverine and urban habitats. On average, the tiger beetle species in coastal habitats [*Hypaetha biramosa*, *Lophyra* (*Lophyra*) *catena*, *Myriochila* (*Monelica*) *fastidiosa*] and in reservoir habitats [*Calomera angulata*, *Cylindera* (*Oligoma*) *lacunosa*, *Lophyra* (*Lophyra*) *catena*, *Myriochila* (*Monelica*) *fastidiosa*] were larger than those in riverine habitats [*Calomera angulata*, *Ca. cardoni*, *Cylindera* (*Ifasina*) *labioaenea*, *Cy.* (*Ifasina*) *waterhousei*,*Cy.* (*Ifasina*) *willeyi*].

Thus, tiger beetles with larger body sizes can be expected to be found in open habitats (coastal and reservoir) with high wind speed, low soil moisture and neutral to alkaline soils, while smaller species can expected to be found in habitats with low wind speed, high soil moisture and acidic soils. It has also been reported that tiger beetles with larger body sizes inhabit in bare-ground sites such as mountain climbing paths, trails and areas used for livestock grazing in China and Korea (Hori, 1982) while species with body lengths ranging from 12.61 – 13.30 mm occupy beach habitats in Northeast Arizona (Schultz and Hadley, 1987). *Cicindela hirticollis* (body length = 12-15 mm) occurs on water-edge habitats of Atlantic and Pacific coasts, major estuaries and the Great Lakes of the United States and Canada (Allen and Acciavatti, 2002; Knisley and Fenster, 2005). Smaller species (with body lengths less than 10 mm), such as *Cicindela cursitans* have been recorded from bunch-grass prairies near rivers (Brust *et al.*, 2005). *Cicindela viridicollis* having a body length of 6-7 mm inhabits in grassy fields of Cuba (Schiefer, 2004).

Table 1. Average values (± standard error of mean) and the range (within brackets) of the measured habitat microclimatic parameters

Habitat type	**Number of sampling locations (the location no. as in Figure 1)**	**Temperature (°C)**	**Solar radiation (w/m^2)**	**Relative humidity (%)**	**Wind speed (MPH)**	**Soil temperature (°C)**	**Soil pH**	**Soil moisture (%)**	**Soil salinity (ppt)**	**Soil colour**
Coastal	10 (11, 28, 29, 30, 31, 32, 33, 34, 36, 37)	$35.5^{a} \pm 1.13$ (31.0 - 41.0)	$490.8^{a} \pm 103.3$ (132 – 1023)	$61.0^{a} \pm 3.23$ (45 – 77)	$6.70^{a} \pm 2.52$ (0 – 22)	$34.71^{a} \pm 0.95$ (30.5 – 39.0)	$7.57^{a} \pm 0.14$ (7.0 – 8.2)	$4.59^{a} \pm 1.41$ (0.18 – 10.71	$0.06^{a} \pm 0.03$ (0.1 – 0.2)	Yellowish brown to pale brown
Riverine	14 (12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 25, 26, 27)	$35.00^{a} \pm 1.13$ (32.0 – 38.6)	$401.3^{a} \pm 73.2$ (105 – 947)	$59.15^{a} \pm 1.75$ (49 – 66)	$0.77^{b} \pm 0.43$ (0 – 4)	$31.23^{a} \pm 0.82$ (27.0 – 37.0)	$6.00^{b} \pm 0.33$ (4.2 – 7.1)	$16.45^{b} \pm 5.89$ (1.67 – 52.21)	$0.00^{b} \pm 0.00$	Yellowish brown to dark brown
Reservoir	11 (1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 35)	$34.27^{a} \pm 0.89$ (29.5 – 39.0)	$298.4^{a} \pm 77.5$ (56 – 736)	$52.27^{a} \pm 2.61$ (40 – 66)	$8.09^{a} \pm 1.86$ (0 – 21)	$33.23^{a} \pm 1.24$ (28.0 – 42.5)	$7.08^{a} \pm 0.12$ (6.7 – 8.0)	$4.25^{a} \pm 1.29$ (0.12 – 11.49)	$0.00^{b} \pm 0.00$	Yellow to brown
Urban	02 (23, 24)	30.80 ± 0.20 (30.6 – 31.0)	51.0 ± 1.0 (50 – 52)	70.50 ± 0.50 (70 – 71)	0.50 ± 0.50 (0 – 1)	31.50 ± 0.00	6.35 ± 1.25 (5.1 – 7.6)	5.26 ± 4.98 (0.27 – 10.24)	0.00 ± 0.00	Yellow to yellowish brown

Means sharing a common letter (s) within the same column are not significantly different according to Tukey's multiple comparison test.
Urban locations were not included in the statistical analyses.

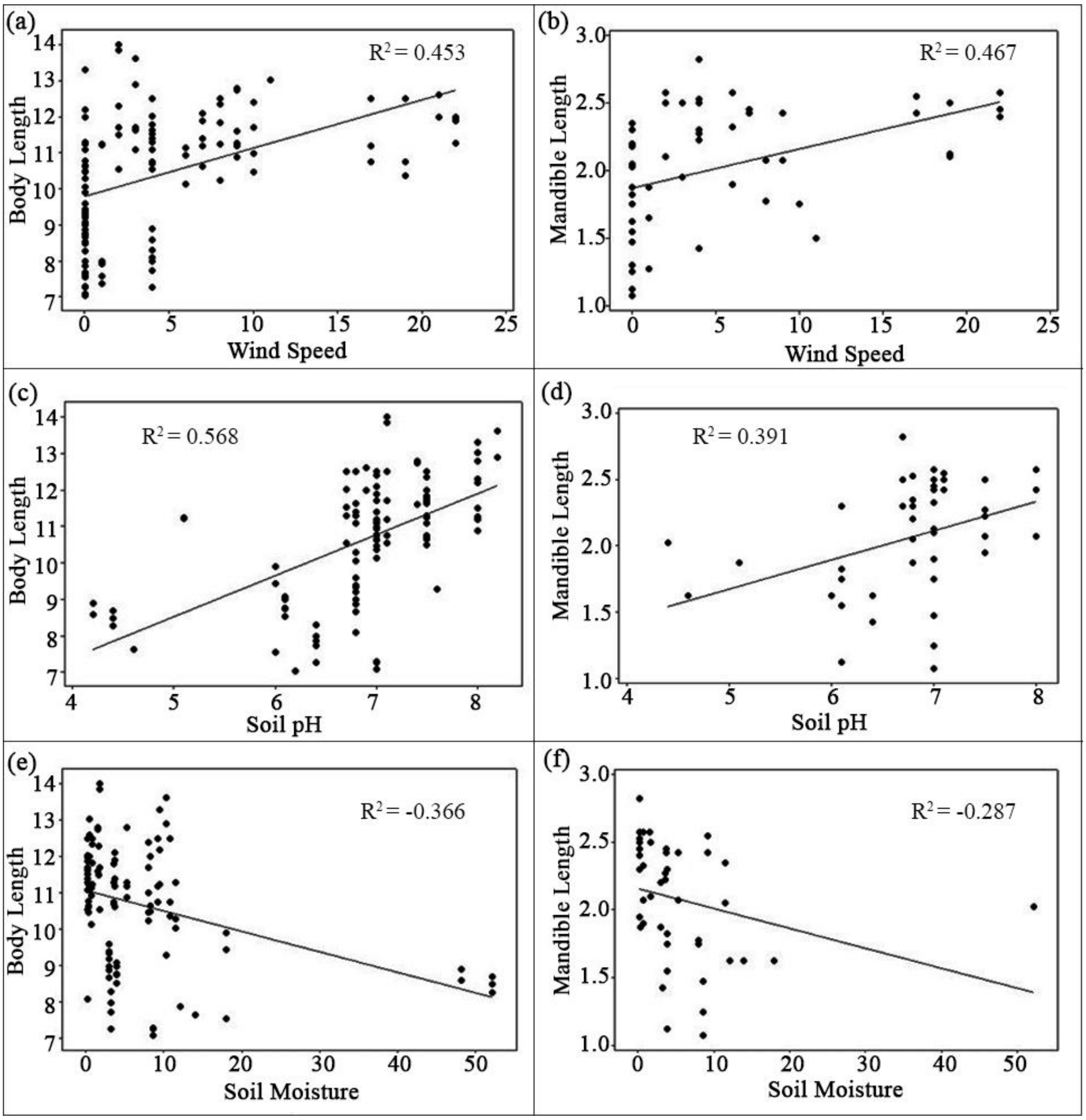

Figure 3. Scatterplots (with regression) showing correlation between (a) wind speed and the body length; (b) wind speed and the mandible length; (c) soil pH and the body length; (d) soil pH and mandible length; (e) soil moisture and the body length and (f) soil moisture and the mandible length of tiger beetles.

Coastal areas possess a high diversity of habitats arranged from the coast to inland sand dunes and therefore promotes a rich insect-species diversity (Spungis, 2002). Reservoir habitats also attract many invertebrates due to accumulated organic matter and high food supply. The reservoirs of Sri Lanka are known to constitute one of the richest sources of wetland biodiversity (GIAHS, 2005; Boccardo *et al.*, 2006). Tiger beetles are predators of a range of invertebrates such as earthworms, spiders, larval glow worms, sandhoppers, bugs, ants and other insects (Hori, 1982; Knisley and Hill, 1992; Satoh *et al.*, 2006; Sinu *et al.*, 2006; Pearson, 2011). Tiger beetles with large mandibles prey upon organisms with a broad range of sizes (1-46 mm), while species with small mandibles are limited to smaller prey (1-12 mm) (Pearson and Stemberger, 1980). Therefore, coastal and reservoir habitats with a rich diversity of invertebrate fauna may favour the presence of larger tiger beetle species in comparison to the smaller ones.

Further, tiger beetles are prey to predators such as insectivorous birds, insectivorous lizards, water scorpions, and dragonflies, wasps of the family

Tiphiidae, beeflies of the family Bombyliidae and robberflies of the family Asilidae (Bhargav and Uniyal, 2008; Pearson, 1990; Schultz, 1983; Sinu *et al.*, 2006). Body size of tiger beetles is related with predation from various predator types and small tiger beetles are consumed by insectivorous lizards, spiders and robber flies while large species are predated upon by insectivorous birds (Pearson, 1990). Robber flies are the most regular predators of tiger beetles and an inverse correlation is found between prey size and attack rate by robber flies (Shelly and Pearson, 1978; Choate, 2010). Robber flies are known to occur in wet habitats of forest ecosystems and their occurrence reflects the availability of prey in the habitat (Vogler and Kelley, 1996; Cannings, 1998). As robber flies prefer tiger beetle species with small body sizes (Shelly and Pearson, 1978), and as their occurrence reflects the availability of prey in the habitat, we can assume that small tiger beetles frequent wet habitats with vegetation such as the shaded banks of rivers.

Soil moisture is a key factor that influences oviposition site selection and habitat segregation of tiger beetles (Cornelisse and Hafernik, 2009; Ganeshaiah and Belavadi, 1986). The female tiger beetle selects sites for oviposition and burrow formation using its posterior abdominal segments that are sensitive to soil moisture content of the habitat. Certain tiger beetle species prefer low moisture levels while others are attracted to high moisture levels. For instance, *Cicindela limbata albissima*, a sand dune specialist, prefers habitats with less than 4% moisture, while *Cicindela tranquebarica* which inhabit riparian and other water edge habitats is always attracted to high moisture levels (Romey and Knisley, 2002). Females of *Cicindela cursitans* and *Cicindela hirticollis* oviposit strictly in moist soils (Brust *et al.*, 2005; Brust *et al.*, 2006). Further, *Cicindela denverensis* and *Cicindela limbalis* which often co-occur in Nebraska are mostly geographically separated as a result of differing moisture preferences (Brust *et al.*, 2012).

Likewise, the tiger beetle species of Sri Lanka may have different soil moisture preferences and species requiring high moisture levels may occupy riverine habitats while species requiring low moisture levels may occupy coastal and reservoir habitats. In the current study the body size of tiger beetles was inversely but weakly correlated with the soil moisture of the habitat (Figures 3 e and f), featuring the presence of large sized tiger beetles in soils of low moisture and smaller species in soils of high moisture.

There are only a few studies that focus on the effects of soil pH differences on tiger beetles. Cornelisse and Hafernik (2009) report that *Cicindela oregona* prefers acidic soil as it is devoid of harmful fungi and bacteria that could infect larvae. However, present study revealed that large populations of tiger beetles were found in coastal habitats with alkaline soils and reservoir habitats with neutral soils. Fungi are known to grow more readily in alkaline sands (Cornelisse and Hafernik, 2009), and coastal habitats that are significantly more alkaline than reservoir habitats (pH = 7.08) can be expected to be unfavourable to the occurrence of tiger beetles. However, as the sandy soils of coastal habitats are significantly saline and as increased salinity negatively affects growth and infectivity of various fungi (Cornelisse and Hafernik, 2009), the low occurrence of tiger beetle species in coastal habitats can be justified. The present study further reports that tiger beetles with large body sizes are found in habitats with neutral to alkaline soils, while species that are small occupy habitats with acidic soils.

Wind speed is also an important feature of tiger beetle habitat, though this has not been studied in detail. Periodic disturbances by wind prevents vegetation from encroaching upon habitats and provides sparsely vegetated areas that are preferred by tiger beetles for foraging and oviposition (Brust *et al.*, 2006; Warren and Buettner, 2008). At Calamus Reservoir, Nebraska, strong winds blow and trap insects such as grasshoppers, bees, wasps and other beetles within sand dunes which are preyed upon by tiger beetles inhabiting these dunes (Thoma and MacRae, 2008). Trapping of insects may be more favourable for larvae of tiger beetles, which are sedentary predators that feed on small arthropods that they capture from the mouth of their burrows (Fenster *et al.*, 2006). Rearing experiments both in the laboratory and the field by Hori (1982) have shown that the size of the adult tiger beetle depends on the quantity of prey animals consumed during the larval period. Thus, larval tiger beetles that have access to a rich source of insects trapped within sand dunes by high winds may result in adults with larger body sizes. Further, wind speed plays an important role in modifying the environment close to the ground and higher wind speeds can have a desiccating effect through mechanical mixing of the air adjacent to the soil surface (McGinn, 2010). According to Renault and Coray (2004), as the size of an insect increases, there is a proportional decrease in the relative surface area. Hence, an insect of smaller size has a larger relative surface area compared with one of larger size. Therefore, water will be lost through evaporation at a higher rate, through the body of smaller insects compared to that of larger insects. Thus, larger body size will be more favoured in windy places as was seen in the present study where a positive correlation was evident between body size of tiger beetles and wind speed of habitats.

We conclude that tiger beetles of coastal and reservoir habitats of Sri Lanka have large body sizes while species of riverine and urban habitats are small-bodied. The wind speed, soil moisture and soil pH of the habitats may affect the body size of species by influencing prey abundance, oviposition site selection, desiccation and habitat suitability. This study is the first to examine the association of body size of tiger beetles with habitat type and the causes for this association. However, more field studies on prey availability in different habitat types, tiger beetle – predator relationships and larval studies are needed to explain the observed patterns more realistically.

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APPENDIX I.

Table 1. Locations and habitat types of Sri Lanka from which tiger beetles were recorded and collected. (C – Coastal; Ri – Riverine; U – Urban; Re – Reservoir)

Location number	Sampling location	Habitat type	No. of species	Species
1	Mahakanadarawa Wewa, Anuradhapura	Re	01	*Calomera angulata*
2	Nuwara Wewa, Anuradhapura	Re	01	*Myriochila* (*Monelica*) *fastidiosa*
3	Thisa Wewa, Anuradhapura	Re	01	*Calomera angulata*
4	Nachchaduwa Wewa, Anuradhapura	Re	02	*Calomera angulata* *Myriochila* (*Monelica*) *fastidiosa*
5	Tabbowa Wewa, Karuwalagas Wewa	Re	02	*Calomera angulata* *Myriochila* (*Monelica*) *fastidiosa*
6	Kala Wewa, Anuradhapura	Re	01	*Calomera angulata*
7	Kandalama Wewa, Dambulla	Re	02	*Calomera angulata* *Myriochila* (*Monelica*) *fastidiosa*
8	Parakrama Samudra, Polonnaruwa	Re	01	*Calomera angulata*
9	Devahuwa Wewa, Dambulla	Re	03	*Calomera angulata, L. catena, Cylindera* (*Oligoma*) *lacunosa*
10	Batalagoda Wewa, Ibbagamuwa	Re	01	*Calomera angulata*
11	Chilaw Coast, Chilaw	C	01	*Lophyra* (*Lophyra*) *catena*
12	Ma Oya, Alawwa	Ri	02	*Calomera angulata,C.cardoni*
13	We Oya, Yatiyantota	Ri	01	*Cylindera* (*Ifasina*) *labioaenea*
14	Maha Oya, DehiOwita	Ri	01	*Cylindera* (*Ifasina*) *willeyi*
15	Maha Oya Falls, DehiOwita	Ri	01	*Cylindera* (*Ifasina*) *labioaenea*
16	Seethavaka River, Thalduwa	Ri	01	*Cylindera* (*Ifasina*) *labioaenea*
17	Aswathu Oya, Awissawella	Ri	01	*Cylindera* (*Ifasina*) *labioaenea*
18	Heen Ela, Waga	Ri	01	*Cylindera* (*Ifasina*) *labioaenea*
19	Kelani River, Malwana	Ri	01	*Cylindera* (*Ifasina*) *labioaenea*
20	Kelani River, Kirielamulla	Ri	01	*Cylindera* (*Ifasina*) *labioaenea*
21	Kelani River, Kaduwela	Ri	01	*Cylindera* (*Ifasina*) *labioaenea*
22	Biyagama	Ri	01	*Cylindera* (*Ifasina*) *labioaenea*
23	National Museum Garden, Colombo	U	02	*Cylindera* (*Oligoma*) *paradoxa* *Lophyra* (*Lophyra*) *catena*
24	Home Garden, Angoda	U	01	*Cylindera* (*Ifasina*) *labioaenea*
25	Wak Oya, Thummodara	Ri	01	*Cylindera* (*Ifasina*) *labioaenea*
26	Water Canal, Handapangoda	Ri	02	*Cylindera* (*Ifasina*) *waterhousei*, *Cy.*(*Ifasina*) *willeyi*
27	Bopath Falls, Ratnapura	Ri	01	*Cylindera* (*Ifasina*) *waterhousei*
28	Katukurunda Coast	C	01	*Lophyra* (*Lophyra*) *catena*
29	Aluthgama Coast	C	01	*Lophyra* (*Lophyra*) *catena*
30	Induruwa Beach	C	01	*Hypaetha biramosa*
31	Kosgoda Beach	C	01	*Hypaetha biramosa*
32	Morampitigoda Coast	C	01	*Hypaetha biramosa*
33	Habaraduwa Beach	C	01	*Hypaetha biramosa*
34	Matara Beach	C	01	*Hypaetha biramosa*
35	RidiyagamaWewa, Ambalantota	Re	01	*Lophyra* (*Lophyra*) *catena*
36	Karagan Salterns, Hambantota	C	01	*Myriochila* (*Monelica*) *fastidiosa*
37	Kirinda Coast	C	01	*Lophyra* (*Lophyra*) *catena*

Table 2. Average body and mandible lengths of tiger beetles in different habitats of Sri Lanka with standard error values (n=number of individuals)

Habitat	Species	Body length (mm)	Mandible length (mm)
Coastal	All species (*n*=34)	11.68 ± 0.16	2.27 ± 0.09 (n=12)
	Hypaetha biramosa (*n*=16)	12.16 ± 0.23	1.79 ± 0.29 (n=2)
	Lophyra (*Lophyra*) *catena* (*n*=15)	11.27 ± 0.16	2.42 ± 0.05 (n=7)
	Myriochila (*Monelica*) *fastidiosa* (*n*=3)	11.21 ± 0.66	2.24 ± 0.13 (n=3)
Riverine	All species (n=40)	8.77 ± 0.24	1.75 ± 0.08 (n=21)
	Cylindera (*Ifasina*) *labioaenea* (*n*=21)	7.89 ± 0.12	1.58 ± 0.09 (n=11)
	Cylindera (*Ifasina*) *willeyi* (*n*=08)	9.19 ± 0.11	1.90 ± 0.17 (n=3)
	Cylindera (*Ifasina*) *waterhousei* (*n*=07)	8.79 ± 0.27	1.84 ± 0.16 (n=4)
	Calomera cardoni (*n*=3)	13.18 ± 0.74	2.50 (n=1)
	Calomera angulate (*n*=1)	10.55	2.10
Urban	All species (*n*=16)	9.72 ± 0.52 (n=11)	1.94 ± 0.14 (n=8)
	Lophyra (*Lophyra*) *catena* (*n*=11)	11.13 ± 0.21 (n=6)	2.19 ± 0.11 (n=5) 1.525 ± 0.13 (n=3)
	Cylindera (*Oligoma*) *paradoxa* (*n*=4)	7.72 ± 0.15 (n=4)	
	Cylindera (*Ifasina*) *labioaenea* (*n*=1)	9.30	-
Reservoir	All species (*n*=38)	11.29 ± 0.15	2.30 ± 0.06 (n=20)
	Calomera angulate (*n*=25)	11.31 ± 0.16	2.33 ± 0.07 (n=17)
	Myriochila (*Monelica*) *fastidiosa* (*n*=10)	11.67 ± 0.17	2.26 ± 0.19 (n=2)
	Lophyra (*Lophyra*) *catena* (*n*=2)	10.83 ± 0.58	1.775 (n=1)
	Cylindera (*Oligoma*) *lacunosa* (*n*=1)	8.1	-

A difference between *n* values for body length and mandible length exists as broken and worn out mandibles have been disregarded.