



Distribution of two endemic bufonids (Anura: Bufonidae) in the Western Ghats

The Anuran family Bufonidae Gray, 1825 is represented by four genera in peninsular India: *Duttaphrynus* Frost, Grant, Faivovich *et al.*, 2006; *Xanthophryne* Biju, Van Bocxlaer, Giri *et al.*, 2009; *Ghatophryne* Biju, Van Bocxlaer, Giri *et al.*, 2009; and *Pedostibes* Günther, 1876. Of these, the three latter genera are endemic to the Western Ghats (Chandramouli & Amarasinghe 2016, Frost 2020). These endemic bufonid genera are represented by two, two and one species respectively. Though the distribution patterns of these endemic toads have been documented in the past, precise published records are few. Reddy *et al.* (2002) reported a range extension of *G. ornata* (Günther, 1876) from Kudremukh. The distribution of *P. tuberculosus* Günther, 1876 was mapped by Dinesh & Radhakrishnan (2008). Likewise, Subramanian *et al.* (2013) presented a point distribution map for *G. ornata* and *G. rubigina* (Pillai & Pattabiraman, 1981). However, further precise distribution records of these endemic taxa are still in need of a proper appraisal. In this paper, I present point maps of the distributions of *G. ornata* and *P. tuberculosus* and reassess their conservation status based on the IUCN criteria.

In addition to the original field observations of *P. tuberculosus* and *G. ornata*, available records of these species were obtained from the online platform <www.inaturalist.org>, combined and subsequently mapped. These records (all but one observation of each species flagged to be of research grade) were subsequently verified by the author based on the photographs linked to each of these observations. Thus, put together, a total of 12 geographic location points of *G. ornata* and 31 of *P. tuberculosus* were compiled and mapped using ARC MAP V.10. The occurrence points were then subjected to predictive distribution modeling using MAXENT v. 3.3.3 (Phillips *et*

al. 2006). For making predictions of probable occurrences of the target species, climatic data were downloaded from the Worldclim database (Hijmans *et al.* 2005), which comprises 19 bioclimatic variables and one topographic variable (altitude). Results of the predictions thus obtained were mapped as likely occurrences and visualized with DIVA GIS ver. 7.5. The validity of the predictions was assessed based on the Area Under the receiver operating characteristic Curve (AUC). Based on these predictions and the geo-coordinates of their occurrences, the possible extent of occurrence and the exact areas of occupancy of the target species were determined (derived from Geocat: <http://geocat.kew.org/>). These were then used as variables to assess the status of *G. ornata* and *P. tuberculosus* as per the IUCN Guidelines version 3.1 (IUCN 2017).

Ghatophryne ornata (Fig. 1), the relatively more range-restricted species among the two studied here, was observed to show a narrow geographic range with an estimated extent of occurrence of 5,093.4 km² and an area of occupancy of 48 km². It is restricted to the southern extremity of the central Western Ghats, between the coordinates 11.43°–13.27° N, and 75.15°–76.16° E, predominantly along the easterly leeward slopes in the mid to high elevation belt between 870–1,773 m a.s.l. This region covers the Vellarimala, Wayanad, Brahmagiri, Pushpagiri and the Kudremukh hill ranges of the central Western Ghats. In the MAXENT distribution model, the parameters, temperature seasonality, annual mean temperature and precipitation of the coldest quarter showed a high positive influence while the other parameters related to temperature, precipitation and topography showed low to no influence on the predicted probability of its occurrence (Table 1, Fig. 2). This indicates that the species prefers areas characterized by low temperature and high precipitation. This species is associated with torrential stream habitats showing the above characteristics. The AUC of the model developed for *G. ornata* was 0.999.

The other endemic bufonid, *P. tuberculatus* (Fig. 3), on the other hand, showed a relatively much wider geographic distribution spanning nearly most parts of the Western Ghats from the southern extremity in the Agasthyamalai Hill Range 8.54°–17.51° N, to the northern part of the Western Ghats between 73.91°–77.54° E. This covered an estimated extent of occurrence of about 54,388.5 km² with an area of occupancy of 116 km². This low estimated area of occupancy within a wide extent of occurrence may well be a sampling artefact, and *P. tuberculatus* may well be widespread in intervening areas with suitable environmental conditions. The altitudinal range of *P. tuberculatus* ranged from 38–1,052 m a.s.l. The species was recorded from the following hill ranges: Agasthyamalai, Ponmudi Hills, Cardamom Hills, Anaimalai, Siruvani, Vellarimala, Brahmagiri Hills, Pushpagiri Hills, Kudremukh and Sharavati River Valley through Goa to the Koyna Hills in the Northern Western Ghats. The MAXENT model predicted its distribution nearly throughout the Western Ghats, with significant positive influence from precipitation of the wettest month followed by isothermality. The other parameters pertaining to temperature, precipitation and topography had very low influence on the prediction (Table 1, Fig. 4). This is indicative of its preference to areas generally characterized by high precipitation, as can be seen from its preference to evergreen forests. The AUC of the model developed for *P. tuberculatus* was 0.994.

The present study has addressed the lacuna in precision of the distribution patterns of two of the five endemic bufonid species of the Western Ghats. The remaining species, *G. rubigina*, *Xanthophryne koynaensis* (Soman, 1963) and *X. tigerinus* Biju, Van Bocslaer, Giri *et al.*, 2009 are still in need of further studies. Among them, *G. rubigina* is known from only a very few localities (Subramanian *et al.* 2013), while members of the genus *Xanthophryne* occupy a rather open and relatively large contiguous landscape in the northern part of the Western Ghats. Though members of the genus *Duttaphrynus* also constitute some endemic species in the Western Ghats, the genus, as a whole, has a wide distribution range, unlike the endemic lineages dealt with herein. The evolutionary uniqueness (Biju *et al.* 2009, Chan *et al.* 2016) and restricted distribution of these focal species studied here make them ideal models for investigation of their distribution

patterns. Both species are largely stenotopic, and are sensitive to habitat disturbances / alterations (pers. obs.). Hence, it would be useful to assess the suitability of the habitat available for them to occupy.

Table 1: Percentage contribution of bioclimatic and physiographic variables (for parameters of abbreviations see Hijmans *et al.* 2005) to the model for *Ghatophryne ornata* and *Pedostibes tuberculatus*

Variable (see Hijmans <i>et al.</i> 2005)	<i>G. ornata</i>		<i>P. tuberculatus</i>	
	% contribution	permutation importance	% contribution	permutation importance
Alt	0	0	1.4	0.6
Bio 1	19.4	0	0	0
Bio 2	7.1	6.3	0.1	0.2
Bio 3	0.7	1.3	21.8	1.5
Bio 4	44.7	87.4	4	92.5
Bio 5	0	0	0	0
Bio 6	0	0	0.6	0.5
Bio 7	1.7	0	0.7	2.6
Bio 8	2.9	4.5	0	0
Bio 9	0	0	0	0
Bio 10	0	0	0	0
Bio 11	0	0	0.5	0.2
Bio 12	0	0	3.4	0.1
Bio 13	4.4	0	63.3	0
Bio 14	4.8	0	1.3	0.1
Bio 15	0	0	0	0
Bio 16	0	0	0.4	0.3
Bio 17	0.4	0.1	0.7	0.1
Bio 18	0.8	0.4	1.6	1.3
Bio 19	13.1	0	0.2	0

Pedostibes tuberculatus, being an arboreal species is relatively more widespread than *G. ornata*, which, on the other hand, shows exclusive association with fast-flowing stream habitats. Despite the availability of such potentially viable stream habitats throughout most parts of the Western Ghats, *G. ornata* shows a restricted distribution only to parts of the mid-high elevation regions in the central Western Ghats. Even for *P. tuberculatus*, the distribution is fragmented into several discontinuous patches. This may be explained by the lack of sufficient surveys in intervening areas of apparently suitable habitat and it is probable that further surveys in regions within the Western Ghats predicted to be suitable (the red, orange and yellow shaded areas in Fig. 4) could reveal new locality records for *P. tuberculatus*. As predicted by the model, both these species show a high sensitivity to

Plate 61



Figure 1. A live male of *Ghatophryne ornata* (not collected) from the Western Ghats, Karnataka, India

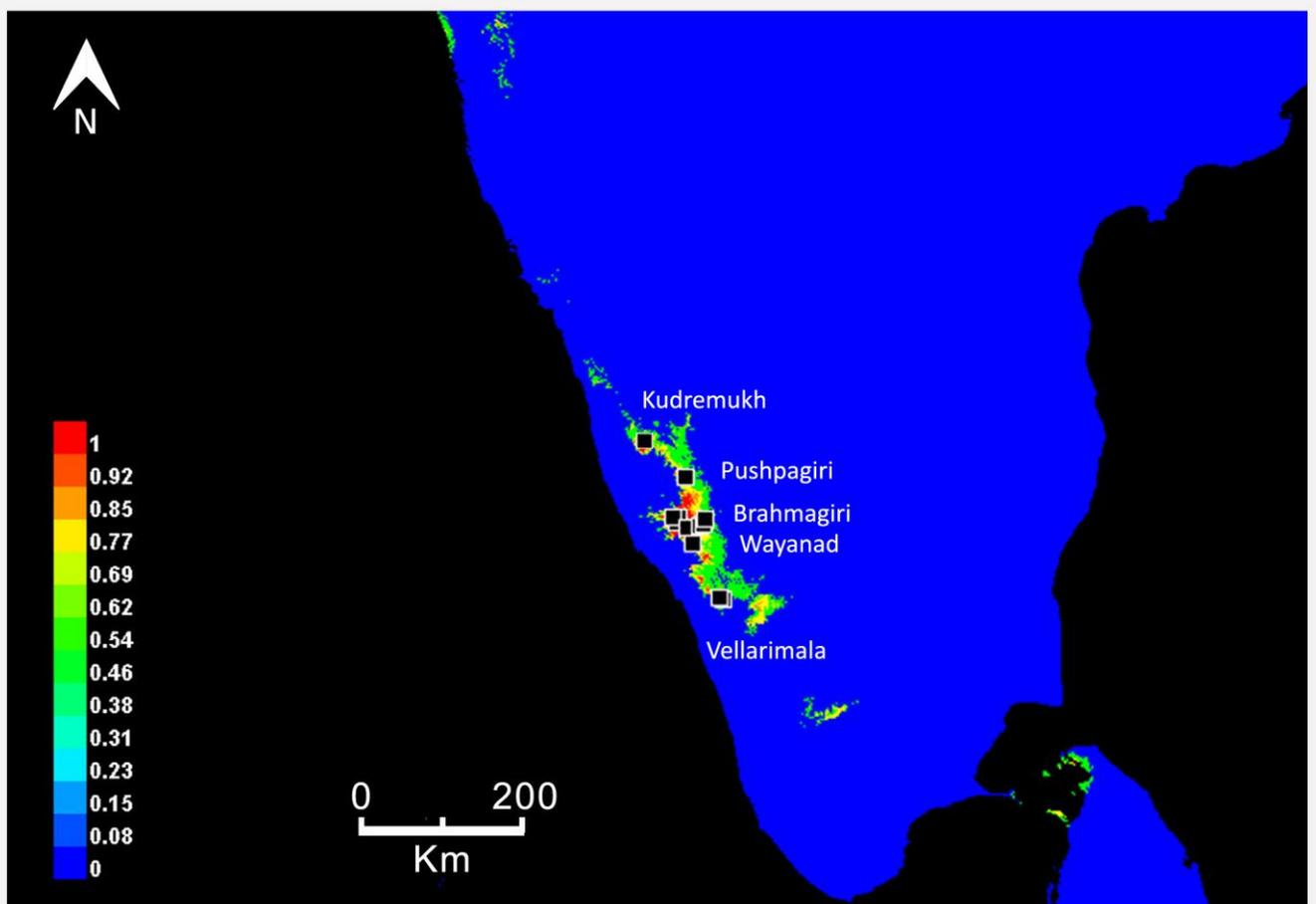


Figure 2. The distribution range of *Ghatophryne ornata*; recorded (squares) and predicted (shaded).

Plate 62



Figure 3. A live male of *Pedostibes tuberculosus* (not collected) from the Western Ghats, Karnataka, India.

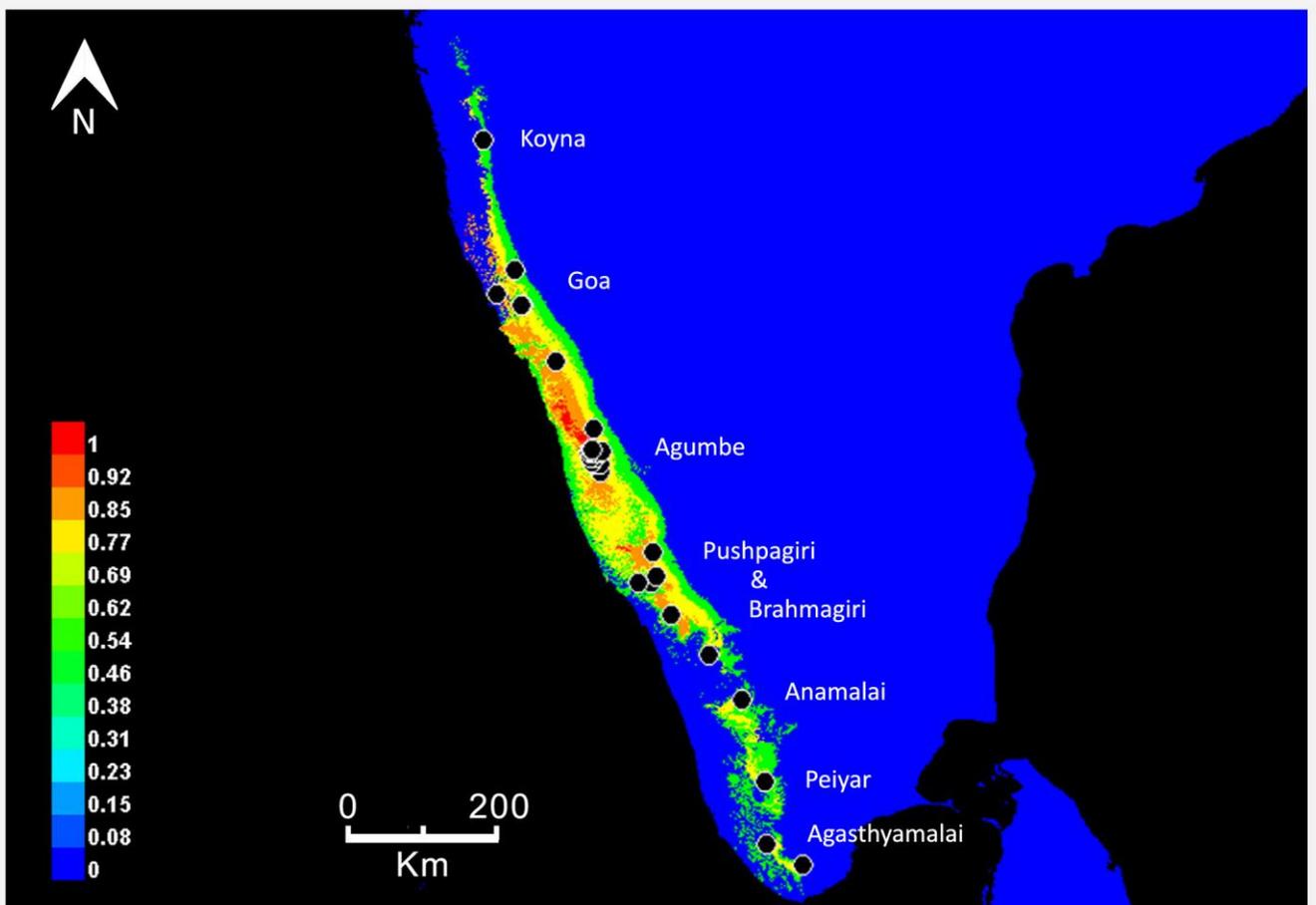


Figure 4. The distribution range of *Pedostibes tuberculosus*; recorded (circles) and predicted (shaded).

precipitation as a predictor of their occurrence, it would be essential to protect forests with high annual rainfall. Based on the implications drawn from the mapping and modeling exercise done herein, it would be ideal to retain *G. ornata* as an endangered species as currently classified (Biju *et al.* 2004a) while *P. tuberculosus* could be downgraded from Endangered (Biju *et al.* 2004b) as it won't qualify as threatened applying extent of occurrence and information is insufficient to confidently determine its area of occupancy, which is expected to be greater than the value calculated from known records, considering its relatively wider geographic distribution.

Acknowledgements

I thank the "iNaturalist" platform for serving as a repository and aiding in the documentation of field observations by people ranging from photographers and nature enthusiasts to researchers. I also thank Nikolay A. Poyarkov (Lomonosov Moscow State University, Russia) for reviewing the manuscript.

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Submitted: 13 September, Accepted: 31 October 2020
Section Editor: Philip Bowles

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