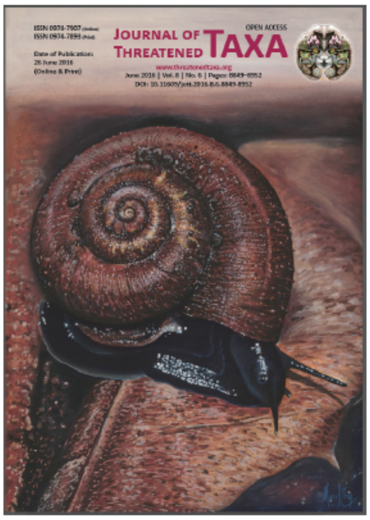

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Commnunication

All that glitters is not gold: A projected distribution of the endemic Indian Golden Gecko *Calodactylodes aureus* (Reptilia: Squamata: Gekkonidae) indicates a major range shrinkage due to future climate change

Aditya Srinivasulu & Chelmala Srinivasulu

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Abstract: Climate change has a perceived threat on biodiversity due to its effect on species range. Species with narrow ranges and highly specific climatic and habitat requirements are at higher risk. To understand the influence of climate change on the Indian endemic gekkonid, the Indian Golden Gecko *Calodactylodes aureus* (Beddome, 1870) we model the present and future predicted distribution (2050 and 2070) under the CMIP5 RCP4.5 and RCP8.5 scenarios using MaxEnt under the HadGEM3-ES Model. Our analysis revealed the negative impact of climate change on the Indian Golden Gecko with a decrease in the amount of climatically suitable areas in the future, and an almost total range shrinkage by 2070. Despite its wide distribution in the eastern Deccan Peninsula, according to our predictions, the species is threatened by a shrinkage in the future range due to climate change.

Keywords: Climate change, Deccan peninsula, MaxEnt, modelling, range shrinkage, South Asia, species distribution.

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Author Contribution: Both authors contributed equally to the study, analysis and writing the manuscript.

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INTRODUCTION

South Asia is considered to be one of the most biologically diverse harbours of endemic species with four global biodiversity hotspots (Himalaya, Indo-Burma, Western Ghats & Sri Lanka, and Sundaland) (Olson & Dinerstein 1998). It is one of the eight Vavilovian centres of origin and diversity of crop plants, and is home to some of the world's most threatened species. It is also very highly affected by human encroachment, habitat loss and degradation and climate change. The impact of climate change is considered to be one of the greatest threats to species diversity in the world (Walther et al. 2005). A great number of studies have indicated that climate change affects phenology, geographical range and in some cases, even local survival (Pounds et al. 1999; Parmesan & Yohe 2003; Root et al. 2003), with a high impact on global biodiversity (Araújo & Rahbek 2006). Local extinctions, high isolation, movement of populations from their original locations to new and unoccupied areas are highly affected by climate change (Thomas et al. 2004). The impact of climate change is particularly great on reptiles, which are in danger of extinctions worldwide (Gibbons et al. 2000; Araújo et al. 2006; Wake 2007; Deutsch et al. 2008; Huey et al. 2009; Kearney et al. 2009; Dillon et al. 2010; Sinervo et al. 2010; Bombi et al. 2011; Duarte et al. 2012).

The impact of climate change on species distribution is frequently determined using species distribution models (SDMs) that correlate the available data on species distribution with current environmental conditions and then use future potential climate conditions to predict future species distribution (Pearson & Dawson 2003; Araújo et al. 2006). Although predicting the impact of climate change on species distribution using SDMs has been considered a challenging task due to various sources of uncertainties (Beaumont et al. 2008; Marmion et al. 2009; Seo et al. 2009), the development of robust statistical modelling methods (Elith et al. 2006) and advanced methodologies (Hijmans et al. 2005; Pearson et al. 2006; Araújo & New 2007; Seo et al. 2009) have led to increased use of SDMs to address issues in ecology, conservation biology and climate change research (Guisan & Thuiller 2005). Despite their popularity, SDMs have been challenged due to between-model differences for the same species and different climate change scenarios (Pearson & Dawson 2003; Thuiller 2004; Guisan & Thuiller 2005; Araújo & Guisan 2006; Austin 2007; Pearson et al. 2007). While these models excel in predicting the current distribution of the species, their ability to predict future distributions under changing climate scenarios have been questioned (Araújo & Rahbek 2006; Austin 2007; Pearson et al. 2007; Thuiller 2007). Maximum Entropy (MaxEnt) modelling is one of the most accurate and trusted modelling methods for presence-only distribution data (Ortega-Huerta & Peterson 2008).

The present study aims to understand the impact of climate change on the distribution of an endemic boulder-surface gecko, the Indian Golden Gecko *Calodactylodes aureus*, and propose management actions for the conservation of this unique species in India. This study involves use of the MaxEnt modelling approach to examine the impacts of climate change in the near (2050) and distant future (2070) through calculating changes in climatically suitable areas for the species under the HadGEM3-ES model using the CMIP5 RCP4.5 and RCP8.5 scenarios.

MATERIALS AND METHODS

Study Species & Data Records

The genus *Calodactylodes* (Beddome, 1870) is restricted to tropical South Asia and is represented by two rupicolous boulder-surface lizard species: the Indian Golden Gecko *Calodactylodes aureus* (Beddome, 1870) and the Sri Lankan Golden Gecko *Calodactylodes illingworthorum* (Deraniyagala, 1953) (Russell & Bauer 1989; Bauer & Das 2001). The Indian Golden Gecko (Image 1) is a large, brightly coloured and highly vocal gecko endemic to India (Bauer & Das 2001; Daniel 2002). Since its description (Beddome 1870; Smith 1935), this species was known only from the type locality ('Tripatty hills' by Smith (1935) which actually is 'Truppatur' (Beddome 1870)) and was not sighted until 1986 whence it was rediscovered after more than 100 years (Daniel &

Image 1. Indian Golden Gecko *Calodactylodes aureus* from Yarada, Vishakhapatnam District, Andhra Pradesh, India

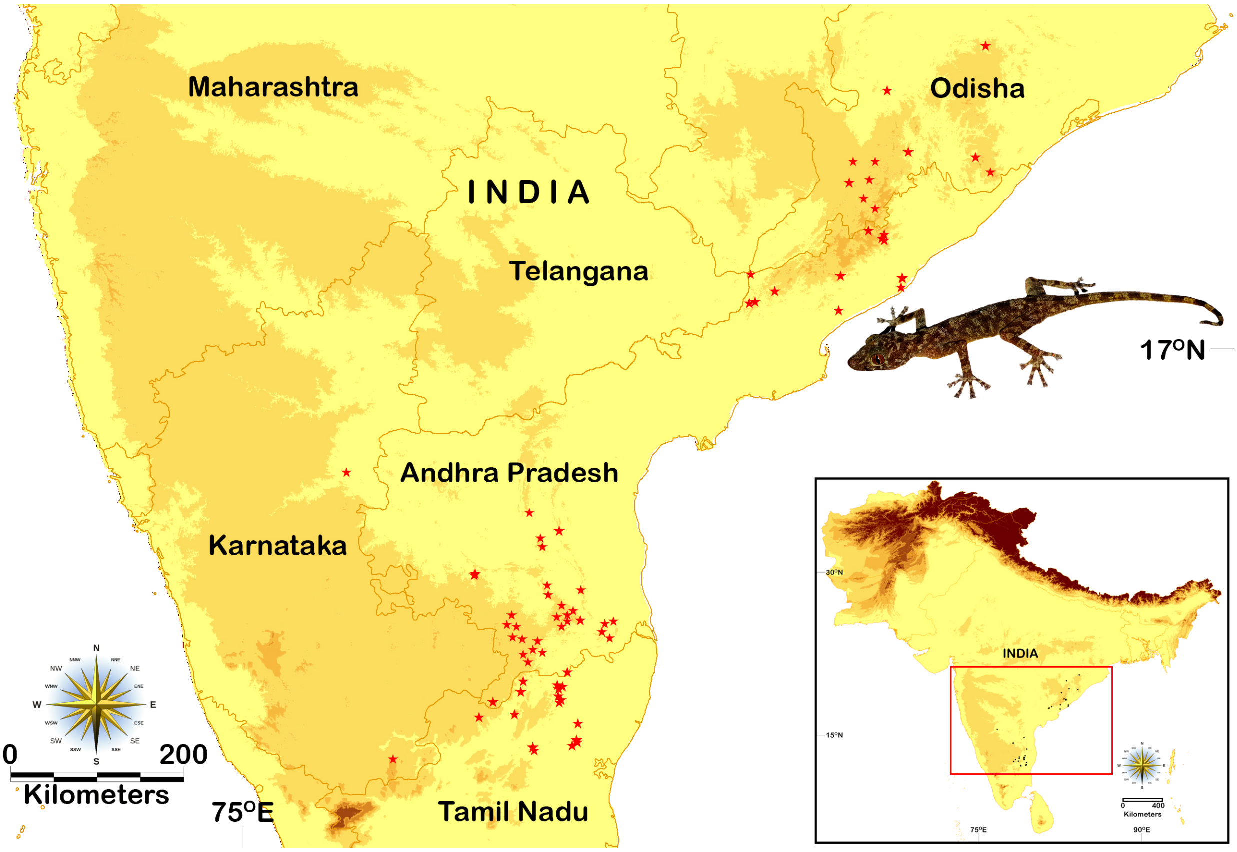

Figure 1. Geographical distribution (as point locations) of Indian Golden Gecko - an endemic species.

Bhushan 1985; Daniel et al. 1986; Russell & Bauer 1989). It occurs along the coastal hills of Andhra Pradesh, Odisha, northern Tamil Nadu and parts of Karnataka (Daniel & Bhushan 1985; Daniel et al. 1986; Molur & Walker 1998; Bauer & Das 2001; Dutta et al. 2005; Javed et al. 2007; Sreekar et al. 2010; Reddy et al. 2013; Srinivasulu et al. 2014; Varadaraju 2014) (Fig. 1). Until 2000 this species had never been studied intensively (Bauer & Das 2001) and since then it has been reported from many sites, both in the vicinity (about 150km radius) of the type locality (Daniel & Bhushan 1985; Daniel et al. 1986; Bauer & Das 2001; Kalaimani & Nath 2012, 2013; Reddy et al. 2013;) and away from it on the northern side of the river Godavari (Dutta et al. 2005; Javed et al. 2007; Chettri & Bhupathy 2010; Sreekar et al. 2010, Varadaraju 2014). This gecko has been reported to prefer rocky areas with deep stream valleys at elevations between 50 and 1000 m and to lay eggs in communal egg deposition sites (Bauer & Das 2001; Javed et al. 2007; Sreekar et al. 2010) on rocky surfaces, mostly on vertical rocks, in natural, human-inhabited and human-disturbed areas. Owing to its rarity and endemicity, this species has been accorded a protected status in India and is listed under Schedule I (Part II) of the Indian Wildlife (Protection) Act, 1972. The species has been assigned the Red List status of Least Concern owing to its wide distribution range in the Eastern Ghats despite localized threats to its habitat (Bauer et al. 2013).

We collated the species records from published sources and field surveys, the majority of which were confirmed during the 2011 Western Ghats Reptile Conservation Assessment and Management Plan (CAMP) Workshop (Srinivasulu et al. 2014). With the inputs from the participants of the CAMP workshop, recent field surveys yielded more species-positive sites. As the Indian Golden Gecko is a protected species, the present study did not involve any collection, or handling of individuals and so no specific permits were required, excepting at one site that was on a private land, where the permission for conducting the survey was acquired from the owner.

A total of 42 records were obtained. We excluded multiple sites within a 5-km radius of reported clusters of sites to avoid duplications. The precise geographic coordinates for all records have been determined using Google Earth 7.1 and we assume that the sites mapped are within a 1-km radius of the actual sites. We mapped the presence points to 30 arc-second resolution for species distribution modelling.

Study Area

We defined our study area (roughly 5,923,789km^2, Fig. 1), following the boundaries of South Asia, including the countries Afghanistan, Bangladesh, Bhutan, India, Nepal, Pakistan, and Sri Lanka. Due to their insularity and isolation from the peninsular area of South Asia, we did not include the Maldives in our study area. The zone is heterogeneous in terms of both climate and vegetation and provides a diverse range of ecological niches for the probable distribution of the species. The majority of the distribution of the species is restricted to the peninsular Indian Deccan Plateau, which is mostly semi-arid and covers an area of approximately 1,397,979km^2. The study area encompasses three global biodiversity hotspots (Himalaya, Indo-Burma, Western Ghats & Sri Lanka) (Olson & Dinerstein 1998).

Environmental Data

We utilized current bioclimatic variables including 11 temperature matrices and eight precipitation matrices obtained from the WorldClim v1.4 database (http://www.worldclim.org/current) (Hijmans et al. 2005), gridded to 30 arc-second (~1 km^2) resolution. These layers correspond to interpolated mean information from 1950 to 2000 from climate stations around the world. Of these, eight variables that were important to shape the climate suitable for the species in the study area and at the same time were not highly correlated ($|\text{Pearson } r| \leq 0.7$) were selected through collinearity analysis in ENMTools (Warren et al. 2008). The eight environmental variables selected for the current study are annual temperature range, mean diurnal temperature range, mean isothermality, mean temperature seasonality, minimum temperature of coldest month, mean precipitation seasonality, and mean precipitation of coldest quarter. We modelled future distributions using the same environmental layers of 30 arc-second resolution and one global-level Earth System Model - HadGEM3-ES (Hadley Centre Global Environment Model v3 - Earth System), developed by the Met Office Hadley Centre for Climate Prediction and Research, obtained from the WorldClim database (downloaded from http://www.ccafs-climate.org/data/) for 2050 and 2070, based on the CMIP5 (Coupled Model Intercomparison Project Phase 5) (IPCC 2014). Of the four available scenarios we used RCP4.5 (Representative Concentration Pathway 4.5) scenario, which predicts that emissions will peak in 2040 and then stabilize (equivalent to the B2 Scenario of CMIP3), and the RCP8.5 scenario, which predicts that emissions will continue to escalate past 2100 (equivalent to the A2 Scenario of CMIP3) (Maloney et al. 2013).

Modelling Methods

The Indian Golden Gecko distributions were predicted using MaxEnt 3.3.3k (Phillips et al. 2006), a grid-based machine-learning algorithm that follows the principle of maximum entropy (Jaynes 1957). MaxEnt analysis was conducted using 25% random test percentage and five bootstrap replicates. The default logistic output format was used, with suitability values ranging from 0=unsuitable, to 1=optimal (Phillips et al. 2006).

Change in Climatically Suitable Areas

We converted the output of the MaxEnt analysis to binary rasters (with a threshold of 0.5), and calculated the percentage (and number, representative of area) of cells gained or lost with respect to the current climatically suitable range for the future predicted range under limited dispersal in 2050 and 2070, using SDMToolbox v.1.1c (Brown 2014) in ArcGIS 10.3.

RESULTS

Model Evaluation

For the current analysis we produced our model using the MaxEnt algorithm (Image 2). An analysis concerning the importance of each selected variable for modelling current and projected distributions showed that the bioclimatic variables that contributed to the model the most were temperature-based, implying that the species is affected by both annual and seasonal temperature ranges. To account for uncertainty in both statistical and climate change models (Buisson et al. 2010) and also to avoid the problem of hidden local refugia (Randin et al. 2009; Maiorano et al. 2011), the final models were produced at fine spatial resolution of 30 arc second (~1 km^2) under HadGEM3-ES. The model was well-supported with an area under (receiver operator characteristic) curve (AUC) value of 0.989 for both the RCP4.5 scenario and the RCP8.5 scenario.

Analysis of Variable Importance

The most relevant variables for the analysis, as obtained by the spatial jack-knifing test done using MaxEnt, were annual temperature range [BIO7] (35.3%), temperature seasonality [BIO4] (21.6%), and precipitation of warmest quarter [BIO18] (8.4%) for the RCP4.5 scenario; and annual temperature range [BIO7] (29.2%), temperature seasonality [BIO4] (26.0%), and

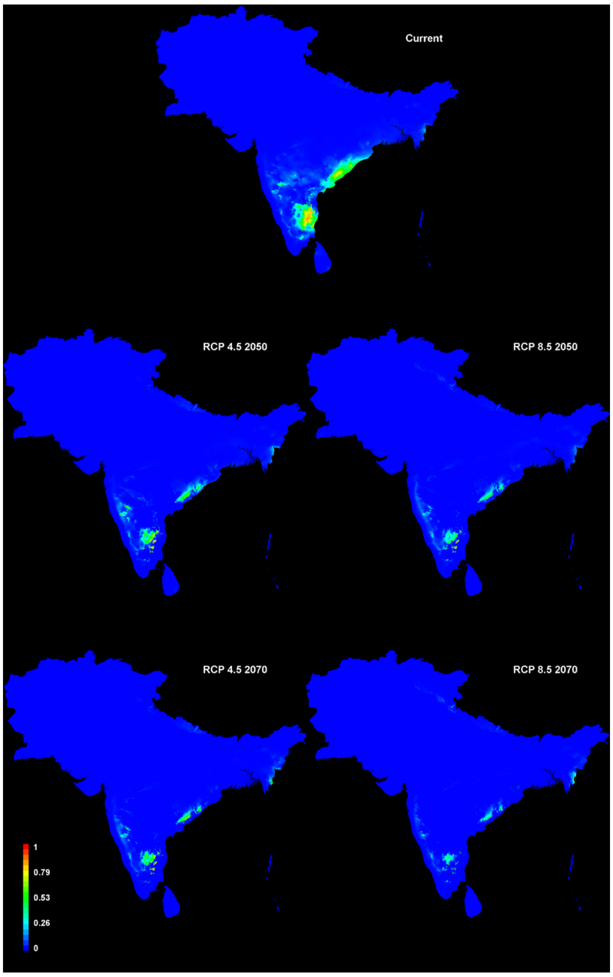

Image 2. MaxEnt prediction of the Indian Golden Gecko *Calodactylodes aureus* for HadGEM3-ES climatic scenario under RCP4.5 and RCP8.5 for current conditions (1950-2000), near future (2050), and distant future (2070). In the maps, red to orange represents highly suitable areas, yellow to blue-green represents moderately suitable areas, and light blue to dark blue represents less suitable areas to unsuitable areas based on the analysis.

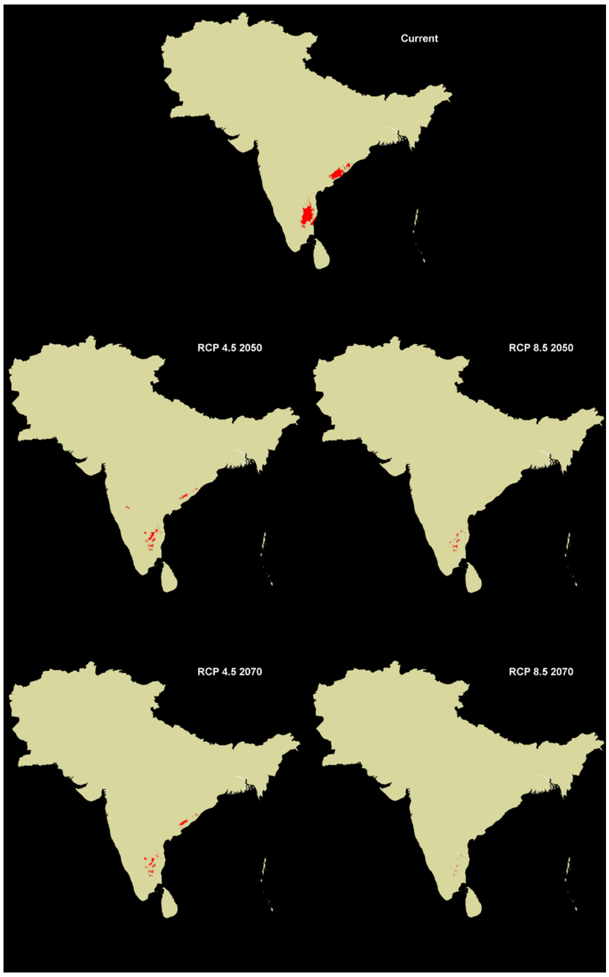

Image 3. Binary plots of the Indian Golden Gecko *Calodactylodes aureus* for HadGEM3-ES climatic scenario under RCP4.5 and RCP8.5 for current conditions (1950-2000), near future (2050), and distant future (2070). Brown areas represent climatically unsuitable areas (< 0.5 threshold) and red areas represent climatically suitable areas (> 0.5 threshold).

minimum temperature of coldest month [BIO18] (7.2%) for the RCP8.5 scenario.

Projected Impacts of Climate Change

In the analysis for all projected future time periods, negative changes in the climatically suitable areas for the Indian Golden Gecko were observed (Image 3). In the RCP4.5 scenario, a negative 73.48% change in climatically suitable area was observed between current (1950–2000) and near future (2050), and a negative 16.57% change in climatically suitable area was observed between near future (2050) and distant future (2070), representing a total decline in climatically suitable area, by 95.79%, from current to 2070; in the RCP8.5 scenario, a negative 91.21 percent change in climatically suitable area was observed between current (1950-2000) and near future (2050), and a negative 75.01% change in climatically suitable area was observed between near future (2050) and distant future (2070), and a total decline in climatically suitable area, by 97.80%, was seen from current to 2070 (Table 1).

Following the threshold set (0.5), in the RCP4.5 scenario, it was seen that 55,821km^2 is climatically suitable for the species to occur in the current scenario, while in 2050 it is 14,803km^2, and in 2070 12,349km^2, representing a total decline of 53,472km^2 in climatically suitable area for species occurrence from current to 2070; in the RCP8.5 scenario, it was seen that 55,821km^2 is climatically suitable for the species to occur in the current scenario, while in 2050 it is 4,903km^2, and in 2070,

Table 1. Changes in climatically suitable areas (in km²) of Indian Golden Gecko under HadGEM3-ES.

Time Period	RCP4.5			RCP8.5		
	Range Size	Loss	Percentage Change	Range Size	Loss	Percentage Change
Current vs. Near Future (1950–2000 vs. 2050)	55,821 vs. 14,803	41,018	–73.48	55,821 vs. 4,903	50,918	–91.21
Near Future vs. Distant Future (2050 vs. 2070)	14,803 vs. 12,349	2,454	–16.57	4,903 vs 1,225	3,678	–75.01
Current vs. Distant Future (1950–2000 vs. 2070)	55,821 vs. 12,349	53,472	–95.79	55,821 vs. 1,225	54,596	–97.80

1,225km², representing a total decline of 54,596km² in climatically suitable area for species occurrence from current to 2070 (Table 1).

DISCUSSION

Species distribution models (SDMs) have widely been used in both basic and applied ecology (Elith et al. 2006). Numerous studies have compared model performances and predictions (see McPherson & Jetz 2007 for review), and have indicated that the predictions of SDMs vary considerably depending on many factors including the nature and complexity of species response, predictor variables and the interaction between them (Guisan & Zimmermann 2000; Elith et al. 2006; Austin 2007). Although predictive SDM has been accepted as a valuable and efficient tool for conservation planning and biodiversity management (Marmion et al. 2009; Araújo & Guisan 2006; Rodriguez et al. 2007), it is imperative that one should have a thorough understanding of the limitations and uncertainties embedded in SDM (Elith et al. 2002; Loiselle et al. 2003; Barry & Elith 2006; Gibson et al. 2007). MaxEnt has been found to reveal better results than most other SDM methods (Elith et al. 2006; Wisz et al. 2008). The algorithm has also been shown to be capable of predicting new presence localities for poorly-known species (Pearson et al. 2007; Weinsheimer et al. 2010).

Our final results are in agreement with the findings of earlier studies on ectotherms (Brereton et al. 1995; Walther et al. 2002; Stuart et al. 2004; Gibbons et al. 2000; Deutsch et al. 2008; Brooks et al. 2009; D'Amen & Bombi 2009; Huey et al. 2009; Kearney et al. 2009; Dillon et al. 2010; Sinervo et al. 2010; Bombi et al. 2011; Duarte et al. 2012) and emphasize the importance of MaxEnt modelling to study the predicted impacts of climate change on species distribution (Ortega-Huerta & Peterson 2008).

Our study provides insight on the effect of predicted climate change on the Indian Golden Gecko using species distribution modelling. The result of our study, which shows a shrinkage in the range of the species by a factor of about 95.79 (RCP4.5) and 97.80 (RCP8.5) percent by the year 2070, is in conformance with earlier reports wherein range shrinkage among reptiles due to predicted climate change has been observed (Gibbons et al. 2000; Bombi et al. 2011). It is also observed that there is a steep decline (75.01%) in RCP8.5 (which is relatively pessimistic in terms of greenhouse gas emissions) between current and 2050, where almost three-quarters of the population of the species is wiped out. Though there is a slight difference in the amount of shrinkage in climatically suitable areas between RCP4.5 and RCP8.5 (owing to RCP4.5 being relatively optimistic in terms of greenhouse gas emissions), both scenarios show a generally drastic decline in the range of the species, amounting to an almost total wipeout (>95.0%) of climatically suitable areas by 2070.

The Indian Golden Gecko has been considered to be a denizen of forested tracts, usually found in rocky habitats near seasonal water sources. The recent detection of its presence in xeric habitats indicates that the species is tolerant to arid to semi-arid conditions. Most sites are located in broken hill with steep ravines and ridges in the spurs of Eastern Ghats with mainly dry deciduous and scrub habitats dominated by huge rock boulders, in close proximity to seasonal running water sources such as rivers or streams.

Although the whole of Deccan Peninsula in India has xeric habitat characteristics with more or less homogeneous thermal and precipitation regimes, the Indian Golden Gecko is patchily distributed and occupies only selected areas indicating requirement of special microclimatic conditions (Sreekar et al. 2010). In the past decade, surveys in many parts of the Eastern Ghats have been conducted and the species has not been reported, especially so in the Nallamala Hills and the Palnad Basin between the Krishna and Godavari rivers (the authors' personal observations). To understand

Table 2. Known locality details of Indian Golden Gecko distribution in India

	Name of the site	Latitude	Longitude	Source
Andhra Pradesh				
1	Tirupati hills, Chittoor District	13.76⁰N	79.33⁰E	Daniel & Bhushan (1985)
2	Velikonda range, Kadapa District	14.75⁰N	79.16⁰E	Daniel & Bhushan (1985)
3	Perantalapally, East Godavari District	17.45⁰N	81.76⁰E	Javed et al. (2007)
4	Shova village, Araku valley, Vishakhapatnam District	18.33⁰N	82.85⁰E	Chettri & Bhupathy (2010)
5	Ananthagiri hills, Visakhapatnam District	18.23⁰N	82.83⁰E	Sreekar et al. (2010)
6	Maredumilli, East Godavari District	17.93⁰N	82.38⁰E	Sreekar et al. (2010)
7	Tyda, Visakhapatnam District	18.23⁰N	83.05⁰E	Sreekar et al. (2010)
8	Borra caves, Visakhapatnam District	18.28⁰N	83.03⁰E	Present study
9	Kalasamudram RF, Anantapur District	14.29⁰N	78.15⁰E	Reddy et al. (2013)
10	Batrepalle RF, Anantapur District	14.27⁰N	78.18⁰E	Reddy et al. (2013)
11	Madhuravada, Vishakhapatnam District	17.81⁰N	83.32⁰E	M. Giridhar pers. comm.
12	Lammasingi, Vishakhapatnam District	17.78⁰N	82.43⁰E	M. Giridhar pers. comm.
13	Lova, East Godavari District	17.37⁰N	82.49⁰E	M. Giridhar pers. comm.
14	Kolluru, East Godavari District	17.47⁰N	81.49⁰E	M. Seetharamaraju pers. comm.
15	Yarada, Vishakhapatnam District	17.65⁰N	83.23⁰E	Bhargavi Srinivasulu, pers. comm.
16	Donkarayi, East Godavari District	17.93⁰N	81.79⁰E	G. Chethan Kumar pers. comm.
Tamil Nadu				
17	Tirupattur, Vellore District	12.49⁰N	78.57⁰E	Beddome (1870)
18	Balamadi Hill, Vellore District	12.90⁰N	79.18⁰E	Bauer & Das (2000)
19	Vellore hill forest, Vellore District	12.89⁰N	79.18⁰E	Bauer & Das (2000)
20	Vallimalai, Vellore District	13.07⁰N	79.26⁰E	Kalaimani & Nath (2012)
21	Syed Basha Malai, Krishnagiri District	12.53⁰N	78.21⁰E	Kalaimani & Nath (2012)
22	Nedungunam Hill, Tiruvanamalai District	12.45⁰N	79.38⁰E	Kalaimani & Nath (2012)
23	Sathgar Hill, Vellore District	12.95⁰N	78.70⁰E	Kalaimani & Nath (2012)
24	Senji, Villupuram District	12.25⁰N	79.39⁰E	N.S. Achyuthan pers. comm.
25	Muttakadu, Villupuram District	12.24⁰N	79.38⁰E	Kalaimani & Nath (2013)
26	Siruvadi, Villupuram District	12.26⁰N	79.37⁰E	Kalaimani & Nath (2013)
27	Pakkamalai, Villupuram District	12.18⁰N	79.30⁰E	Kalaimani & Nath (2013)
28	Sathanur Dam, Tiruvanamalai District	12.20⁰N	78.85⁰E	Kalaimani & Nath (2013)
29	Melthirvadathanur, Tiruvanamalai District	12.14⁰N	78.87⁰E	Kalaimani & Nath (2013)
30	Karadi Parai, Tiruvanamalai District	12.15⁰N	78.90⁰E	Kalaimani & Nath (2013)
31	Kailasagiri, Vellore District	12.83⁰N	78.70⁰E	Kalaimani & Nath (2013)
Odisha				
32	Niyamgiri hills, Rayagada & Kalahandi Districts	20.20⁰N	84.44⁰E	Dutta et al. (2005)
33	Phulbani, Phulbani District	20.48⁰N	84.23⁰E	P. Mohapatra pers. comm.
34	Baphlimali, Rayagada District	19.21⁰N	83.34⁰E	P. Mohapatra pers. comm.
35	Sankesumali, Rayagada District	19.11⁰N	83.18⁰E	Varadaraju (2014)
36	Mahendragiri, Gajapati District	18.97⁰N	84.37⁰E	Varadaraju (2014)
37	Chandragiri, Gajapati District	19.29⁰N	84.28⁰E	Varadaraju (2014)
38	Koraput, Koraput District	18.94⁰N	82.65⁰E	P. Mohapatra pers. comm.
39	Gajapati, Gajapati District	20.35⁰N	85.66⁰E	P. Mohapatra pers. comm.
40	Khandwalmali, Kalahandi District	19.29⁰N	83.10⁰E	Varadaraju (2014)
41	Kutrumali, Kalahandi District	19.28⁰N	83.06⁰E	Varadaraju (2014)
Karnataka				
42	Hampi, Bellary District	15.33⁰N	76.47⁰E	Srinivasulu et al. (2014)
43	Billigiri Rangan Temple Hills, Chamarajnagar District	11.59⁰N	77.80⁰E	Varadaraju (2014)

the availability of suitable habitats where the species could possibly occur we initially used maximum entropy modelling procedure which indicated better suitable habitats in Visakhapatnam District in the species' northern range and Vellore District in its southern range (Table 2). Our field surveys in the species' northern range yielded sighting of the species in seven out of 12 sites randomly selected in Visakhapatnam, East Godavari and Khammam districts (Table 2). Reddy et al. (2013), Srinivasulu et al. (2014) and Varadaraju (2014) reported new records from the southern range from Andhra Pradesh and Karnataka.

The Indian Golden Gecko, despite being large, brightly-coloured and highly vocal, remained an enigmatic species until recently. Owing to its rarity in the past, the Indian government has accorded protection to this species, although it has recently been assessed as a Least Concern species as per the Red List (Bauer et al. 2013). This species, in its range, is present in two protected areas, Sri Venkateshwara National Park and Papikonda Wildlife Sanctuary (both in Andhra Pradesh). All sites where the species has been reported are greatly influenced by human-induced disturbances as >90 percent of the sites are either within townships or tourism sites. The increased anthropogenic disturbance in the species' habitat coupled with a looming impact of climate change on the species will cast negative impacts on the species in future. It is imperative that despite its wide range and present day population trends, future research should focus on its physiology, microclimatic requirements (in spatio-temporal terms), the species' ability to cope with anthropogenic pressures and land use changes. Given the massive decline in climatically suitable areas in the southern range of the species, it is imperative that conservation efforts are focused towards these areas (in addition to the northern range as well), in order to ensure the continued existence of this species. The results of the present study on the predicted impact of future climate on the species' range will help formulate better strategies for conserving this unique gekkonid species.

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