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## NATURAL HISTORY AND CONSERVATION OF HALY'S TREE SKINK (*DASIA HALIANA*) IN DRY ZONE FORESTS OF SRI LANKA

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**Abstract.**—The endemic lizard *Dasia haliana* of Sri Lanka is considered an arboreal skink. There is little information on the natural history and distribution of this species. To fill-in such knowledge gaps of this endemic skink, we conducted a multi-year survey within the dry and intermediate climatic zones of Sri Lanka and conducted investigations on habitat associations, microhabitat use, foraging, behavior, and basic community structure. Their presence showed close affinities with relatively closed canopy with dappled sunlight, moderate humidity, and high substrate and ambient temperatures. While our study confirmed that *D. haliana* is primarily arboreal, the skink also occupied non-arboreal (terrestrial and sub-fossorial) habitats to a substantial extent, especially when inactive. We also emphasized the urgent need to promote conservation of *D. haliana* and other understudied, cryptic herpetofauna of Sri Lanka through a multitude of conservation actions including habitat management inside and outside the protected area network, conservation-driven ecological research, public outreach, and science-based policy revisions.

**Key Words.**—behavior; climate; distribution; ecology; microhabitat; population; threats

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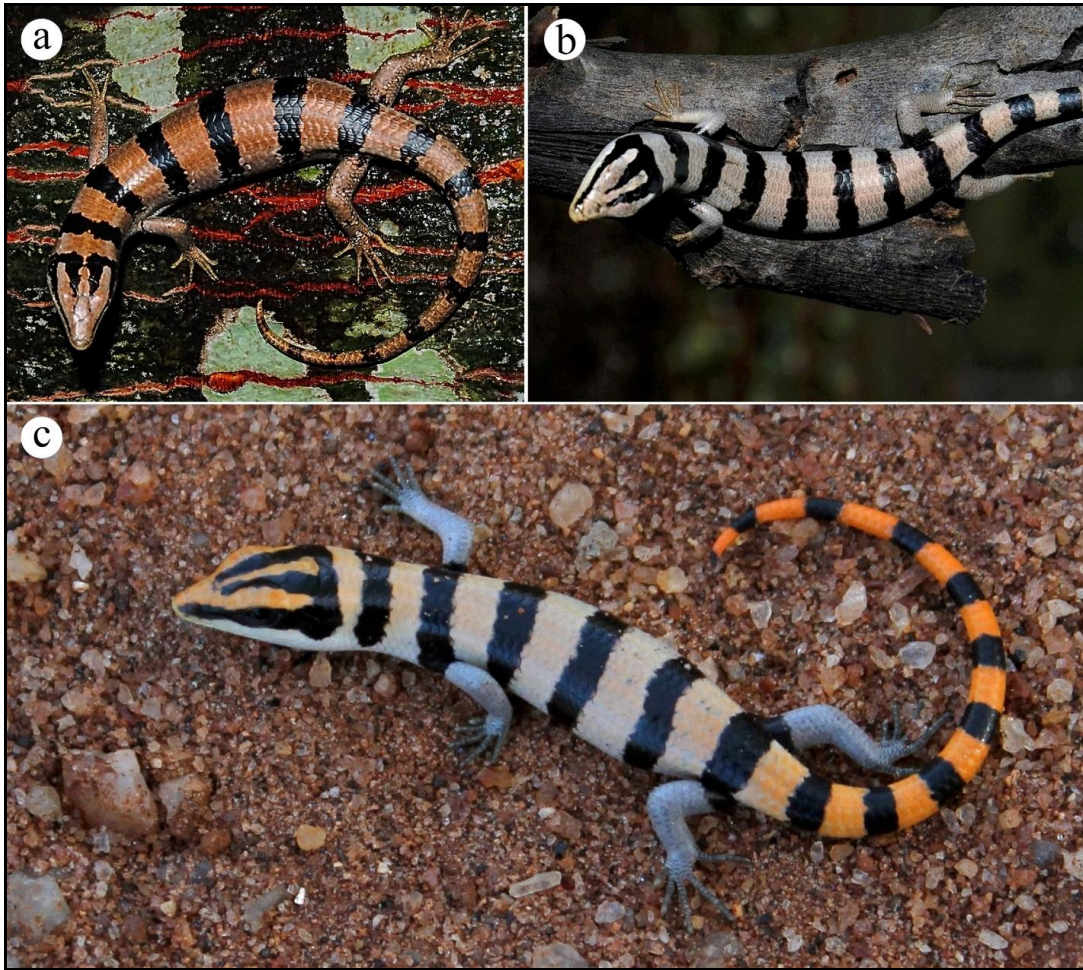
### INTRODUCTION

There are 32 species of skinks (Sauria, Scincidae) found in the Indian Oceanic tropical island of Sri Lanka and of those, 25 are endemic (Karunaratna et al. 2008; Somaweera and Somaweera 2009). Currently, four species are considered Critically Endangered, 13 Endangered, three Vulnerable, one Near Threatened, and five Data Deficient (Ministry of Environment 2012). These national-level conservation assessments are in stark contrast to those of the International Union for Conservation of Nature (IUCN) Red List that classifies only one Endangered species, one Near Threatened Species, three Least Concerned species, and one Data Deficient species (International Union for Conservation of Nature 2015). Although both conservation assessments used the same IUCN Red List criteria, the national assessment is based on a greater volume of literature and expert knowledge of Sri Lankan field biologists and thus may reflect more accurate assessment of species endangerment than the IUCN Red List (Gärdenfors et al. 2001).

Skinks are largely microcarnivores that occupy a diverse array of fossorial, terrestrial, and arboreal habitats. For instance, basal genera such as *Chalcidoseps* and *Nessia* are largely fossorial and *Lankascincus* are terrestrial and sub-fossorial, whereas more derived

genera such as *Eutropis* are terrestrial (Das and de Silva 2005). The skink fauna of Sri Lanka is composed of 19 evolutionary relict taxa belonging to the following genera: *Chalcidoseps* (one species), *Lankascincus* (10 species) and *Nessia* (eight species; Somaweera and Somaweera 2009).

The members of the genus *Dasia* (Gray 1839) are mostly arboreal skinks, and they live on large trees with dense canopy cover in dry habitats (Smith 1935; Taylor 1950; Greer 1970; Harikrishnan et al. 2012). Globally, there are nine species in the genus *Dasia* with three species restricted to India (Chandramouli and Amarasinghe 2015; Uetz, P., and J. Hallermann. 2015. The Reptile Database. Available from <http://www.reptile-database.reptarium.cz> [Accessed 20 August 2015]), but only a single endemic skink is found in Sri Lanka: *Dasia haliana* (Nevill 1887; Fig. 1). Although the taxonomy and phylogenetic relationships of *Dasia haliana* (Haly's Tree Skink) are well established (Deraniyagala 1953; Wickramasinghe et al. 2011, Harikrishnan et al. 2012; Chandramurthi and Amarasinghe 2015), we are not aware of any long-term, field-based studies across a broad geographic region that have focused on habitat associations. *Dasia haliana* is a rare species restricted to the low country intermediate zone and the lowland dry zone, and it appears to be relatively common in the latter (Adithya 1968; Samarakoon 2004; de Silva et al. 2005;



**FIGURE 1.** Known color variation or color morphs of *Dasia haliana* in Sri Lanka: (a) female from Karandagolla forest in 2010, (b) male from Mihintale forest in 2014, (c) sub-adult from Giritale forest in 2012. (Photographed by Dushantha Kandambi [a,b] and A. Jayasooriya [c]).

Somaweera and Somaweera 2009; Karunaratna and Amarasinghe 2011). Currently, this species is categorized as Near Threatened in the national Red List of threatened species (Ministry of Environment 2012). According to published literature, *D. haliana* has been mostly recorded from northern, eastern, and north-central parts of Sri Lanka (Deraniyagala 1931, 1953; Taylor 1950; de Silva et al. 2005; Somaweera and Somaweera 2009). In this research, we investigated the distribution, habitat use, behavior, and ecology of *D. haliana* based on field observations, experiments, and published literature.

#### MATERIALS AND METHODS

**Field work and data collection.**—We surveyed the focal species, *D. haliana*, using 158 random field visits island-wide, across both dry and intermediate

bioclimatic zones of Sri Lanka during different seasons for 10 y (2004–2014). We surveyed different types of habitats in protected and unprotected forests, well-shaded monasteries, and home gardens located at the ecotone of the above bioclimatic zones. In a given survey site, we actively searched an area of 10 ha, thoroughly examining the arboreal habitats such as tree trunks, foliage, rock outcrops, as well as fossorial habitats such as leaf litter, downed woody debris, and earthen crevices. We visited sites during the morning, evening, and night, before and after the sunset (0700–1500, 1600–1900, 2000–2400). The survey time was determined based on the active period of the focal species. In addition to our field observations, we examined museum specimens (National Museum of Sri Lanka, Colombo), consulted other herpetologists, interviewed local people on their opportunistic observations, and read all available literature.

TABLE 1. Current distribution records and habitat data of *Dasia haliana* in Sri Lanka.

District	Closest city/town	Coordinates (N & E)		Elevation (m)	Habitat types	Climatic zones
Ampara	Buddhangala	07°20'11.75"	81°42'34.58"	28	Dense forest	Dry
Ampara	Kekirihena	07°30'27.02"	81°19'59.06"	83	Forested home garden	Dry
Ampara	Hulannuge	06°54'54.39"	81°41'26.24"	48	Dense forest	Dry
Ampara	Kudumbigala	06°40'12.03"	81°44'40.14"	64	Dense forest	Dry
Puttalam	Kalivillu	08°28'55.97"	79°56'26.33"	16	Dense forest	Arid
Anuradhapura	Mihintale	08°20'58.14"	80°30'53.16"	174	Dense forest	Dry
Anuradhapura	Jethawanaramaya	08°21'11.37"	80°24'18.00"	81	Dense forest/ monasteries	Dry
Anuradhapura	Eppawa	08°08'43.52"	80°24'51.17"	48	Forested home garden	Dry
Matale	Pidurangala	07°58'02.20"	80°45'19.95"	195	Forested home garden	Intermediate
Matale	Kandalama	07°56'58.47"	80°43'31.13"	298	Forested home garden	Intermediate
Matale	Sigiriya	07°57'01.46"	80°45'42.12"	225	Dense forest/ monasteries	Intermediate
Matale	Pitawala	07°32'50.61"	80°45'17.15"	820	Dense forest	Intermediate
Matale	Thelgamuoya	07°32'11.64"	80°46'21.17"	496	Dense forest	Intermediate
Polonnaruwa	Kawudulla	08°13'28.00"	80°56'42.61"	97	Dense forest	Dry
Polonnaruwa	Giritale	08°00'02.47"	80°35'37.44"	131	Agriculture	Dry
Polonnaruwa	Angammedilla	07°54'29.10"	80°54'44.72"	128	Dense forest	Dry
Polonnaruwa	Minneriya	08°01'49.94"	80°49'59.09"	122	Dense forest	Dry
Polonnaruwa	Dimbulagala	07°51'20.54"	81°07'45.19"	127	Forested home garden	Dry
Badulla	Ulhitiya	07°28'40.62"	81°06'13.11"	377	Dense forest	Intermediate
Badulla	Karandagolla	06°49'36.04"	81°05'41.67"	425	Dense forest	Intermediate
Hambantota	Sithulpauwa	06°23'23.76"	81°27'08.91"	54	Dense forest/ monasteries	Arid
Hambantota	Akasa-chaihya	06°20'33.71"	81°27'48.59"	47	Dense forest	Arid
Monaragala	Nilgala	07°12'13.59"	81°19'29.85"	218	Dense forest/ monasteries	Intermediate
Monaragala	Heenoya	06°30'29.98"	81°08'12.71"	85	Dense forest	Dry
Monaragala	Pokunutenna	06°34'31.22"	80°53'52.53"	128	Dense forest	Dry
Monaragala	Agunukolapalessa	06°27'31.74"	81°01'52.39"	149	Dense forest	Dry

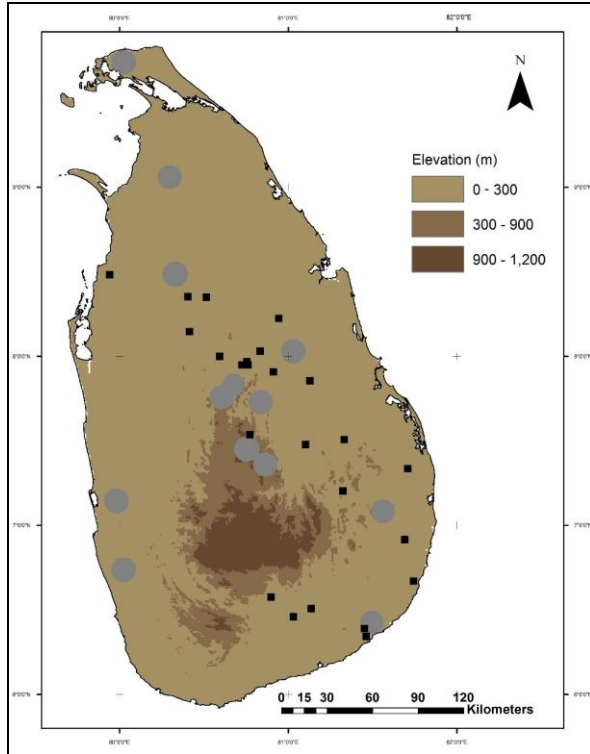
During the field survey, we made notes on many aspects of the natural history of the focal species and habitat characteristics of the survey sites. We recorded the ambient temperature with a standard thermometer, substrate temperature with N19 Q1370 an infrared thermometer (Dick Smith Electronics, Shanghai, China), and relative humidity and light intensity with a QM 1594 multifunction environment meter (Digitek Instruments Co., Ltd, Hong Kong, China). We measured elevation using an eTrex® 10 GPS (Garmin, Johannesburg, South Africa). We made behavioral observations at an average distance of 3–4 m from the focal individuals. We also measured the locomotion speed of seven lizards (total distance travelled continuously along natural vertical substrates divided by time taken for such movements).

**Ex-situ experiment.**—We conducted a brief (two-month long) mesocosm experiment in a small (length × width × height = 120 × 70 × 50 cm) enclosure using six captive animals to investigate their habitat use. The enclosures resembled the natural environment of the species. The bottom contained dry, sandy soil to a depth

of 60 mm. We placed three pieces of dry coarse woody debris (150–200 mm long, 40–80 mm wide, and 20–40 mm deep) horizontally on the soil. We placed three tree branches (300–400 mm long) vertically inside the mesocosm. We intermittently noted the habitat occupancy of all individuals for 14 h per day for the entire duration of the experiment. All daily observations were done during 1600–1900 and 2000–2400, which was the same as our field observation period.

## RESULTS

Throughout our survey, we recorded 23 adults, 11 sub-adults, and two juveniles; we did not find eggs or gravid females. The focal species was rare in our study areas: we only found on average fewer than two individuals per site. Most often, we found lizards at densely forested home gardens, well-shaded monasteries, and lowland (16–496 m elevation) Tropical Dry Mixed Evergreen and Tropical Moist Semi-evergreen forests (Table 1). We found them in the Ampara, Anuradhapura, Badulla, Hambantota, Matale,



**FIGURE 2.** Distribution map of *Dasia haliana* in Sri Lanka (historic records: grey-color circles / current records: black-color square). Elevation given as meters above sea level. (Historical records were based on Somaweera and Somaweera 2009).

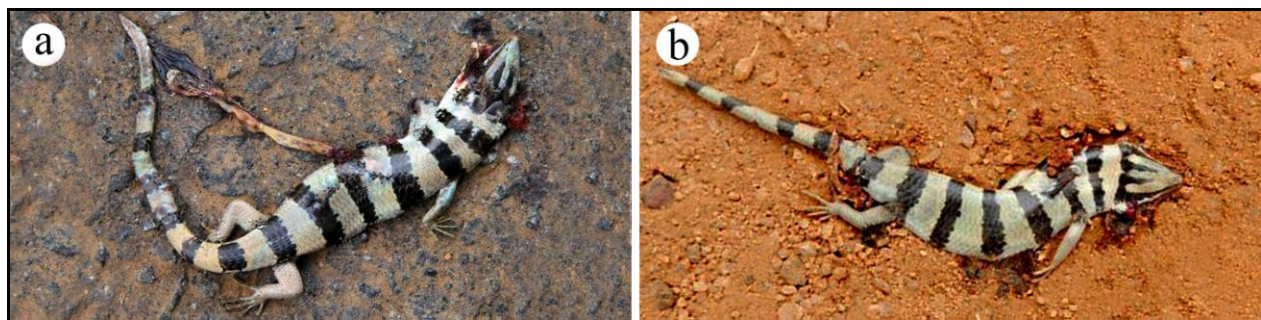
Monaragala, Polonnaruwa, and Puttalam districts of Sri Lanka (Fig. 2). In addition, through opportunistic observations, we noted five road kills of the focal species (Fig. 3) at different road types (e.g., tar roads and gravel roads) at five distinct locations.

Of 36 diurnal observations, we found *D. haliana* predominantly in arboreal habitats (20 observations: 55.6%). We infrequently noted our focal species in several non-arboreal habitats (44.4%): subfossorial habitats (five occasions), rocks and coarse woody debris

(seven occasions), and leaf litter (four occasions). Their microhabitats included mature tree trunks with cracked (18–45 cm in diameter), partially peeled bark as well as inside tree holes of mature woody tree species (*Mangifera zeylanica*, *Madhuca longifolia*, *Ficus mollis*, *Chloroxylon swietenia*, *Schleichera oleosa*, *Tamarindus indica*, *Bridelia retusa*, *Drypetes sepiaria*, *Careya arborea*, *Mischodon zeylanicus*, *Mimusops hexandra*). At the Knuckles Massif, we observed a single individual of *D. haliana* for several days living inside a tree hole and coming out around 0900 to bask. In a few occasions, we found this species on smooth tree trunks (without many crevices in the bark) of introduced tree species (*Acacia auriculiformis*). The above-mentioned microhabitats were relatively dry, relatively cool, well-shaded, but had a humid microenvironment (Fig. 4).

During our attempts to capture and handle these skinks, they occasionally bit the capturer. Therefore, it is unlikely that *D. haliana* frequently displays biting behavior as a sign of aggression or for defensive purposes. If disturbed, *D. haliana* hid in tree crevices or tree holes but never attempted to descend to the ground nor sought fossorial refugia. When disturbed with presence of birds of prey or a shadow of similar appearance, they ran upward along the trunk and hid within the bark or tree holes. We have never observed them running downward to seek refuge upon detecting a threat. They ascended tree trunks for an average height of 4 m up to a maximum height of 7 m at a very slow pace (0.016–0.020 m/s).

During observations on basking behavior, we noted 1–4 sun spot openings (diameter about 20–50 mm) in close association of their microhabitats. We noted that this species started basking in sunspots between 1000–1200. The temperature of the basking substrate varied between 28.4–29.7° C; the light intensity and the humidity ranged between 3,428–4,047 lux and 51–64%, respectively. During the evening hours (after 1600), the lizard sought refuge in crevices or holes.



**FIGURE 3.** Road kills *Dasia haliana* in Sri Lanka: (a) near Giritale Forest in 2012, (b) near Sigiriya Forest in 2014. (Photographed by Ishara Wijewardana [a] and Tharanga Herath [b]).



**FIGURE 4.** Habitats of *Dasia haliana* in Sri Lanka: (a) dense forest in Heenoya, Monaragala District in 2008, (b) elimination of forest covers for development project, Eluwankulam, Puttalam District in 2009. (Photographed by D.M.S. Suranjan Karunaratna).

**Observations on the ex-situ experiment.**—All individuals burrowed into the loose sand and remained inactive inside sandy soil (10–30 mm depth) of the enclosures during the night. None of the lizards used the erected tree branches or woody debris as nocturnal refugia. During day time (0700–1400), lizards emerged from the sand and stayed under the woody debris.

**Diet and foraging strategies.**—The diet consisted mostly of ants, small tree-dwelling spiders (including jumping spiders), tree dwelling hoppers, crickets, and coleopterans. When foraging actively, we noted that this skink moved through leaf-litter layer on the ground. In temporary *ex-situ* conditions (six animals, two enclosures), we successfully fed them with grasshoppers (10–20 mm long and 3–5 mm width / brown and green colors), small centipedes (25–40 mm long), cockroaches (10–15 mm long), and house flies (10–15 items of each prey type, with 30–40 feeding sessions where prey items were simply released into the enclosures in a day). *Dasia haliana* appeared to be a solitary, active hunter but rarely performed sit-and-wait hunting. During our field observations, we only observed one individual per site when they hunt. We never observed them feeding or foraging in groups, or denning together.

**TABLE 2.** Environmental variables measured for all captured individuals of *Dasia haliana* in Sri Lanka.

Environmental variables	Average value (± SD)	Range
Percentage canopy cover (%)	52.95 ± 14.04	30–80
Body surface temperature (°C)	28.77 ± 0.21	28.5–29.1
Substrate temperature (°C)	29.24 ± 0.47	28.4–29.7
Ambient temperature (°C)	30.9 ± 0.87	30.0–32.5
Relative humidity (%)	60.2 ± 4.77	51–67
Light intensity (Lux)	3,780.6 ± 226.1	3,428–4,047

**Habitat features and the community structure.**—*Dasia haliana* occurred in relatively warm, humid (about 60% relative humidity) habitats with a moderate canopy cover (> 50%) where both ambient and substrate temperatures were relatively high (30° C; Table 2). We did not find any other skink species in close association with *D. haliana*; however, four species of geckos (*Hemidactylus depressus*, *H. frenatus*, *H. leschenaultii*, *H. parvimaclulatus*) and two species of agamid lizards (*Calotes calotes* and *C. versicolor*) were sympatric with *D. haliana*. We also noted a few natural predators (three snake and one bird species) of our focal species: Sri Lanka Flying Snake (*Chrysopelea taprobanica*), Common Bronze Back (*Dendrelaphis tristis*), Ceylon Cat Snake (*Boiga ceylonensis*), and Grey Hornbill (*Ocyrceros gingalensis*; Fig. 5).

## DISCUSSION

Our field observations suggested that *D. haliana* is a diurnal, predominantly arboreal skink widely distributed in both dry zone and intermediate zone of Sri Lanka. More than half of the individuals were recorded in arboreal habitats, mostly on mature tree trunks. These findings are consistent with previous observations (Deraniyagala 1953; Wickramasinghe et al. 2011). However, the focal species was not exclusively arboreal. Field surveys as well as the mesocosm experiment revealed substantial use of fossorial habitats, especially as refugia when the skinks were inactive. Use of non-arboreal habitats by *D. haliana* was rarely reported in scientific literature (Deraniyagala 1953; de Silva et al. 2005) and we were not aware of any such records from recent publications. Our study indicated that the distribution of *D. haliana* is patchy and fragmented within its extent of occurrence; the altitudinal distribution is restricted to a narrow, low-elevation range of 16–496 m.

In general, diurnal skinks of Sri Lanka are active from 0700 to 1500 and are able to move very briskly on tree



**FIGURE 5.** Partially eaten *Dasia haliana* by chicks of Sri Lanka Grey Hornbill (*Ocyrceros gingalensis*) in the breeding season in 2006 in the Wilpattu Forest of Sri Lanka. (Photographed by D.M.S. Suranjan Karunarathna).

barks, especially when disturbed (Deraniyagala 1953; pers. obs.). In contrast, *D. haliana* is much slower than any other Sri Lankan skinks in terms of movements, even when searching for foods or climbing a tree (Somaweera and Somaweera 2009). Our study emphasized the importance of densely forested areas for the persistence of *D. haliana* populations. Such patterns of distribution and habitat use are consistent with other Sri Lankan skinks that are largely dependent on well-shaded, mature forests with thick leaf litter (de Silva et al. 2005; Karunarathna et al. 2008).

**Threats and conservation.**—Habitat degradation and loss of mature dry evergreen and moist deciduous forests could be the major threat encountered by *D. haliana* throughout its distribution range. Furthermore, mature forest patches and scrubland habitats where we found this species are small in size and are highly fragmented. The population densities of *D. haliana* are already low (approximately 1.5 individuals/km<sup>2</sup>) in those habitats (pers. obs.). Therefore, conservation of these small habitat fragments and establishment of connectivity to facilitate metacommunity dynamics is crucial to ensure long-term viability of these imperiled populations. The roadkills we noted suggested that habitat fragmentation might impede movements and dispersal of our focal species. In addition, habitat loss due to exurban development (development of semirural, human-inhabited communities outside suburban areas), infrastructure expansion, and commercial agriculture make conservation challenging (Ranjitsinh 1997; FAO 2001). Setting fire on grasslands to manage cattle and chena (slash-and-burn) cultivation may have a strong negative impact on our focal species.

Although the skink fauna of Sri Lanka is protected by both the Fauna and Flora protection (Amendment) Act, (No. 22, 2009) and the Forest (Amendment) Act, (No. 65 of 2009), enforcement of such laws are not satisfactory. These statutes have not been effectively used to develop land-use policies or to enforce strict environmental regulations in the context rural land

development. We strongly suggest that public-sector land stewards of Sri Lanka revise current environmental policies to support preservation and management of cryptic herpetofauna. Implementation of eco-friendly land management practices in rural development and controlled fire regimes may benefit conservation of regional wildlife and their habitats. Similar efforts in community-based conservation and participatory natural resource management have been strongly advocated elsewhere (Gunatilake 1998; Joblin et al. 2004; Ovaska et al. 2004). Of the 25 surveyed locations where *D. haliana* was present, 17 of them were located outside the network of state protected areas in Sri Lanka. Because none of these habitats are committed to conservation, the persistence of these populations in future is questionable. Therefore, incorporation of undeveloped and least-modified private lands for conservation is imperative.

**Concluding remarks.**—Our study confirmed that *D. haliana* is largely arboreal, especially during their active period. Being limited to dense, well-shaded close-canopy mature forests provide further evidence of the arboreal nature of *D. haliana*; however, they use non-arboreal habitats extensively when they are inactive during the night. Our findings on habitat requirements and other niche dimensions of *D. haliana* may help develop basic local-scale habitat management plans. Although our focal species is found across multiple bioclimatic zones of Sri Lanka, their distribution is patchy and they are locally rare (fewer than two individuals per surveyed locations). Intensive, multi-seasonal continuous population monitoring that accounts for imperfect detection is required to ascertain the true population size of this species, especially in locations where this species was historically detected but not found in the current study. Detailed investigations on their breeding biology (mating frequency, mating systems, mate choice, and reproductive success) can substantially contribute to conservation efforts. Give the high endemism of skinks of Sri Lanka (about 78% of species), natural history studies such as ours are of great value to support conservation of these unique species.

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## Herpetological Conservation and Biology



**SURANJAN KARUNARATHNA** is a Field Biologist conducting research on herpetofaunal behavior, ecology, taxonomy, and promoting conservation awareness of the importance of biodiversity among the Sri Lankan community. He worked as an ecologist for the IUCN Sri Lanka, and as a country assistant for the Born Free Foundation Sri Lanka. Also he is an active member of many specialist groups in the IUCN/SSC, and expert committee member of Herpetofauna in National Red List development program, Sri Lanka. (Photographed by Seshadri Kadaba Shamanna).



**THILINA SURASINGHE** did his Ph.D. in Wildlife Biology at Clemson University, South Carolina, USA. He is an ecologist; his academic training encompasses different aspects of biology, ecology, and environmental sciences and natural resources management. He is experienced in teaching undergraduates in biology, environmental sciences, and social sciences. Currently, he works for Bridgewater State University as an Assistant Professor in Biological Science. He takes part in projects on landscape-scale biodiversity assessments, Red List assessments, conservation planning, GIS based threat and GAP analyses, and EPA protocols. (Photographed by Nathan Weaver).



**MAJINTHA MADAWALA** is a Naturalist who began his career and wildlife interests in 1995 as a member of the Young Zoologists Association (YZA), Department of National Zoological Gardens of Sri Lanka. He holds a Diploma in biodiversity management and conservation from the University of Colombo. As a conservationist, he is engaged in numerous habitat restoration and snake rescue programs in biodiversity research projects. Also, he is an active member of Crocodile Specialist Group in the IUCN/SSC. (Photographed by Kushani Dharmabandu).



**DUSHANTHA KANDAMBI** working as a venom extractor at the Snake Venom Research Laboratory and Herpetarium in Faculty of Medicine, University of Colombo. He is also engaged in a captive breeding program on threatened species and lots of snakes rescue events. He started his passion to explore much of the islands rare and endangered animals at a very young age (15 years old). Additionally, he promotes conservation awareness of the importance of snake fauna among the Sri Lankan community. He is a wildlife artist and photographer enjoying the nature. (Photographed by Ranjani Jayasundara).



**THARAKA PRIYADARSHANA** is a graduate from the University of Sabaragamuwa, and his scientific exploration of biodiversity began with the Young Zoologists' Association (YZA) in late 2008. He is a dedicated researcher doing the study of the life cycle, distribution, behavior, ecology, and conservation of butterflies, dragonflies, and wild orchids in Sri Lanka. He also is conducting wildlife photographic, biodiversity conservation, and education programs for the Sri Lankan community. (Photographed by Loshana Wickramasingha).



**ANSLEM DE SILVA** M.Sc, D.Sc (Univeristy of Peradeniya) started keeping turtles and reptiles at an early age of seven, and he is currently teaching herpetology at the Rajarata University of Sri Lanka. He has conducted surveys on the herpetofauna in most of the important ecosystems in the country and has published more than 400 odd papers of which nearly 60 are books and chapters in books. Anslem had done yeomen service to the country and the region for more than 50 y. He is the Regional Chairman of the Crocodile Specialist Group for South Asia and Iran, Co-Chair of the Amphibian Specialists Group IUCN/SSC Sri Lanka, and the president of the Amphibian and Reptile Research Organization (ARROS) of Sri Lanka. (Photographed by Panduka de Silva).