Journal of Wildlife and Biodiversity 4(3): 80-90 (2020)

(http://jwb.araku.ac.ir/)

DOI: 10.22120/jwb.2020.122080.1120

Research Article

Population status, habitat suitability and threat assessment of Indian spiny-tailed lizard *Saara hardwickii* (Gray, 1827) in the Thar desert of Rajasthan

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Received: 23 February 2020 / Revised: 29 March 2020 / Accepted: 7 April 2020 / Published online: 20 April 2020. Ministry of Sciences, Research, and Technology, Arak University, Iran.

Abstract

In India, the population of the Indian spiny-tailed lizard is extinct in many parts of its past distribution. Currently, the species is mainly confined to the desert areas of northwestern India. The present study was carried out from January 2014 to May 2017 in the Thar desert of Rajasthan (TDR) to know the population status and habitat suitability of the species and to assess the threats it faces. For this, the population was estimated through active burrow counting in selected 15mx15m quadrats. GIS-based weighted overlay analysis was used for habitat suitability analysis for which habitat and microhabitat information was collected through 'perambulation,' and 'quadrat sampling-time constrained' methods. Threats were documented using various methods viz. through vehicular surveys, perambulation, opportunistic searches, and by interacting with local people as well as forest staff. The species was recorded in six districts of the TDR. The overall density of the lizard was found to be 314.6±142.1 active burrows/ha in the study area. The maximum density was observed in the Jaisalmer district (362.5±102.3/ha) and the lowest in Jodhpur district (228.0±49.1/ha). Suitability analysis identified different potential habitat zones of the species in the TDR which are 1.71%, 13.49%, 59.51%, 10.65%, and 14.64% as most suitable, moderately high suitable, moderately low suitable, low suitable and unsuitable respectively. The majority of the most suitable areas found to fall in the Jaisalmer district of western Rajasthan that needs to be protected immediately. The study also revealed the species had been continuously facing various threats in the TDR that lead to local extinctions.

Keywords: Conservation, crucial habitats, GIS, India, local extinction

Introduction

Members of genus *Saara* represents one of the fascinating group of diurnal lizards, ground-dwelling, burrowing and live in colonies (Dutta and Jhala 2007, Ramesh and Ishwar 2008, Das *et al.* 2013). This group comprises three species worldwide, which are exclusive to Asia and distributed from southwest to southeast Asia from eastern Iraq to western India through Iran, Afghanistan, and Pakistan (Wilms *et al.* 2009). In the Indian sub-continent, the group is represented by a single species *Saara hardwickii* (Gray, 1827) that is popularly known as the Indian spiny-tailed lizard (Fig. 1A). This species is restricted to India, Pakistan and Afghanistan (Wilms *et al.* 2009) which is herbivorous and inhabits grassland habitats in sandy or gravely plains of arid or semiarid areas (Dutta and Jhala 2007, Ramesh and Ishwar 2008, Das *et al.* 2013) (Fig. 1B). Conservation of this species is of serious concern because of its declining population throughout its distribution due to its heavy exploitation in the pet trade for its meat, skin, and oil, the latter

supposed to be aphrodisiac (Knapp 2004, Dutta and Jhala 2007, Ramesh and Ishwar 2008, Wilms *et al.* 2009, Rais *et al.* 2012, Das *et al.* 2013). In India, illegal pet trade along with habitat destruction for urbanization and agriculture has been pushed the species locally extinct in many parts of its past distribution (Knapp 2004, Dutta and Jhala 2007, Ramesh and Ishwar 2008, Das *et al.* 2013). Hence, the species is protected under Schedule II of the Indian Wildlife (Protection Act), 1972, and enlisted in Appendix II of CITES (Anonymous 1994, CITES 2020). But due to lack of proper information on this species, it has been declared as Data Deficient nationally though it has not been accessed by IUCN (Molur and Walker 1998, IUCN 2020). Moreover, recent genetic analysis of the species by Sharma *et al.* (2018) has also been revealed the monomorphic nature of the Indian populations of this species and suggested for urgent conservation of this species in this region. Hence, there is a need for immediate population assessment of this species in its current distribution in India. Keeping this in mind, the present study was undertaken in the Thar desert of Rajasthan (TDR) to fill this gap. In India, since the species at present occurs mostly in small fragmented populations in the dry areas of northwestern India i.e., the Indian desert (Knapp 2004, Dutta and Jhala 2007, Ramesh and Ishwar 2008, Wilms *et al.* 2009, Das *et al.* 2013) and the TDR represents the major part of the Indian desert (about 62%) (Baqri and Kankane 2002), population assessment of the species in the TDR will be no doubt very helpful to understand the current population status of the species in India.

The study also aimed at habitat suitability analysis for the species in the TDR using geospatial techniques to understand habitat attributes of the species in this region. For this, GIS-based weighted overlay analysis was followed that used different environmental variables along with species occurrence data collected from ground-truthing (Malczewski 2004, Walke *et al.* 2012, Joshi *et al.* 2017).

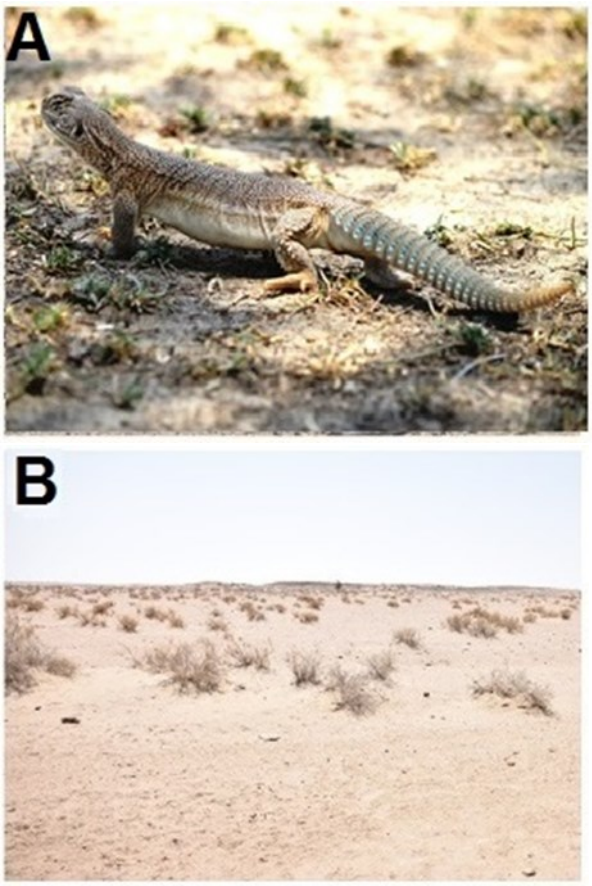

Figure 1. A: Indian spiny-tailed lizard while foraging; B: General habitat of Indian spiny-tailed lizard.

Material and methods

Study area

The study area is the Thar desert of Rajasthan (22°30' to 32°05'N and 68°05' to 74°45'E) (Fig. 2). The area lies in the Biogeographic Zone 3A-Thar Desert (Rodgers *et al.* 2002) and represents a unique ecosystem which is bounded by the Aravali Hills in the east, the fertile Indus and Nara valley in the west, the great salt marsh of Kachchh in the south and the semiarid districts of Haryana and Punjab in the north (Baqri and Kankane 2002). It is an extension of the Sahara desert, through Arabian and Persian deserts and continues with the desert portion of Pakistan on its west, supporting a rich biodiversity (Baqri and Kankane 2002).

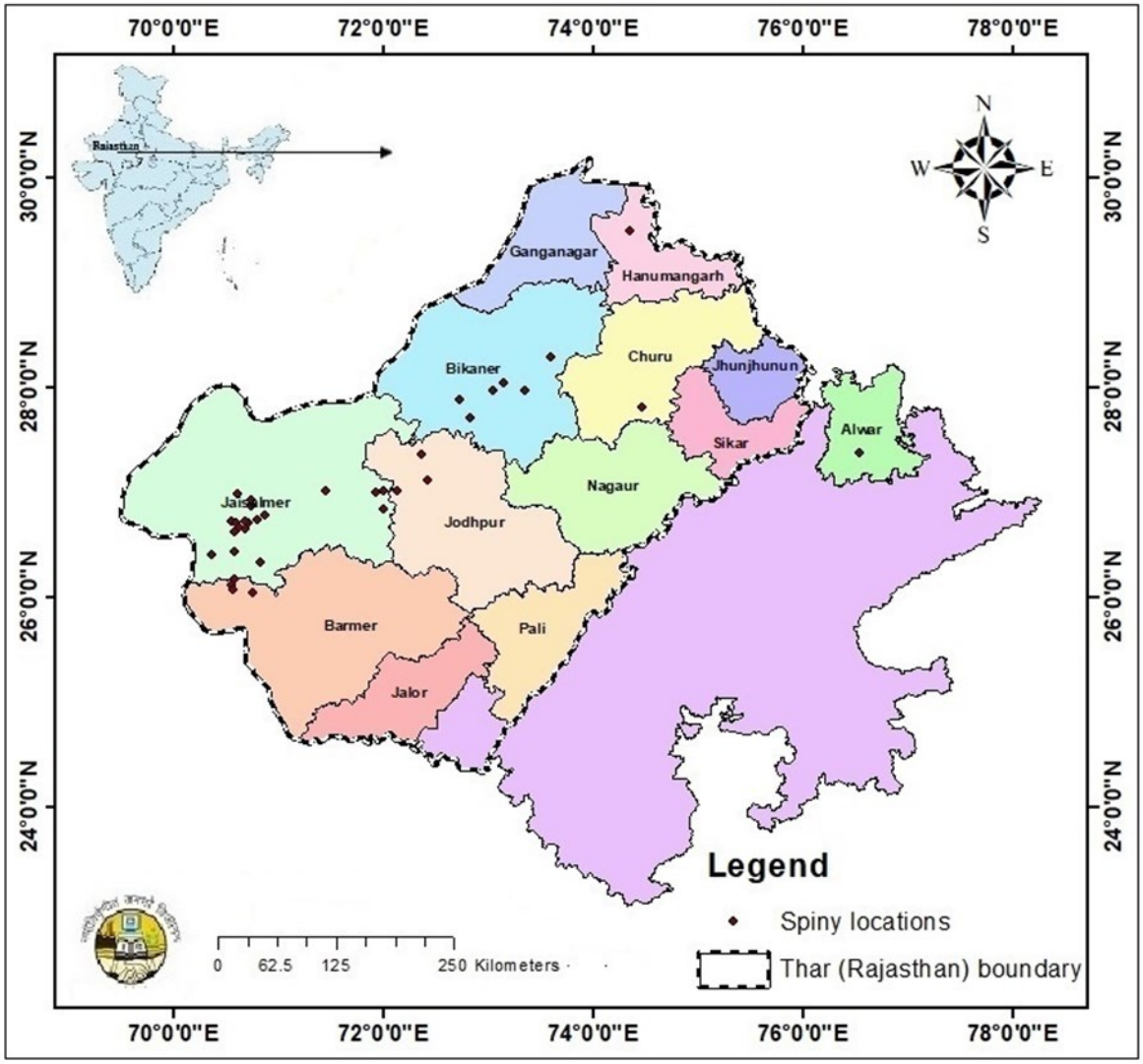

Figure 2. Distribution of Indian spiny-tailed lizard in Rajasthan

Field data collection

The field data was collected through regular field surveys in the study area from January 2014 to May 2017. Priority was given to survey areas where the species was recorded earlier.

Population estimation and preparation of the distribution map

For population estimation, active burrows were counted during the resting time of the lizard by observing trails or fresh pellets in nearby areas in 15mx15m plots (Wilms *et al.* 2009, Das *et al.* 2013). The population of species was estimated from active burrow density for different areas (no. of active burrows/area) (Das *et al.* 2013) (Table 1). GPS points were recorded for species occurrence in the area. The distribution map of the species was prepared by importing ground control points (GCPs) for species on the base map of the study area.

Habitat suitability analysis

Habitat and microhabitat information were collected through the 'perambulation' method (Ralph *et al.* 1993, Dieni and Jones, 2002). At selected sites, ecological sampling was carried out following the 'quadrat sampling-time constrained' method (Campbell and Christman 1982, Vogt and Hine 1982, Das *et al.* 2013) in 15mX15m plots and information on habitat and microhabitat collected through such sampling was also taken into consideration for habitat suitability analysis.

The analysis was carried out following GIS-based weighted overlay analysis (Malczewski 2004, Walke *et al.* 2012, Joshi *et al.* 2017). For

this, thematic maps for vegetation, land use/land cover, annual rainfall, soil, and monthly maximum and minimum temperature of the study area given by Joshi *et al.* (2017) were used as source maps. All the maps were geometrically rectified using geographic projection system UTM. The spheroid and datum used were WGS 1984 with UTM zone 42N. The geo-databases for all maps were generated in ArcGIS environment. GCPs for species occurrence were imported on the base map, and multiple ring buffers were generated for all the locations (Fig. 3A). All the polygon features were converted into a grid with 50 meters pixel size. Percentile influences were assigned to all geographically referenced input data for different criteria that were used for suitability analysis and weights (1-9) to different attributes within each criterion based on habitat and microhabitat information of the species collected in the field (Table 2). Finally, all the geo-referenced inputs were overlaid in ArcGIS environment to derive the suitability map (Fig. 3B).

Table 1. Population status of Indian spiny-tailed lizard in the TDR.

Districts	Localities	No. of Quadrats	Active burrow density/ha
Barmer	Ashadhi; Bandera; Munihari; Piparli	16	268.1±71.1
Bikaner	Jorbeer; Karnisar; Near Gajner Sanctuary; Near Lakhasar village; Near Nal village, Diyatra	22	262.2±56.89
Churu	Gaushala, Tal Chappar village	54	326.1±193.9
Jaisalmer	Barana; Bersiala; Bidda; Chohani; Daw; Dhanela; Dhursar; Khuri; Kumbharkota; Near Eka village; Near Ramdevra Temple; Near Sorhakhor village; Nimba; Pithla; Sam; Shahgarh; Sudasari; Sipla	41	362.5±102.3/ha
Jodhpur	Near Khara village; Near Khichan village, Bap	8	228.0±49.1
Overall	-	141	314.6±142.1/ha

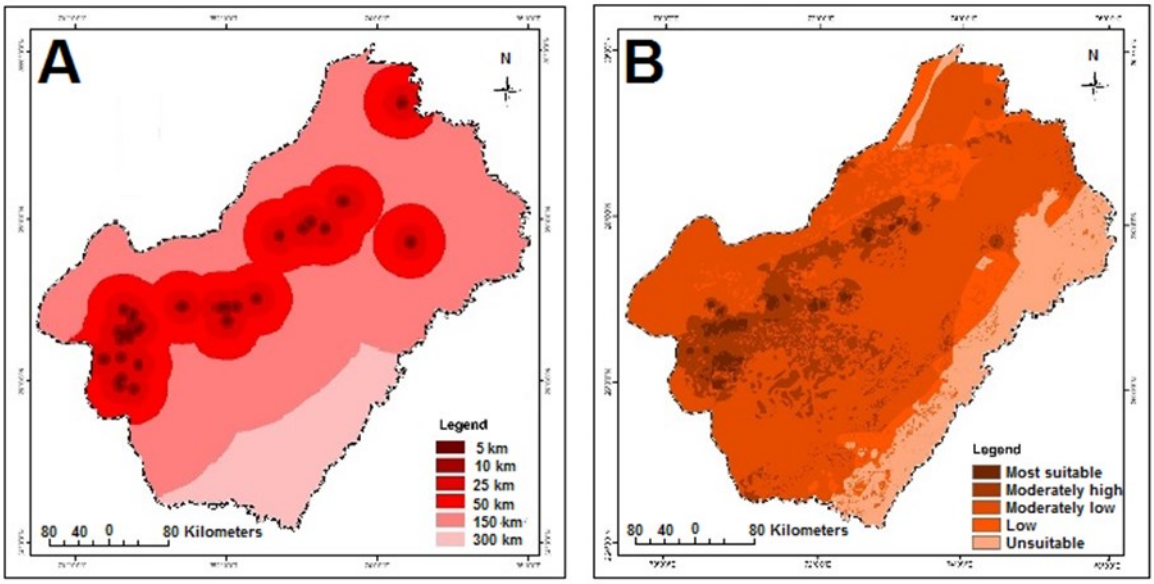

Figure 3. A: Location buffer of Indian spiny-tailed lizard in the TDR; B: Habitat suitability of Indian spiny-tailed lizard in the TDR

Table 2. Influences and weightages of different thematic layers used for habitat suitability modeling of Indian spiny-tailed lizard in TDR.

Thematic layers	Influence	Field class	The weightage (1 -
Vegetation	13	*Calligonum-Haloxylon-Leptadenia*	5
		Salvadora-Prosopis-Capparis	8
		Acacia nilotica-Acacia tortilis	1
		Prosopis-Capparis-Ziziphus	9
		Prosopis-Tecomela	3
		Acacia nilotica	1
		Acacia senegal-Euphorbia caducifolia	1
		Ziziphus-Capparis	7
		Anogeissus pendula-Boswellia serrate	1
		Anogeissus pendula-Euphorbia-Rhus mysorensis	1
		Suaeda fruticosa-Salsola baryosma	4
		Acacia leucophloea-Prosopis cineraria-Acacia nilotica	1
Land use/ land cover	13	Arable	1
		Water body	1
		Culturable wasteland	5
		Forest	1
		Grassland	8
		Scrubland	6
		Rural settlement	3
		Sand/ pasture	8
		Unculturable wasteland	6
		Urban settlement	1
Average anuual rainfall (in cm)	13	<20	7
		20-40	6
		40-50	1
Soil	13	Alluvial	3
		Desert	9
		Grey brown	1
Maximum temperature (July in °C)	13	32.5-35	7
		35-37.5	8
		>37.5	9
Minimum temperature (January in °C)	13	<5	4
		5.0-7.5	5
		7.6-10	7
		>10	8
Sighting location (distance in km.)	22	5	9
		10	6
		25	3
		50	1
		150	1
		300	1

Threat assessment

Threat data was collected using various methods during field surveys viz. through vehicular surveys using both four-wheelers as well as a bike (running mostly at a moderate speed of around 30-35 km/h for optimal detection of road accident deaths of small animals), perambulation, opportunistic searches and by interacting with local people as well as staffs of Rajasthan Forest Department (Dieni and Jones 2002, Hill *et al.* 2005, Gomes 2009).

Results

Distribution and population status of Indian spiny-tailed lizard in TDR

The present study recorded the species in six districts, i.e., Barmer, Bikaner, Churu, Hanumangarh, Jaisalmer, and Jodhpur districts out of 13 districts of the TDR (Table 1; Fig. 2). The species occurrence from one locality, i.e., Near Kohla forest in Hanumangarh district, was based on indirect evidence and local people's information only. The study herewith provides a distribution map of the species in Rajasthan, i.e., in the TDR and one locality outside the TDR where the species exists at present (Fig. 2).

The active burrow density of this species was found to be highest in Jaisalmer district (362.5±102.3/ha) followed by Churu (326.1±193.9/ha), Barmer (268.1±71.1/ha), Bikaner (262.2±56.89/ha) and Jodhpur (228.0±49.1/ha) districts and 314.6±142.1/ha in the overall area of TDR (Table 1).

Habitat suitability of Indian spiny-tailed lizard in TDR

In this study, a thematic map prepared under geospatial environment for species occurrence data collected from ground-truthing (Fig. 3A) was used as an independent factor along with thematic maps for other environmental variables such as vegetation, land use/land cover, average annual rainfall, soil, monthly maximum and minimum temperatures to produce the final habitat suitability map of Indian spiny-tailed lizard in the TDR (Fig. 3B). The map identified different potential habitat zones of Indian spiny-tailed lizard in the TDR, which are 1.71%, 13.49%, 59.51%, 10.65%, and 14.64% as most suitable, moderately high suitable, moderately low suitable, low suitable and unsuitable respectively (Fig. 4).

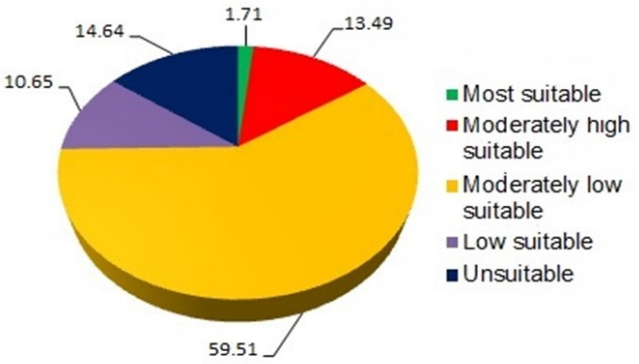

Figure 4. Suitable area percent cover for Indian spiny-tailed lizard in the TDR

Threats to Indian spiny-tailed lizard in TDR

Habitat destruction, poaching for the illegal pet trade, and road accident deaths found to be common threats for the species in the study area (Table 3). The present study reports one conservation conflict that has recently wiped out the population of the species inside one Protected Area in the TDR as mentioned in Table 3, details of which will be published separately in the future. The study also first time reports accidental intake of plastic by the lizard (Table 3, Fig. 5).

Figure 5. An ingested plastic piece in the pellet of Indian spiny-tailed lizard (under the microscope)

Table 3. Threats to Indian spiny-tailed lizard in the TDR.

S. No	Threat types	Particular	Areas where observed	Remark
1	Habitat Destruction	Human settlement or developmental purpose	Throughout TDR; the species is locally extinct in the surrounding area of Bikaner-Gajner State Highway which was once considered one of the best habitats (Das and Pandey, 2005) of the species.	One of the major threats as human population is increasing and agriculture is expanding due to introduction of India Gandhi Nahar (Canal) Project (IGNP) in the TDR.
		Agricultural activity		
2	Poaching	Trapping of Indian spiny-tailed lizards for their meat, skin and oil; oil extracted from their skin and tail is considered an aphrodisiac.	Throughout TDR; more intense in western Rajasthan	For illegal trade.
3	Road accident deaths	The lizard many times get crushed under vehicles passing with uncontrolled speed on roads passing through their habitats.	Throughout TDR	Lack of roadside displays in such areas acknowledging wildlife of the area and recommending safe vehicular speed.
4	Conservation conflict	Replacement of short grasses by long grasses in order to avoid food scarcity in the area for increasing black buck population.	Tal Chhapar Wildlife Sanctuary	Complete elimination of Indian spiny-tailed lizard from the Sanctuary though population of several thousand (Das et al. 2013) existed inside the Sanctuary before 2012. At present, the lizard exists only outside the Sanctuary that is not part of the Protected Area.
5	Plastic intake	During pellet analysis under a microscope in one pellet, a piece of plastic was observed embedded within vegetative parts (Fig. 5).	Jaisalmer	Accidental (as only one out of 200 pellets it was observed), but point towards keeping habitat of the species plastic-free.

Discussion

The present study reports the population of the species in six districts of TDR (Table 1, Fig. 2), though the existence of the species no longer observed in many parts of these districts from where it was previously reported (Biswas and Sanyal 1977, Sharma and Vazirani 1977, Das and Pandey 2005, Ramesh and Ishwar 2008, Das *et al.* 2013). Moreover, in the present study reporting of the species from Hanumangarh district is based on indirect evidence only and no population was recorded in any localities of Pali and Ganganagar districts from where the species was reported earlier (Biswas and Sanyal 1977, Sharma and Vazirani 1977, Ramesh and Ishwar 2008). Hence, the current occurrence of the species in these districts of TDR is subjected to further investigation. Ramesh and Ishwar

(2008), in their study, had indicated that the species had been continuously facing local extinctions in many parts of the TDR, and the result is in accordance with their findings. This suggests for immediate protection of the species in the TDR. Further, the study provides a distribution map of the species in Rajasthan that includes one locality outside the TDR viz. Kalakadi village, Sariska National Park, where the species at present exists (Das *et al.* 2015).

It is worthy of mentioning here that In India, outside Rajasthan, the species was earlier reported from Delhi, Haryana, Uttar Pradesh, Madhya Pradesh and Gujarat (Smith 1935, Husain 1997, Vyas 2000, Chandra and Gajbe 2005, Dutta and Jhala 2007, Uetz *et al.* 2020, Srivastava *et al.* 2018). At present, the species is locally extinct in Delhi (personal observations by authors), exists at two localities viz. Kalwas and Rawat Kheda villages in Hisar district of Haryana (Srivastava *et al.* 2018) and in desert areas of Kachchh district of Gujarat (Vyas 2000). However, at present, the existence of this species in Uttar Pradesh and Madhya Pradesh is doubtful and subjected to further investigation as reporting of the species in these states is based on very old literature of pre-independence India (Smith 1935) without any further reporting later. This is the reason Kanaujia *et al.* (2017), in their recent study, could not able to trace the species in Uttar Pradesh and have been excluded the species from the herpetofauna checklist of the state. However, in recent past, Chandra and Gajbe (2005) had mentioned distribution of the species from Bandhoharh Tiger Reserve, Rewa district of Madhya Pradesh based on the literature of Smith (1935), Khajuria (1986) and Sanyal (1993), though very, unfortunately, Khajuria (1986) and Sanyal (1993) had no mention about the species. This is the reason Sur *et al.* (2007) have later excluded the species from the checklist of reptiles of the state.

In this study, though several environmental factors have been used along with species occurrence data to assess habitat suitability, maximum influence is given to species occurrence data (Table 2). Further, for each environmental factor, weightages are assigned to different field classes based on habitat and microhabitat information collected through ground-truthing (Table 2). The maximum density of the lizard was observed in the Jaisalmer district (362.5±102.3/ha). The habitat suitability analysis revealed that though the species can survive in a significant portion (most suitable, moderately high suitable, moderately low suitable) of the TDR, only a small area of that (1.71%) is best suitable for the species (Fig. 3B, 4). Of the best suitable area, the maximum area comes under the Jaisalmer district, followed by Bikaner and Barmer districts of western Rajasthan (Fig. 3B). Hence, Jaisalmer district supports most of the crucial habitats for the species in the TDR. In the absence of any detailed study, the previous occasional reporting and short-term studies on the species by Das and Pandey (2005), Ramesh (2008), Ramesh and Ishwar (2008), Das *et al.* (2013) and Solanki *et al.* (2015) in the TDR support this finding. The study also shows a significant part (25.29%) of the TDR is either less suitable or unsuitable for the species (Fig. 3B, 4).

Common threats to this species in the TDR as documented in this study is following findings of Knapp (2004), Dutta and Jhala (2007), Ramesh and Ishwar (2008), Das *et al.* (2013) and Joshi *et al.* (2019). Other threats to this species i.e., conservation conflict and accidental plastic intake is quite interesting and must bring the attention of conservationists.

Conclusion

The present study brings into knowledge the current distribution and population status of the Indian spiny-tailed lizard in the TDR**.** The study reveals the species has been continuously facing various threats in the TDR that lead to local extinctions. This, points towards immediate conservation attention for this species in the

TDR. Through this study, the first time the habitat suitability analysis for this conservation dependent species is carried out in the TDR using geospatial techniques to identify crucial habitats of the species. This will no doubt help to save the species from further exploitation, also in designing conservation priorities areas for this species in the region.

Acknowledgments

The authors are grateful to the following personnel and institutions: Mr. R.K. Tyagi, Chief Wildlife Warden, Rajasthan for granting permission for field study, Mr. Anoop K.R., Field Director, Desert National Park and Mr. Surat Singh Poonia, Assistant Conservator of Forest, Talchhapar Wildlife Sanctuary for their cooperation and logistic support during field surveys; the Department of Science and Technology (DST), Government of India, New Delhi for funding the spiny-tailed lizard project (SERB No: SB/SO/AS-042/ 2013) which made field surveys possible, Mr. Somanath Sahoo, Research Scholar, Guru Gobind Singh Indraprastha University, Mr. Tarun Singh, Jaisalmer and Mr. Bhagwanram, Churu for assisting in field surveys during the study, Prof. Anubha Kaushik, Ex-Dean, USEM, GGSIP University, New Delhi for providing necessary facilities and for her constant encouragement throughout the work.

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