Arboreal Tiger Beetles Recorded from Lowland Crop Cultivations in Sri Lanka

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ABSTRACT

Purpose: Thirty-one species of arboreal tiger beetles are known from Sri Lanka of which 25 species are endemic. However, their habitat types are poorly documented and the available records are far outdated. Therefore, a survey of tiger beetles was carried out to determine their present occurrence with emphasis on agricultural habitat types.

Research Method: Forty-six locations of the country, covering eighteen districts, all provinces, representing a majority of bioclimatic zones except those in Montane Sri Lanka were surveyed for arboreal tiger beetles. Sampling was conducted using the visual encounter method. Collected beetles were identified using taxonomic keys and descriptions.

Findings: Eight species of arboreal tiger beetles were collected from the survey. Majority of the species (06) were collected from crop cultivations of coconut and also from tea, fruit farms, betel leaf, cinnamon and pepper. Four species of Derocrania and two species of Tricondyla were recorded from the cultivations and all had fused elytra and hence unable to fly. Derocrania scitiscabra was the dominant arboreal tiger beetle species in the crop cultivations.

Originality/Value: The study documents hitherto unrecorded habitat types for a poorly documented important beetle group of Sri Lanka. It further provides information for future research on the possibility of using arboreal tiger beetles as bio-control agents of insect pests of agricultural crops.

Keywords: Crop cultivations, Arboreal tiger beetles, Derocrania, Tricondyla

INTRODUCTION

Arboreal tiger beetles are predatory insects found predominantly in the tropical and subtropical regions of Asia (Toki et al., 2017). They are found on trees mainly in forested areas such as Pogonostoma sp. inhabiting tree trunks in primary forests of Madagascar (Andriamampianina et al., 2000), species of Tricondyla and Neocollyris found on trees in secondary and primary forests of Philippines (Trautner and Schawaller, 1996), Neocollyris sp. in green vegetation of forests of Kerala, India (Saha and Halder, 1986) and Ctenostoma sp. found in tropical moist forests of Costa Rica (Franzen, 2004). Furthermore, species of Neocollyris and Therates have been recorded from mixed agricultural ecosystems of Philippines (Cabras and Wiesner, 2016), and Neocollyris from coffee plantations in Vietnam (Toki et al., 2017).

Arboreal tiger beetles of Sri Lanka belong to five genera – Collyris, Neocollyris, Protocollyris, Derocrania, Tricondyla, and their habitat types are mostly unknown except Neocollyris and Derocrania who have been recorded from forests (Fowler, 1912) and no recent information is available.

However, it is likely that arboreal tiger beetles can occur in habitat types other than in forests,
as do terrestrial tiger beetles, recorded from Sri Lanka by Dangalle et al., 2012; Dangalle, 2013; Dangalle et al., 2014; Thotagamuwa et al., 2016a; Thotagamuwa et al., 2016b; Thotagamuwa et al., 2017.

Thus, a survey of arboreal tiger beetles was carried out to document their habitat types in the country (Abeywardhana et al., 2019). The present article reports a preliminary finding of this ongoing study – a new habitat type for arboreal tiger beetles, species encountered in this habitat type and locality records.

MATERIALS AND METHODS

Study Area

Forty-six locations in 18 districts representing all provinces and climatic zones of Sri Lanka were surveyed for arboreal tiger beetles from August 2017 to June 2019. Majority of the bioclimatic zones of the country were covered by the survey, except montane zones (Wijesinghe et al., 1993). Several habitat types such as coastal areas, beaches, marshlands, forests, woodlands, river banks, reservoir banks, urban areas and habitats disturbed by human activities, and crop cultivations were included in the survey. The large-scale and small-scale crop cultivations included coconut, tea, mango, pineapple, banana and cashew, cinnamon, pepper and stands of betel leaf.

Collection and identification of arboreal tiger beetles

Arboreal tiger beetles were collected by visual encounter surveys (VES) for a time period of 10 hrs; (8.00hrs. – 18.00hrs.) in a given location. When beetles were encountered, three specimens per site were collected using a standard insect net or by hand picking and preserved in 70% alcohol. Specimens were identified using taxonomic keys of Fowler (1912).

RESULTS AND DISCUSSION

Arboreal tiger beetles recorded from lowland crop cultivations

Arboreal tiger beetles were found in 13 of the 46 locations surveyed. The habitat type of seven of the 13 locations were large to small-scale crop cultivations. Six species of arboreal tiger beetles belonging to the two genera; Derocrania and Tricondyla were identified from the crop cultivations. Four of the species recorded belonged to the genus Derocrania, two species to the genus Tricondyla (Table 01 and Figure 01).

The identified specimens of collected arboreal tiger beetle species have been deposited in the insect collection in the Department of Zoology and Environment Sciences, University of Colombo and bear the voucher specimen numbers LA_DOZE.28 to LA_DOZE.56. This is the first record of arboreal tiger beetles from crop cultivations of Sri Lanka although terrestrial tiger beetles have been documented previously from such habitats. They are Cylindera (Oligoma) paradoxa from a rubber and tea estate in Keeragala, Ratnapura (Thotagamuwa et al., 2017), and Cylindera (Ifasina) labioaenea from rubber estates of the lowland wet zone (Thotagamuwa A. Personal Communication, May 2018). However, the ecological role of the terrestrial tiger beetles of Sri Lanka in agricultural lands has not been studied as their occupancy in agro-ecosystems is rare when compared to other habitat types. However, as arboreal tiger beetles occur more frequently in crop cultivations than in other habitats, their ecological role in crop cultivations of Sri Lanka is worth studying.

According to past literature arboreal tiger beetle species belonging to five genera are found in Sri Lanka. Of them, the three genera – Collyris, Neocollyris, Protocollyris, do not have fused elytra and are able to fly (Dangalle, 2018). However, species of the other two genera, Derocrania and Tricondyla, found in the crop cultivations have fused elytra and are unable to fly. As to why arboreal tiger beetles that are unable to fly are found in the study sites is unclear. Tiger beetles are visual predators on small live arthropods (Cornelisse et al., 2013) and forage in...
search of ants (Satoh and Hayaishi, 2007), other insects, spiders and small crustaceans (Rewicz and Jaskula, 2018). Most of these arthropods are non-fliers and accounts for the largest percentage of animal biomass and biodiversity in agro-ecosystems (Naureen et al., 2019). The presence of large numbers of wingless arthropods may attract the flightless arboreal tiger beetle species more than the species with flying ability. Further, the genera *Derocrania* and *Tricondyla* comprise of larger tiger beetles than the genera *Collyris, Neocollyris* and *Protocollyris* (Fowler, 1912). Large sized tiger beetle species have been known to predate upon small sized tiger beetle species (Hoback et al., 2008) and thus may be the reason why large and small sized species do not occur together.

**TABLE 01: Collection locations of arboreal tiger beetles with their habitats and micro-habitats.**

| Location                                                                 | Spatial Coordinates       | Habitat Type                      | Micro-habitat of Beetles                                      | Beetle Species Collected                                      |
|--------------------------------------------------------------------------|---------------------------|----------------------------------|-------------------------------------------------------------|-------------------------------------------------------------|
| Dambadeniya, Kurunegala District, North-Western Province (Intermediate zone) | 7°39´98" N 80°17´60" E   | Coconut cultivation              | Coconut tree trunk 10 – 25 cm above ground.                  | *Derocrania scitiscabra*                                     |
| Opanayaka, Ratnapura district, Sabaragamuwa province (Wet zone)          | 6°62´55" N 80°64´62" E   | Tea cultivation                  | Tea bushes                                                  | *Derocrania scitiscabra*                                     |
| Mahawa, Kurunegala district, North-Western province (Intermediate zone)  | 7°69´12" N 80°26´28" E   | Coconut cultivation              | Coconut tree trunk closer to the ground.                    | *Derocrania scitiscabra*                                     |
| Malsiripura, Kurunegala district, North-Western province (Intermediate zone) | 7°61´89" N 80°54´73" E   | Coconut cultivation mixed with pepper. | Coconut tree trunk.                                           | *Derocrania scitiscabra*                                     |
| Aralaganwila, Polonnaruwa district, North-Central province (Dry zone)    | 7°76´25" N 81°15´55" E   | Betel cultivation                | On vines                                                    | *Derocrania scitiscabra*                                     |
| Vellankulam, Mannar district, Northern province (Dry zone)               | 9°18´65" N 80°15´01" E   | Fruit farm consisting of mango and cashew | Trunk and branches of trees                                 | *Derocrania concinna*                                          |
| Waulpane, Ratnapura district, Sabaragamuwa province (Wet zone)           | 6°43´23" N 80°72´31" E   | Mixed cultivation of cinnamon and pepper | On ground amongst cultivation                               | *Derocrania concinna*                                          |
| Thoppigala, Batticaloe district, Eastern province (Dry zone)             | 7°49´73" N 81°24´52" E   | Forest                           | Trunk and branches of trees                                 | *Derocrania concinna*                                          |
| Bodinagala, Kalutara district, Western province (Wet zone)               | 6°72´45" N 80°15´59" E   | Forest                           | Trunk and branches of trees                                 | *Neocollyris bonelli*                                          |
| Kirinda, Hambantota district, Southern province (Dry zone)               | 6°24´04" N 81°33´69" E   | Area surrounding a reservoir     | Trunk and branches of trees                                 | *Tricondyla gounellei*                                         |
| Bibile, Moneragala district, Uva province (Intermediate zone)            | 7°17´59" N 81°29´64" E   | Home garden                      | On a tree log                                               | *Derocrania scitiscabra*                                     |
| Beliatta, Hambantota district, Southern province (Dry zone)              | 6°10´61" N 80°71´06" E   | Woodland                         | Bark of tree trunks                                         | *Derocrania scitiscabra*                                     |
| Kantalai, Trincomali district, Eastern province (Dry zone)               | 8°38´39" N 81°00´85" E   | Woodland                         | Trunk and branches of trees                                 | *Derocrania scitiscabra*                                     |
The most common arboreal tiger beetle species found from the crop cultivations was *Derocraania scitiscabra*. The species was found from five agricultural lands of which three were coconut cultivations and the others a tea estate and a betel leaf cultivation. The coconut cultivations were located in the Kurunegala district of the intermediate zone of the country while the tea estate was located in Opanayaka, Ratnapura district of the wet zone. The betel leaf cultivation was in the dry zone in Aralaganwila of Polonnaruwa district (Table 01 and Figure 01).

*Derocraania scitiscabra* has been recorded more than a century ago from the forests of Kandy (Fowler, 1912), but never in agricultural lands with crop cultivations. However, their micro-habitat has been recorded as trunks of trees by Fowler (1912), which is confirmed by the present study.

*Derocraania scitiscabra* occurred as the only arboreal tiger beetle species in all of its locations and did not co-occur with other arboreal tiger beetle species. Other species of the genus *Derocraania* such as *D. concinna* and *D. nietneri* co-occur in the fruit farms of Vellankulam, and *D. concinna* and *D. schaumi* in cinnamon and pepper cultivations of Waulpane were found to co-occur. The species at Vellankulam further co-occur with two other species of the genus *Tricondyla*, *T. granulifera* and *T. gounellei*, and were found on the trunks and branches of mango and cashew trees (Table 01). The present study recorded *Tricondyla gounellei* for the first time in Sri Lanka.
Furthermore, the present study recorded four arboreal tiger beetle species to co-occur in the fruit farms of Vellankulam.

Co-occurrence is a common phenomenon observed in different species of tiger beetles for different reasons. It has many advantages such as providing thermoregulation, camouflaging against birds and other potential vertebrate predators and synchronizing reproduction and dispersal (Bhargav and Uniyal, 2008). However, co-occurrence initiates competition amongst species for resources (Brosius and Higley, 2013) and therefore, tiger beetles that co-occur are known to display many physiological and behavioral responses to partitioning of niches within the habitats to reduce competition (Ganeshaiah and Belavadi, 1986; Hoback et al., 2000; Satoh and Hori, 2004). Niche partitioning and habitat segregation may not be possible in coconut and other crop cultivations occupied by Derocrania scitiscabra, due to the lack of a diversity of niches for resource partitioning. The agricultural farms in Vellankulam and Waulpane provide a diversity of niches for the successful co-occurrence of arboreal tiger beetles.

**Characters of the lowland crop cultivations selected by arboreal tiger beetles**

According to the present study, lowland crop cultivations with coconut were the most common habitat type of arboreal tiger beetles even though they were also found in tea, betel leaf, cinnamon, pepper and fruit cultivations. This was also evident in the Philippines when arboreal tiger beetles were recorded from the Mati Protected Landscape which has now been converted to a farmland. Arboreal tiger beetles of genus Neocollyris was found in crop areas thriving with coconut, corn, tamarind and fruit trees (Cabras and Wiesner, 2016). The species recorded from Sri Lanka were found on tree trunks closer to the ground level and on branches, bushes, vines and one species on the ground among crop plants (Table 01).

Tiger beetles are predatory insects that prey upon a large spectrum of insects including Coleoptera, Hymenoptera, Orthoptera, larvae of Lepidoptera, arachnids and small crustaceans (Rewicz and Jaskula, 2013). Crop cultivations consist of such prey in the form of pests, pollinators and members of food webs. Therefore, the habitat preference of arboreal tiger beetles to crop cultivations maybe associated with the prey types and densities that they offer. Further, according to Jaskula (2013) tiger beetles have shown a vegetarian feeding behavior and feed on seeds of maize crop and fruits in periods with low prey availability. As crop cultivations offer both suitable prey and vegetarian foods, preference of arboreal tiger beetles to such habitats can be speculated.

The arboreal tiger beetles of the genera Neocollyris and Tricondyla are reported to oviposit on young branches of Arabic coffee and Liberian coffee trees. The larvae of these genera develop, pupate and emerge as adults from interior branches indicating the importance of coffee plants in the completion of the tiger beetle life cycle (Toki et al., 2017). The crop cultivations of Sri Lanka may also consist of particular plant species that are required for the life cycle completion of arboreal tiger beetles of the country.

**CONCLUSIONS**

Lowland crop cultivations are suitable habitats for arboreal tiger beetles of Sri Lanka. Most of the crop cultivations occupied by these beetles are coconut cultivations. However, species were also observed in tea plantations, fruit farms, betel leaf, cinnamon and pepper cultivations. Six species of arboreal tiger beetles of two genera – Derocrania and Tricondyla, were found from the lowland crop cultivations, of which the majority of species represented genus Derocrania. All species of arboreal tiger beetles recorded from crop cultivations had fused elytra and were unable to fly, while those capable of flight were not recorded from such crop cultivations. Derocrania scitiscabra was the dominant arboreal tiger beetle species of the crop cultivations of Sri Lanka and occurred as the only arboreal tiger beetle species in all locations. However, the other species of Derocrania and species of Tricondyla co-occurred in their respective habitats.
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REFERENCES

Abeywardhana, D.L., Dangalle, C.D. and Mallawarachchi, Y.W. (2019). New record of *Tricondyla gounellii* Horn (Coleoptera, Cicindelinae), an arboreal tiger beetle from Sri Lanka. Proceedings of the 39th Annual Sessions of the Institute of Biology. pp. 24. https://doi.org/10.4038/jnsfsr.v48i2.9402

Andriamampianina, L., Kremen, C., Vane-Wright, D., Lees, D. and Razafimahatratra, V. (2000). Taxic richness patterns and conservation evaluation of Madagascan tiger beetles (Coleoptera: Cicindelidae). Journal of Insect Conservation. 4: 109-128. https://doi.org/10.1023/a:1009667712512

Bhargav, V.K. and Uniyal, V.P. (2008). Communal roosting of tiger beetles (Cicindelidae: Coleoptera) in the Shivalik Hills, Himachal Pradesh, India. Cicindela. 40(1-2): 1-12.

Brosius, T.R. and Higley, L.G. (2013). Behavioral niche partitioning in a sympatric tiger beetle assemblage and implications for the endangered salt creek tiger beetle. PeerJ. 1-18. doi: 10.1777/peerrj.169. https://doi.org/10.7717/peerrj.169

Cabras, A.A. and Wiesner, J. (2016). Tiger beetles (Coleoptera: Carabidae: Cicindelinae) of Mainit Hotspring and Mati Protected Landscape, Mindanao with notes on their ecology and threats. International Research Journal of Biological Sciences. 5(9): 16-21. www.isca.in

Cornelisse, T.M., Vasey, M.C., Holl, K.D. and Letourneau, D.K. (2013). Artificial bare patches increase habitat for the endangered Ohlone tiger beetle (*Cicindela ohlone*). Journal of Insect Conservation. 17(1): 17-22. doi: 10.1007/s10841-012-9482-3. https://doi.org/10.1007/s10841-012-9482-3

Dangalle, C., Pallewatta, N. and Vogler, A. (2012). Tiger beetle (Coleoptera: Cicindelidae) of ancient reservoir ecosystems of Sri Lanka. Journal of Threatened Taxa. 4(4): 2490-2498. https://doi.org/10.11609/jott.o2896.2490-8

Dangalle, C.D. (2013). The current status of the tiger beetle species of the coastal habitats of Sri Lanka. Journal of Tropical Forestry and Environment. 3(2): 39-52. https://doi.org/10.31357/jtte.v3i2.1841

Dangalle, C.D. (2018). The forgotten tigers: the arboreal tiger beetles of Sri Lanka. Journal of the National Science Foundation of Sri Lanka. 46(3): 241-252. doi: http://dx.doi.org/10.4038/jnsfsr.v46i3.8477

Dangalle, C.D., Pallewatta, N. and Vogler, A.P. (2014). Distribution and habitat preferences of tiger beetles (Coleoptera: Cicindelidae) of the riverine ecosystems of Sri Lanka. Journal of Threatened Taxa. 6(9): 6195-6203. https://doi.org/10.11609/jott.o3674.6195-203

Fowler, W.W. (1912). Fauna of British India including Ceylon andBurma (Coleoptera general introduction and Cicindelidae and Paussidae). Today and Tomorrow’s Printers and Publishers, New Delhi, India. 529pp. https://doi.org/10.5962/bhl.title.83566
Franzen, M. (2004). Tiger beetle assemblages in a climatically transitional area of northwestern Costa Rica. Mitteilungen der Münchner Entomologischen Gesellschaft. 94: 87-95.

Ganeshiah, K.N. and Belavadi, V.V. (1986). Habitat segregation in four species of adult tiger beetles (Coleoptera: Cicindelidae). Ecological Entomology. 11: 147-154. doi: 10.1111/j.1365-2311.1986.tb00289.x

Hoback, W.W., Golick, D.A., Svatos, T.M., Spomer, S.M. and Higley, L.G. (2000). Salinity and shade preferences result in ovipositional differences between sympatric tiger beetle species. Ecological Entomology. 25: 180-187. https://digitalcommons.unl.edu/entomologyfacpub/349 https://doi.org/10.1046/j.1365-2311.2000.00256.x

Hoback, W.W., Higley, L.G. and Stanley, D.W. (2008). Tigers eating tigers: evidence of intraguild predation operating in an assemblage of tiger beetles. Ecological Entomology. 26(4): 367-375. https://doi.org/10.1046/j.1365-2311.2001.00333.x

Jaskula, R. (2013). Unexpected vegetarian feeding behavior of a predatory tiger beetle Calomera littoralis nemoralis (Olivier, 1790) (Coleoptera: Cicindelidae). Journal of the Entomological Research Society. 15(1): 1-6.

Naureen, R., Maryam, S., Waqar, M., Fatima, J., Nazia, E. and Shalah, N. (2019). Diversity of arthropods regarding habitat specialty in agro-ecosystem of Faisalabad, Pakistan. GSC Biological and Pharmaceutical Sciences. 6(2): 1-8. doi: https://doi.org/10.30574/gscbps.2019.6.2.0008

Reynolds, S.G. (1970). The gravimetric method of soil moisture determination. Part I: A study of equipment, and methodological problems. Journal of Hydrology. 11: 258-273. https://doi.org/10.1016/0022-1694(70)90066-1

Rewicz, T. and Jaskula, R. (2018). Catch fast and kill quickly: do tiger beetle use the same strategies when hunting different types of prey? PeerJ. 6: 1-17. doi: 10.7717/peerj.5971

Saha, S.K. and Halder, S.K. (1986). Tiger beetles (Coleoptera, Cicindelidae) of Silent Valley (Kerala, India). Records of the Zoological Survey of India. 84(1-4): 137-142.

Satoh, A. and Hayaishi, S. (2007). Microhabitat and rhythmic behavior of tiger beetle Callytron yuasai okinawense larvae in a mangrove forest in Japan. Entomological Science. 10: 231-235. doi: 10.1111/j.1479-8298.2007.00218.x

Satoh, A. and Hori, M. (2004). Interpopulation differences in the mandible size of the coastal tiger beetle Lophyridia angulata associated with different sympatric species. Entomological Science. 7: 211-217. https://doi.org/10.1111/j.1479-8298.2004.00065.x

Thotagamuwa, A., Dangalle, C., Lokupitiya, E., Pallewatta, N. and Wijerathne, T. (2017). New distributional record of Cylindera (Oligoma) paradoxa (W. Horn, 1892) (Coleoptera: Cicindelidae) in Ratnapura district, Sri Lanka. Checklist. 13(3): 1-3. doi: 10.15560/13.3.2127.

Thotagamuwa, A., Dangalle, C.D., Pallewatta, N. and Lokupitiya, E. (2016a). Tiger beetles (Coleoptera: Cicindelidae) of Sri Lanka’s coastal zone: present distribution and diversity. Sri Lanka Journal of Marine Environmental Sciences. 1: 33-43. https://doi.org/10.15560/13.3.2127

Thotagamuwa, A., Sumanapala, A., Dangalle, C., Pallewatta, N. and Lokupitiya, E. (2016b). Found after 107 years: Rediscovery of an endemic tiger beetle Jansenia laeticolor W. Horn (Coleoptera: Cicindelidae) in Sri Lanka. Cicindela. 48(3-4): 77-83. https://doi.org/10.15560/13.3.2127
Toki, W., Pham, H.T. and Hori, M. (2017). Pupa of an arboreal tiger beetle, *Neocollyris similis* (Lense) (Coleoptera: Carabidae: Cicindelinae), from the internode cavity of a reed. The Coleopterists Bulletin. 71(1): 202-203. doi: 10.1649/0010-065X-71.1.202

Trautner, J. and Schawaller, W. (1996). Larval morphology, biology and faunistics of Cicindelidae (Coleoptera) from Leyte, Philippines. Tropical Zoology. 9: 47-59. doi: 10.1080/03946975.1996.10539302.

Wijesinghe, L.C.A de S., Gunatileke, I.A.U.N., Jayawardene, S.D.G., Kotagama, S.W. and Gunatileke, C.V.S. (1993). Biological conservation in Sri Lanka: A national status report. IUCN World Conservation Union, Sri Lanka. https://doi.org/10.1016/0006-3207(85)90032-1