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Original Research Article

An update of distribution, habitats and conservation status of the Indian pangolin (*Manis crassicaudata*) in Sri LankaPriyan Perera ^{a, b, *}, Hasitha Karawita ^a^a Department of Forestry and Environmental Science, University of Sri Jayewardenepura, Sri Lanka^b IUCN SSC Pangolin Specialist Group, C/o Zoological Society of London, Regent's Park, London, NW1 4RY, United Kingdom

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ABSTRACT

The Indian pangolin (*Manis crassicaudata*) is the only pangolin species present in Sri Lanka. Growing concerns over international trading and trafficking of pangolins and the recent listing of all eight extant pangolin species in Appendix I of CITES have generated considerable interest in *M. crassicaudata* among conservationists in Sri Lanka. However, only limited research has investigated the distribution, abundance, and threats to Indian pangolins and robust estimates of distribution, population size, and threats require intense research based on long-term data. This study presents an update on the distribution, knowledge of habitats and conservation status of the Indian pangolin in Sri Lanka based on an extensive data set collected from primary and secondary data sources. Our findings confirmed the occurrence of Indian pangolin in habitats up to 1850m above mean sea level with a higher concentration of Indian pangolin populations occurring in the North-west, North-central, South-west lowlands and South-eastern parts of the island. The species was mostly recorded from tropical shrubland, tropical dry forest, tropical moist lowland forest, tropical dry grassland and tropical heavily degraded former forest habitats. The findings of the study revealed that wildlife crimes related to the Indian pangolins are rising. Hunting for subsistence, live capture to sell as meat, hunting for scales, and traps intended for other agricultural pests are the main threats to *M. crassicaudata* in Sri Lanka. Recent confiscations of pangolin scales by law enforcement authorities and growing incidents of poaching pangolins for illegal trade hint at the existence of local niche markets for pangolin meat and scales with a possible international trading pathway of *M. crassicaudata* scales from Sri Lanka to South India. The data presented here provide important information for global and national conservation status assessment of *M. crassicaudata*, and an impetus for conservation planning for the species in Sri Lanka.

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1. Introduction

The Indian pangolin (*Manis crassicaudata*) is a solitary, elusive and predominantly nocturnal medium-sized mammal native to South Asia. The behavioral plasticity of Indian pangolin has successfully enabled it to live in an array of natural and human-modified habitats such as tropical rain forests, subtropical thorn forests, deciduous forests, and open scrublands. Despite its ability to adapt to different habitats, Indian pangolin populations are considered to be declining across its range

* Corresponding author. Department of Forestry and Environmental Science, University of Sri Jayewardenepura, Sri Lanka.

E-mail address: priyan@sjp.ac.lk (P. Perera).

(Baillie et al., 2014; Heinrich et al., 2016). Key threats include hunting and poaching for its meat and scales, illegal international trade, habitat loss and fragmentation (Mahmood et al., 2012; Heinrich et al., 2016; Perera et al., 2017). Pangolins are considered to be the most trafficked wild animals in the world as scales, meat and other derivatives have a high demand in East Asian markets (Shepherd, 2009). For instance, the prices of pangolin scales is estimated to have increased tenfold in China during the last decade, providing an impetus for the trafficking and illegal trading of pangolins (Challender et al., 2015). According to Heinrich et al. (2016), more than 17,500 whole Asian pangolins had been traded in the international market from 2001 to 2014. As such, all eight pangolin species are currently listed in Appendix I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). In recognition of the threat to the species, the International Union for the Conservation of Nature (IUCN) has classified the Indian pangolin as Endangered (Baillie et al., 2014).

M. crassicaudata is the only pangolin species occurring in Sri Lanka and it is known to occur throughout the lowlands, from coastal habitats up to 1,100m above sea level (Phillips, 1981; Perera et al., 2017). The population of *M. crassicaudata* in Sri Lanka is largely unknown, and their abundance varies with only a few known locations in the country where pangolins are rather frequently recorded (Pabasara et al., 2015; Karawita et al., 2018). In Sri Lanka, evidence for using pangolin body parts in traditional uses are scarce, instead, it has been long consumed as a bush-meat by local communities (Chandraratne, 2016; Karawita et al., 2016). Therefore, hunting for meat may be the main threat for Indian pangolin populations in Sri Lanka, though recent reports hint at the existence of a niche local market for pangolin meat, body parts and possible international trading of pangolin scales from the country through multiple channels (Perera et al., 2017). However, the species has been strictly protected under the Flora and Fauna Protection Ordinance (amendment) Act No. 22 of 2009 of Sri Lanka, and further listed as 'Near Threatened' in the National Red List of Sri Lanka (Weerakoon, 2012).

The growing knowledge on the international trading and trafficking of pangolins (Shepherd, 2009, Challender et al., 2015; Heinrich et al., 2016; Nijman et al., 2016; Zhang et al., 2017), and the recent listing of Indian pangolin in Appendix I of CITES has generated considerable interest on the Indian pangolin among researchers and conservationists in Sri Lanka. Meanwhile, overexploitation of Chinese pangolin (*Manis pentadactyla*) and Sunda pangolin (*Manis javanica*) populations in Asia is believed to have resulted in increased exploitative attention on *M. crassicaudata* in Pakistan, India and possibly Sri Lanka for illicit international trade (Baillie et al., 2014; Challender and Macmillan, 2014; Perera et al., 2017). Exploitation and trade of Indian pangolins in some range countries have been studied far more intensively than others (Mahmood et al., 2012, 2014; Katuwal et al., 2013; Mohapatra et al., 2015; Akrim et al., 2017), but more comprehensive research is still needed.

In the Sri Lankan context, little research has been conducted to understand the distribution, abundance, and threats for Indian pangolins (Pabasara et al., 2015; Karawita et al., 2016, 2018; Perera et al., 2017), and robust estimates of distribution, population size, and threats for conservation require intense research that are based on long-term data. However, the absence of such long-term data is a major impediment in determining the precise distribution of the Indian pangolins in the country and assessing the conservation status. The latest available description on the distribution of Indian pangolins in Sri Lanka (Phillips, 1981) was published nearly 40 years ago, and is in need of updating. Hence this study was aimed at bridging this important literature gap by updating the distribution, knowledge of habitats and conservation status of the Indian pangolin occurring in Sri Lanka.

2. Methodology

In this study, we used both primary and secondary data gathered through mixed methods to update the distribution and crimes involving *M. crassicaudata* in Sri Lanka. Such methods have been employed in similar studies in the literature (Storch, 2007; Newton et al., 2008; Brito et al., 2011).

2.1. Systematic review of literature and biodiversity field surveys

A systematic review of field records of *M. crassicaudata* was undertaken with published literature, reports of non-governmental conservation organizations (NGOs) working in Sri Lanka, and reliable unpublished observations. Several online indexing databases including Scopus, Web of Science and Google Scholar were used to search for published literature on Indian pangolins in Sri Lanka. In addition, library catalogues of institutions conducting wildlife research were searched to gather relevant information. Reliable unpublished observations included the records of pangolin sightings extracted from field journals/records maintained by conservation organizations and researchers. Field data gathered by the research group headed by the corresponding author at three study locations in Sri Lanka i.e. Yagirala (6°21' to 6°26' N and 80°08' to 80°11' E), Wilpattu (°13' to 8°40'N and 79°50' to 80°10'E) and Yala (6°18' to 6°42'N and 81°24–81°43'E) from August 2013 to December 2018 provided important primary data on pangolin recordings. These included the data from ecological surveys to determine the abundance (Pabasara et al., 2015; Perera et al., 2017), and habitat utilization of Indian pangolins (Karawita et al., 2018; Karawita et al., In review) in the South-west lowland forest and associated landscapes in Sri Lanka. Additional primary data for this study came from the field observations and camera trap/photographic evidence collected by the authors and their networks during preliminary field surveys conducted in Wilpattu and Yala study sites as well as from the opportunistic observations made by the team. Approximate GPS (Global Positioning System) coordinates of the localities of pangolin sightings were further recorded.

Records on rescued pangolins and wildlife crimes related to pangolins were secured from the registries maintained at the beat offices, range offices, national parks, and regional offices of the Department of Wildlife Conservation, Sri Lanka (DWC).

These offices by mandate, are required to maintain records of rescued wild animals and wildlife crimes reported in their respective administrative regions. Due to the difficulty of retrieving old records, only the cases reported between January 2000 and December 2018 were extracted for this study. Data on rescued pangolins were also collected from the animal history records maintained at the Pinnawala Zoological Garden of the Department of National Zoological Gardens, Sri Lanka (7° 18' 2" N, 80° 23' 18" E). The Pinnawala Zoo receives injured, rescued and dead Indian pangolins, from a radius of approximately 25 km from its location. The locality from which the Indian pangolins were rescued/received is documented by the officials. Furthermore, records on rescued Indian pangolins were gathered from animal rescue centers managed by the DWC, and similar facilities operated by non-governmental organizations. The data on attempts of smuggling pangolin scales or other body parts were obtained from the Department of Customs, Sri Lanka. The information on the special raids was collected from respective Police Stations. Also, cases of crime, rescue and attempted trading of live or dead pangolins reported by media (newspapers and web-media reports) were further collected after verifying their authenticity with relevant agencies. Other bibliographic references on Indian pangolins were further used as secondary data in updating the distribution maps of the species.

2.2. Semi-structured interviews

We interviewed selected wildlife officers at regional offices and national parks of DWC, villagers around selected national parks and local hunters to gain a better understanding on the nature of wildlife crimes/exploitation of pangolins, issues in law enforcement, prosecutions, markets for pangolin meat and scales, and possible trafficking pathways of pangolins. Semi-structured interviews were the main research tool used. A two-person team trained on a pre-defined interview framework carried out all interviews. The interview framework encompassed guidelines on the key information requirements, but more leeway was allowed for following up on whatever angles are deemed important by the interviewee (Brinkmann, 2014). Open-ended questions were predominantly used to avoid leading the respondent to a fixed answer. Owing to the method of interview employed, the interviews varied in length and content, largely determined by the respondent's willingness to engage in dialogue, and their knowledge on the subject. Each interview was audio-recorded using a portable voice recorder and uncertainties were clarified immediately after the interview.

All interviewees were selected on their willingness and availability to participate in an informal interview. At each DWC office, 1 to 3 officials were interviewed. To gain a perspective on the traditional uses/consumption of Indian pangolins, we interviewed the Chief of the "Vedda" community; the only forest-dwelling indigenous group of people living in Sri Lanka. The sample selection for interviews of local villagers and hunters was predominantly respond-driven and resembled the snowball sampling method; a technique used in social research when the potential participants are hard to find (Browne, 2005). Since hunting and trading pangolins is an illegal activity, the information disclosed during interviews were highly sensitive, hence, the use of a random sampling method was not feasible. As the sample needed to include only those who are familiar with the subject, interviewees were recruited based on previous interviewees reference or direction. Villagers and hunters living in the proximity of our 3 major study sites (Yagirala, Wilpattu, and Yala sites) as well as around selected national parks/protected areas (Girithale, Galoya, Angammadilla, Horton Plains, Maduru Oya, Uda Walawe, Minneriya, Kaudulla, Kumana, Hikkaduwa, Lunugamwehera, Kalawewa, Lahugala and Ritigala) were interviewed to gather information on pangolin hunting practices and the nature of the illegal trade. Local hunters were identified based on information received from villagers. A total of 148 individuals (N = 148) which included 46 DWC officers, 67 villagers, 31 local hunters, and 4 veterinarians/caretakers at animal rescue centers were interviewed for this study.

2.3. Data recording and mapping of the distribution

All confirmed field records of Indian pangolin occurrences (i.e. sightings of live or dead pangolins, origins of specimens reported in crime records, rescue events and other records) were entered into a database in Microsoft Excel. Each field record contained the location of record (province, district, town/village and protected area if applicable), approximate geographic coordinates, altitude (in meters), habitat type according to IUCN classification, record type (observation, camera trap, specimen, DWC record, other government source record, NGO record or from literature) and the date of record. Localities of Indian pangolin presence were collected directly from the data sources with geographic coordinates or with clear geographic designations from which it was possible to gather approximate coordinates from Google Earth® maps. Locations of pangolin occurrences were displayed in ArcGIS 10.1. The Kernel density tool in ArcGIS 10.1 software was used to calculate the density of points that represent the pangolin occurrences. Accordingly, the distribution and density maps of Indian pangolin were generated. The point locations were overlaid on the mammal habitats proposed by Eisenberg and Mckay (1970) to understand the type of habitats of the Indian pangolin. The same methodological approach was used to generate the map on crimes related to Indian pangolins.

3. Results

3.1. Distribution and habitats

A total of 281 confirmed pangolin sightings/records were used in generating the distribution map. As indicated in Table 1, the highest number of documented pieces of evidence confirming the presence of Indian pangolins was recorded from Kurunegala District in Northwestern province (14.23%), followed by Puttalam District (11.03%), Anuradhapura District (10.68%), Moneragala District (8.90%) and Hambanthota District (7.12%).

Eisenberg and Mckay (1970) described seven mammalian zones in Sri Lanka; A - monsoon scrub jungle (A1- North-east and A2 -South-east), B - monsoon forest and grassland, C - inter-monsoon forest, D - rain forests and grasslands (D1 - below 914m Mean Sea Level (MSL), D2 - between 914 and 1524m, D3 - above 1524m MSL). According to Fig. 1b, the Indian pangolin has been recorded from all the mammalian zones of Sri Lanka, indicating their island-wide distribution. However, we found no confirmed recent records of Indian pangolin from the Jaffna peninsula area of the country. According to the records maintained at the DWC regional offices, the Indian pangolin is present at the elevation above 1700m MSL (Diyathalawa and Bandarawela areas), and the highest recorded elevation is above 1850m MSL where the species has been recorded from the Galway's National Park, Nuwaraeliya. Distribution maps further suggest that the Indian pangolin also inhabit coastal lowlands of the country such as Mullaitivu, Trincomalee and Kuchchaweli in the North-east coast, Kalamatiya, Waligama, Dikwella, Bundala, and Unawatuna in the Southern coast, and Norochchola, Ilanthadiya, and Kalpitiya in the North-west coast of the country.

According to the localities where the Indian pangolins were recorded, it was evident that the species inhabits a variety of habitats, ranging from natural to anthropogenic. Subtropical/tropical shrubland (n = 74), Subtropical/tropical Dry Forest (n = 54) and Subtropical/tropical moist lowland forest (n = 43) were the habitat types (as defined by IUCN, 2019) with the highest number of records indicating the presence of Indian pangolins (Table 2). Interestingly, 15 confirmed records of Indian pangolins were reported from Subtropical/tropical moist montane forests, which represent the lower and upper montane forests (cloud forests) at altitudes above 1200m. However, results further indicated that pangolins have been occasionally recorded from semi-urban areas, seasonal freshwater marshes, and coastal habitats such as tropical mangrove vegetation above high tide level, sand dunes, and seashore vegetation.

3.2. Contemporary threats

Understanding the threats and challenges for the conservation of Indian pangolin in Sri Lanka was one of the main objectives of the study. Analysis of documented crimes related to Indian pangolins, interviews with local communities and hunters as well as field observations were used for this purpose. A total of 96 reliable records were analyzed. As indicated in Table 3, the highest number of wildlife crimes related to Indian pangolins was recorded from Anuradhapura District in North-central province (13.54%), followed by Polonnaruwa (12.50%), Hambanthota (10.42%), Moneragala (9.38%) and Kalutara (8.33%). Accordingly, the main exploitation threats facing Indian pangolins are hunting for subsistence (47.4%), hunting for bush-meat trade (27.8%), incidental capture in traps intended for other pests/animals (11.3%), hunting for scales (6.2%), and trading of live animals for meat (6.2%).

Table 4 summarizes the crimes related to Indian pangolins documented by the DWC and Sri Lanka Customs during the period from the year 2000–2018. Out of the 59 reported crimes, 46 (78%) were related to possession of meat or killed animals. Of the 46 cases of possession of meat or killed animals, 13 were reported within protected areas while the rest were reported from outside protected areas.

The largest quantity of pangolin meat discovered by the DWC officers is 6 kg from Horowupathana in the North-central province in 2017, where the offender was fined LKR 30,000 (approximately 175 USD). It was revealed that the selling price

Table 1

Administrative Districts in Sri Lanka with the most number of records confirming the presence of *Manis crassicaudata*.

Administrative District	Province	Climatic zone	Number of records	Percentage (%)
Kurunegala	North-west	Intermediate	40	14.23
Puttalam	North-west	Dry	31	11.03
Anuradhapura	North-central	Dry	30	10.68
Moneragala	Uva	Dry/Intermediate	25	8.90
Hambantota	Southern	Dry	20	7.12
Polonnaruwa	Northcentral	Dry	18	6.41
Galle	Southern	Wet	15	5.34
Matara	Southern	Wet	12	4.27
Kalutara	Western	Wet	10	3.56
Kegalle	Sabaragamuwa	Wet	10	3.56
Other	Other	Wet/Dry/Intermediate	70	24.90

Approximately 27% (n = 76) of records were from the wet zone, while the intermediate zone and dry zone accounted for 28% (n = 78) and 45% (n = 127) of records respectively. According to the Kernel density analysis, higher concentration of records of Indian pangolins can be observed in the North-west region, North-central region, South-west region and South-east region of the country (Fig. 1a).

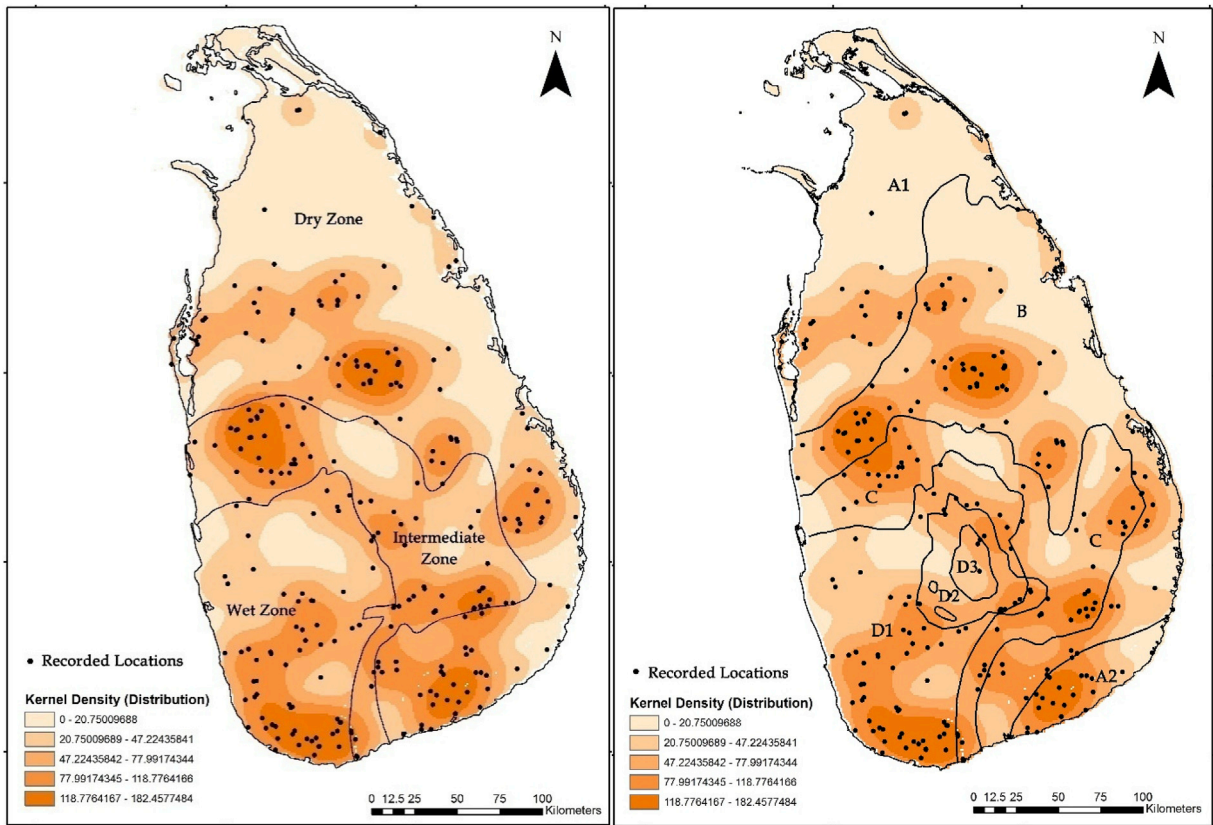


Fig. 1. Distribution of Indian pangolins (a) in different climatic zones and (b) mammalian zones of Sri Lanka (Eisenberg and Mckay, 1970).

Table 2

Habitat types important for *Manis crassicaudata* in Sri Lanka.

Habitat types (IUCN, 2019*)	Number of records	Percentage (%)	Habitat Suitability
Subtropical/Tropical Dry Forest	54	19.22	Suitable
Subtropical/Tropical Moist Lowland Forest	43	15.30	Suitable
Subtropical/Tropical moist montane forest	15	5.34	Marginal
Moist Savanna	3	1.07	Unknown
Subtropical/Tropical Dry Shrubland	74	26.33	Suitable
Subtropical/Tropical Moist Shrubland	20	7.12	Suitable
Subtropical/Tropical Dry Grassland	33	11.74	Suitable
Subtropical/Tropical Heavily Degraded Former Forest	25	8.90	Suitable
Plantations	10	3.56	Marginal
Rural gardens	4	1.42	Unknown

*Habitat categories adapted from IUCN Red List of Threatened Species (IUCN, 2019).

Habitat Suitability options.

Suitable - the species occurs in the habitat regularly or frequently.

Marginal - The species occurs in the habitat only irregularly or infrequently, or only a small proportion of individuals are found in the habitat.

Unknown - The habitat is of unknown importance to the species.

of pangolin meat by local hunters ranged from LKR 400 to LKR 2000/kg (approximately 2.25–12 USD), depending on the customer. Cases of selling pangolin meat in restaurants especially for foreign/Asian workers who are employed in mega-development projects in the country have been reported.

According to DWC records, two cases related to the possession of pangolin scales and one case related to the possession of pangolin skin have been reported. In October 2008, 3 kg of scales were found from the Rajanganaya, area in the North-west province. In November 2017, the largest stock of 130 kg of pangolin scales was discovered from Kalpitiya in the North-western part of the country, extracted from approximately 150 killed pangolins according to the source (conversion parameters not specified). The police investigations have further revealed that the stock of scales was prepared to smuggle to India via fishing boats. Four attempts to smuggle the scales of Indian pangolin through the Bandaranaike International Airport (BIA), Katunayake were recorded from the Department of Customs between 2012 and 2017. India was the suspected destination in 3

Table 3Administrative Districts in Sri Lanka with the most number of wildlife crimes related to *Manis crassicaudata* (2000–2018).

Administrative District	Province	Number of records	Percentage (%)
Anuradhapura	North-central	13	13.54
Polonnaruwa	North-central	12	12.50
Hambanthota	Southern	10	10.42
Moneragala	Uva	9	9.38
Kalutara	Western	8	8.33
Kurunagala	North-western	7	7.29
Ampara	Eastern	6	6.25
Galle	Southern	5	5.21
Puttalam	North-west	4	4.17
Matara	Southern	3	3.13
Other		19	19.79

According to the kernel density analysis, high concentrations or hot-spots of wildlife crimes related to Indian pangolins can be observed in the North-west region, North-central region, South-west region and South-east region of the country (Fig. 2).

Table 4

Wildlife crimes involving Indian pangolins documented by the Department of Wildlife Conservation and Sri Lanka Customs (2000–2018).

Nature of the crime	Number of cases	Percentage
Possession of meat or killed animals	46	78%
Possession of live animals	4	7%
Attempted smuggling of scales	4	7%
Possession of scales or body parts	3	5%
Other (including non-purposive kills)	2	3%
Total	59	100%

cases while China was the intended destination in one reported case. The largest consignment of pangolin scales seized by the Sri Lanka Customs at the BIA is 11 kg (Table 5).

Examination of DWC crime registries further revealed four cases of keeping and selling live Indian pangolins. In 2018, investigations by the Police in May 2018 found a live Indian pangolin kept in a deep-freezer at a Chinese restaurant in Kollupitiya, Colombo District where the restaurant was operated by a Chinese national. Remaining 3 cases of keeping or selling live pangolins were recorded from Kalutara, Elahera and Balangoda regions of the country between the period 2008 and 2014. DWC records further included numerous cases of unintentional killings of Indian pangolins due to entangling in electric fences and nylon nets intended for other animals such as cropland pests.

3.2.1. Pangolin rescues

The DWC records included 114 rescues of Indian pangolins between 2000 and 2018, with most of the rescue events recording from rural villages, forested areas, cultivations, and semi-urban settings. About 33% of cases involved rescuing injured or sick animals. In most cases, the injuries were due to entangling in barbs, nylon nets used in cultivations to prevent pest animals entering the cultivation, falling into ditches or agricultural wells, attacks by dogs, and orphaned young becoming weak due to poor nutrition. The injuries due to road accidents or any other machinery were not very common.

The majority of the rescues (73%) have been initiated based on information received by the local villagers or villagers bringing/handing over injured pangolins to the responsible authorities such as DWC or animal rescue centers/veterinary hospitals. Out of the 114 rescue events documented by the DWC sources, 76 (66.7%) were successful where the rescued animals have been released in healthy condition back to their original habitats ($n = 54$) or translocated to a different habitat ($n = 22$) after medical treatments. In 38 (33.3%) documented cases, the rescued Indian pangolins did not survive in captivity and died while receiving treatments. Interviews with DWC officials revealed that some rescue attempts have failed due to their inability to attend to injured animals on time, largely because of the lack of trained personnel and physical resources such as transport and animal care facilities. Villagers keeping pangolins in uncondusive conditions (such as inside polythene sacks or poorly ventilated boxes) till DWC officers arrive or transporting pangolins in such conditions is another reason for failures in rescue attempts. Furthermore, it was revealed that there are many undocumented rescue events where the animals have been released immediately back to the wild as they were in good health condition.

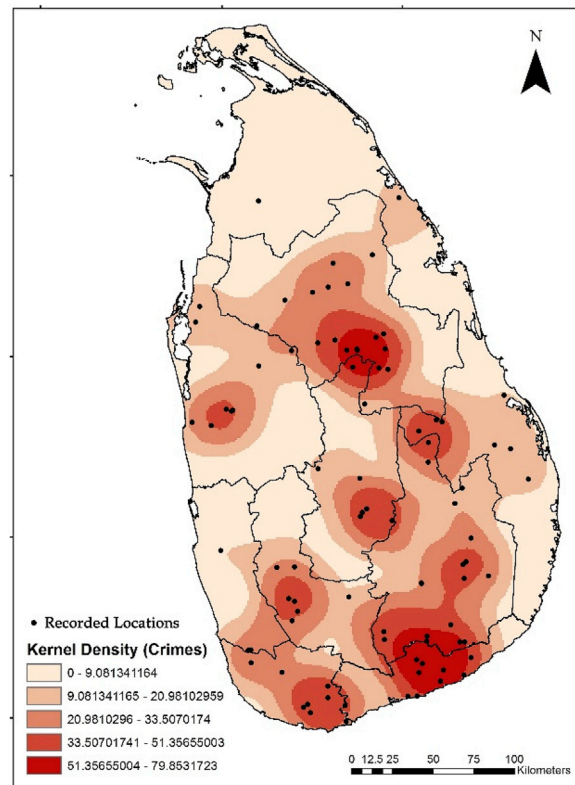
Most rescue events have been recorded from Kurunegala (25.45%), Galle (18.50%), Matara (16.43%), Polonnaruwa (12.35%) and Rathnapura (5.20%) Districts of the country. The Kernel density analysis of rescue event locations indicated that rescue events of Indian pangolins are mostly concentrated in North-west, South-west, and North-central regions of the country (Fig. 3).

With respect to the recorded number of crimes related to Indian pangolins, a slight increase in the number of crimes can be observed after year 2012 (Fig. 4). The highest number of crimes have been recorded in the year 2017. Similarly, the number of rescue events of Indian pangolins has increased after 2015, and shown a sharp increase in 2017 (Fig. 4).

Table 5

Summary of attempted smugglings of Indian pangolin scales through the Bandaranaike International Airport, Sri Lanka (Source: Sri Lanka Customs).

Date	Nature of the case	Expected destination	Nationality of the offender	Area of Origin	Fine (LKR)
November 12, 2012	2.2 kg of pangolin scales hidden inside baggage	India	Indian	Unknown	50,000.00
17.02.2017	11.0 kg of pangolin scales hidden inside baggage	India (Chennai)	Sri Lankan	Unknown	100,000.00
14.05.2017	3.8 kg pangolin scales hidden inside baggage (same suspect as in case dated 17.02.2017)	India (Chennai)	Sri Lankan	Unknown	
20.07.2018	1.7 kg pangolin scales hidden inside a baggage	China	Chinese	Moragahakanda	50,000.00

**Fig. 2.** Recorded locations of wildlife crimes involving Indian pangolins (2000–2018).

Semi-structured interviews conducted with DWC regional officers, villagers and local hunters revealed useful information on contemporary threats to the conservation of Indian pangolin populations in the country. According to the respondents, hunting for subsistence is the main threat faced by Indian pangolins throughout the country ($n = 101$). A frequently cited emerging threat for Indian pangolins is the hunting or live capture of animals to sell as meat ($n = 57$). Hunting for scales ($n = 18$), unintentional kills such as deaths due to traps intended for other agricultural pests ($n = 15$) were among the other contemporary threats posed by humans to Indian pangolin (Fig. 5).

According to responses, killing as a pest in oil palm, plantations ($n = 9$) is another threat faced by the Indian pangolin populations in South-west parts of Sri Lanka. These killed pangolins are locally consumed or sold. The illegal trade channels typically include local hunters and sellers, where they directly purchase killed or live pangolins from hunters. In some cases, middlemen are involved. Pangolins are predominantly sold by local hunters for meat rather than for scales or other derivatives. As revealed during the interviews, there may be a secondary market for scales from the pangolins sold for meat, which is not reflected in trading.

4. Discussion

Although it is documented that the Indian pangolin occurs throughout Sri Lanka in variety of habitats (Phillips, 1981; Weerakoon, 2012), in reality, there is a paucity of knowledge on its distribution, knowledge of habitats, ecology, and

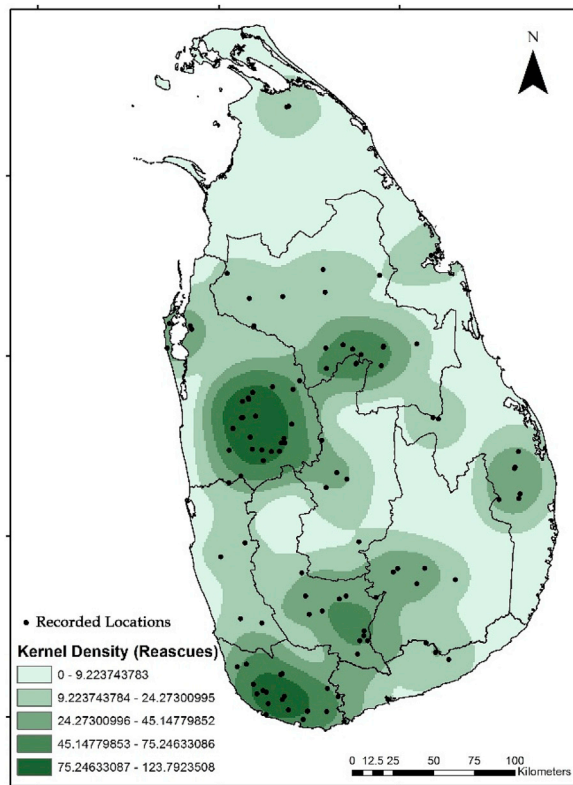


Fig. 3. Recorded locations of rescue events of Indian pangolins (2000–2018).

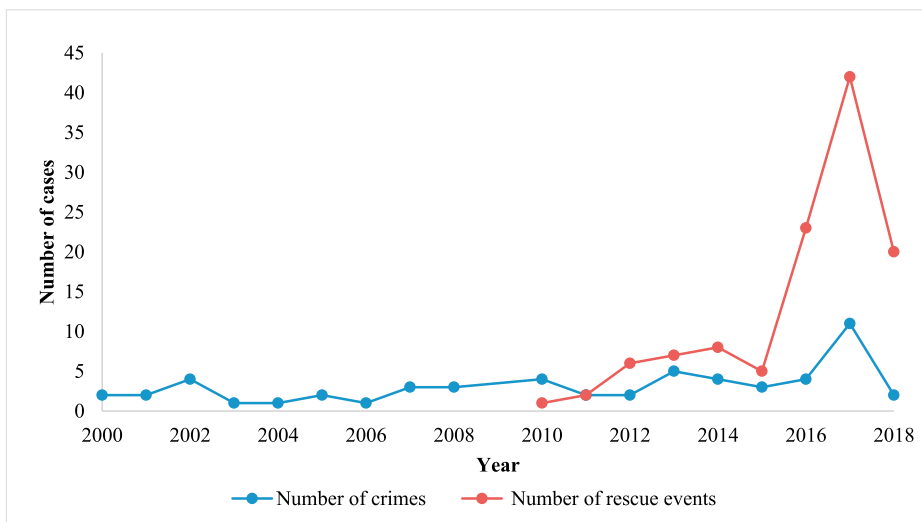


Fig. 4. Trends in crimes and rescue attempts of Indian pangolins (2000–2018).

conservation status. No accurate and published description of the distribution of Indian pangolin in Sri Lanka is available except [Phillips \(1981\)](#). Hence, this study presents an update of the distribution, habitats and conservation status of the Indian pangolin in Sri Lanka based on an extensive data set collected from a variety of sources.

In gathering information to update the distribution of the species and analyze crimes, the authors exerted similar effort across the country by covering 100% of the DWC regional offices and most national parks. The DWC regional offices receive data on animal rescues and wildlife crimes from the respective range offices and beat offices. However, records of non-governmental conservation organizations and reliable unpublished observations (such as records of pangolin sightings

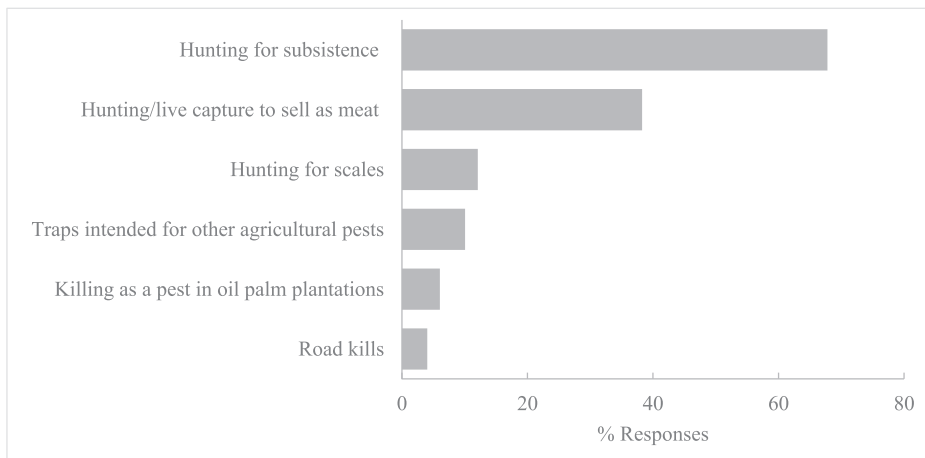


Fig. 5. Contemporary threats for Indian pangolins (N = 148 with multiple responses possible).

extracted from field records of researchers and conservation organizations) can introduce a geographical bias to the dataset as many NGOs and researchers operate/work in specific geographical areas. For instance, field data from North and North-east provinces were scarce as these areas were affected by the civil war which prevailed in the country till 2009.

About 75% of the confirmed pangolin sightings analyzed in this study came from DWC sources. DWC does not have a regional office network that effectively covers the entire island and some regional offices are more efficient in law enforcement compared to others. As such, the number of official records at each office and geographic region may vary. Furthermore, all pangolin rescue events are not officially recorded by DWC especially in cases where the animals are immediately released back to the wild after rescuing. The limitations in acquiring reliable data from all parts of the country may particularly affect the accurate understanding of the distribution and conservation threats to the species. Nonetheless, the authors used the best available data in this study, and the results were cautiously interpreted.

Higher concentration of Indian pangolin populations seem to occur in the North-west (Kurunegala and Puttalam Districts), North-central (Anuradhapura District) and South-west lowlands and South-eastern parts (Hambantota and Monaragala Districts) of the island, as evident by the number of records. Kurunegala Districts has relatively less closed-canopy natural forests (Edirisinghe et al., 2012), yet the Indian pangolin seems to be abundant in the natural and semi-natural habitats such as degraded forests/scrublands, rocky outcrops and plantations in the North-west region. Tropical dry forest, tropical moist shrub-lands, and degraded forest lands/scrublands are the prominent natural and semi-natural habitats in North-central region where higher concentration of Indian pangolins seems to exist. The hotspot of Indian pangolins in the South-east of the country mainly include tropical dry forest, degraded forests/scrublands, and dry lowland savannas. A study on habitat preference of Indian pangolins in the South-west lowlands of Sri Lanka by Karawita et al. (2018) revealed that Indian pangolins in general, prefer habitats with dense canopy cover (>75%) to construct their resting burrows. However, the environmental features such as canopy closure, undergrowth cover and elevation are likely to be site specific or habitat-specific, and show a substantial variability across the range of *M. crassicaudata* (Mahmood et al., 2013, 2014; Perera et al., 2017). Furthermore, it should be acknowledged that the inherent bias associated with the available data may influence the distribution hotspots in the maps.

Most distribution records of Indian pangolins in the dry zone have been reported in and around national parks and other protected areas. Therefore, the protected area network of the country seems to be highly important for the survival of Indian pangolin populations. Distribution maps further suggest that Indian pangolins are abundant in Wet zone lowlands of Sri Lanka. However, the remaining natural forests in the South-west of the country are highly fragmented and on the decline (Edirisinghe et al., 2012). Human pressure on natural habitats in the South-west is increasing, and the region at present, predominantly include human-modified habitats. Hence, these human modified habitats such as plantations, agricultural lands and rural home gardens especially adjoining forests seem to be important habitats for Indian pangolin populations in the South-west (Karawita et al., 2018; Karawita et al., In review).

According to IUCN (2019) habitat suitability assessment guidelines, Tropical Dry Shrub-land, Tropical Dry Forest, Tropical Moist Lowland Forest, Tropical Moist Shrub-land, Tropical Dry Grassland and Tropical Heavily Degraded Former Forest are the most suitable and critical habitats for *M. crassicaudata* in Sri Lanka. These findings are comparable with the published literature (Perera et al., 2017; Karawita et al., 2018). Forest plantations and agricultural plantations such as tea, rubber, oil palm, and cinnamon in the South-west lowlands of the island have been particularly identified as important foraging habitats of Indian pangolins (Pabasara et al., 2015, Karawita et al., 2018; Karawita et al., In review). In contrast to the distribution of Indian pangolins described in Phillips (1981), results of this study confirmed the occurrence of Indian pangolins in altitudes up to 1850m MSL in habitats such as lower and upper montane forests (tropical moist montane forests). However, these habitats may be of marginal importance for the species.

The data presented here highlight several important issues for the conservation of *M. crassicaudata* in Sri Lanka. Wildlife crimes involving Indian pangolins appear to be frequent in the North-west region, North-central region, South-west region and South-east region of the country. These crime hotspots closely overlap with areas where Indian pangolins are mostly recorded in the island. Hunting and poaching for illegal trade in general, is considered as the greatest threat to the survival of all pangolin species in the world (Baillie et al., 2014; Challender and Macmillan, 2014). However, in the Sri Lankan context, the major threat for Indian pangolins is the hunting for subsistence as the Indian pangolin meat is considered a delicacy by locals in many parts of the country. Excessive hunting has almost eliminated the Indian pangolin in areas where they stray into contact with people (Perera et al., 2017). Hunting and poaching for trade as meat has become an emerging threat for Indian pangolins. Certain niche markets have emerged especially in South, North-central, and North-west parts of the country where large scale development projects are ongoing. Interviews with local hunters and DWC officials revealed that the demand for pangolin meat is driven largely by the foreign Asian workers who are employed in these projects. Our findings further confirmed the existence of niche local markets for pangolin meat where some restaurants catering predominantly for foreigners, have reportedly paid lucrative money for the suppliers of pangolin meat.

Findings of this study suggest an increase in crimes related to Indian pangolin, especially after 2012, with hunting for scales and illegal trading being emerged as a concern. In the global context, hunting and poaching for illegal trade is seen as the major impediment for the conservation of Indian pangolin (Baillie et al., 2014; Challender and Macmillan, 2014). China is believed to be the key market driver of pangolins, and their products (Challender et al., 2015; Harrison et al., 2015; Nijman et al., 2016), though Heinrich et al. (2016) have underlined the dominant role of the USA in the global pangolin trade based on trade reported to CITES. Nonetheless, with Chinese pangolin (*Manis pentadactyla*) and Sunda pangolin (*Manis javanica*) which were frequently traded in Chinese markets becoming critically endangered and rare, pangolin scales from India and Nepal have entered the markets to supplement the growing demand (Challender, 2011). The increasing number of seizures from these countries implies a shift in source areas - including countries where the Indian pangolin occurs, and posing risks for the populations of Indian pangolins (Challender, 2011).

Reported cases of international illegal trade or smuggling of pangolin scales is rather limited in Sri Lanka with only five cases of seizures of pangolin scales being reported between 2012 and 2018. Interestingly, four cases have been reported during 2017/2018 period with one attempted smuggling of scales via sea and three attempted smuggling of scales through the airport. The largest shipment of 130 kg of pangolin scales confiscated at Kalpitiya and 3 other cases of attempted smugglings through the airport were destined to India. Well-established international illegal trade in pangolin scales and other derivatives from Northeast India to Myanmar and possibly to China exist, and such trade has more recently included *M. crassicaudata* scales (Misra and Hanfee, 2000; Mahmood et al., 2012). As such, our findings hint at a possible international trading pathway of *M. crassicaudata* scales from Sri Lanka to South India. These are likely to enter the international markets as scales originated in India, as CITES seldom reported cases of trading pangolin derivatives originated from Sri Lanka in the international market. Given the weaknesses in law enforcement related to wildlife crimes and the difficulty of identifying pangolin derivatives, international illegal trading of *M. crassicaudata* scales in much larger magnitude from Sri Lanka can be anticipated.

Deaths of pangolins due to traps intended for other pest mammals especially in agricultural croplands in the South-west of the country is another threat for conservation. This has been prominently recorded in South-west parts of the country where the cinnamon is cultivated as a commercial crop. Indian pangolins are further considered as a pest in oil palm plantations in the South-west parts of Sri Lanka. Indian pangolins tend to dig around the termite-infested base of oil palm trees, resulting in damages to the young trees. Killing of pangolins as pest of oil palm were mainly recorded from Kaluthara and Galle districts. Road kills are a cause of concern, but not very frequent as pangolins tend to naturally avoid disturbance from vehicles (Mahmood et al., 2018).

Most pangolin rescues have been recorded from agricultural lands or rural home gardens where pangolins have been attacked by domestic dogs or entangled in traps intended for other animals. The rising number of rescue events from such habitats may further indicate the depletion of preferred foraging habitats of Indian pangolins, and them seeking foraging opportunities in human-modified habitats (Karawita et al., 2018). The increased awareness of the law enforcement agencies and the general public on the conservation importance of Indian pangolins may have further contributed to the increasing number of pangolin rescues.

5. Conclusions

This study used an extensive data set collected from mixed methods to update the distribution, habitats and conservation status of *M. crassicaudata* in Sri Lanka. Accordingly, the species occur in all parts of the country, up to an elevation of 1850m ASL. However, records from Jaffna peninsula is scarce. A higher concentration of Indian pangolin populations occur in the North-west (Kurunegala and Puttalam Districts), North-central (Anuradhapura District) and South-west lowlands and South-eastern parts (Hambantota and Monaragala Districts) of the island. Tropical shrubland, tropical dry forest, tropical moist lowland forest, tropical dry grassland and tropical heavily degraded former forest were the most important habitats for Indian pangolin though it inhabits a variety of habitats ranging from natural to human-modified. Our results indicate that the number of wildlife crimes related to Indian pangolin has increased since 2012. Hunting for subsistence, hunting/live capture to sell as meat, hunting for scales and traps intended for other agricultural pests were the main threats for *M. crassicaudata*

populations in Sri Lanka. The outcomes of this study have important implications in national and global conservation status assessment and conservation planning of the species.

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Declaration of competing interest

None.

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Appendix A. Supplementary data

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