Projected impact of climate change on the potential distribution of amphibians in Thailand: a case study of the Crocodile newt (*Tylototriton verrucosus*)

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Abstract

The climate change may affect the distribution of flora and fauna of their endemic, endangered and common species. This scenario includes most amphibian: being ectotherms they are consequently highly dependent of some environmental conditions. This study aimes to evaluate a distribution map for the *Tylototriton verrucosus*, rareness distributed in the northern and northeastern mountain in Thailand, base on literature locations and ecological models to predict distribution caused by climate change base on eight environmental variables projected for the current, 2020, 2050 and 2080. The results indicate that the variable with highest gain was annual mean temperature and elevation, annual precipitation, East UTM, NDVI and NDWI for predicting a potential distribution respectively and loss of suitable habitat areas for *T. verrucosus.* This study confirmes an initial understanding on how the distribution of *Tylototriton verrucosus* will be affected by climate change in Thailand. The generated species distribution models and habitat suitability maps could be used as basis in formulating appropriated for conservation decision of those threatened species and their natural ecosystems to current and future climate.

Key Word: Environmental variables, Maxent, potential distribution**,** *Tylototriton verrucosus*

Introduction

Ecosystems and global biodiversity patterns have been significantly changed at this time, mainly due to anthropogenic and climatic effects. Human caused overgrazing and dry periods have led to land degradation and will cause an eventual loss of biodiversity in ecosystems of earth. For conservation and rehabilitation of natural ecosystems especially monitoring and determination of habitat suitable for flora and fauna in different parts with different environmental conditions is necessary. The models species distribution and prediction habitat suitability have been increasingly used in ecology. These models evaluate relations between existences of species and environmental conditions. Several species distribution models are offered for predicting potential suitable habitats of research species.

The Crocodile newt (*Tylototriton verrucosus*) is a single species of the family Salamandridae in Thailand (Nabhitabhata et al., 2000; Nabhitabhata and Chan-ard, 2005). The global status of *T. verrucosus* was evaluated and classified as Least Concern (LC) by the International Union for the Conservation of Nature (IUCN) (IUCN, 2012) but in nation level it is listed as Near Threatened (NT) by the Office of

Natural Resources and Environmental Policy and Planning (OEPP, Thailand) (Nabhitabhata and Chan-ard. 2005). Habitat suitability of the *T. verrucosus* in Thailand is poorly known. Reportedly the species distributed from the northern and northeastern mountain in Thailand. The main objectives of the present study are estimation of the geographic distribution of *T. verrucosus* in current and future from climate change and finding the most important environmental predictor variables.

Methodology

We used the current distribution of *Tylototriton verrucosus* via published scientific literatures (Smith, 1924; Taylor, 1962; Suvatti, 1965; Beaver, 1982; Wongratana, 1984; Matsui et al., 1996; Chan-ard et al., 1999; Nabhitabhata et al., 2000; Nutphund, 2001; Nabhitabhata and Chan-ard, 2005; Pomchote et.al., 2008). Although 14 occurrence for modeling the species distribution in Figure 1. Based on the presence data and matrices including eight environmental variables to predict the potential distribution of the *T. verrucosus* (Table 1). We used the method of niche modeling based on a maximum entropy to create a map of potential distribution for *T. verrucosus* for the current and future variables with a resolution of 1x1 km for each grid.

For the *Tylototriton verrucosus* potential distribution we used a maximum entropy algorithm available in MaxEnt (Phillips et al., 2004, 2006; Baldwin, 2009). The idea of MaxEnt is to establishing a relationship between a species' known range and habitat variables within that region and then using this relationship to identify other suitable regions. MaxEnt can predict probability distribution of a given occurrence based on presence only data points especially when samples sizes are low (Elith et al., 2006; Hernandez et al., 2006). Results from the MaxEnt model include two model evaluations, the area under the receiving operating characteristic (ROC) curve (AUC) and jackknife testing provides the percent contribution of each independent variable used in the model (Evangelista et al., 2011). The ROC analysis was also used to evaluate how well the MaxEnt model compare to random prediction. The AUC is an index of performance because it provides a single measure of overall accuracy that is independent of any particular threshold (Yost et al., 2008). The AUC value varies from 0.0 to 1.0, with values greater than 0.75 considered sufficiently discriminatory (Elith et al., 2006). For each independent, we used 80% of the presence points to train models and the remaining 20% were withheld for model validation.

To compare current and the future scenario models, the potential distribution of *Tylototritron verrucosus* was reclassified into a scale of habitat suitability from one to five (one indicating poor habitat suitability and five indicating high habitat suitability). That means the sites were identified with the highest conservation value (highest suitability) and then compared those sites between current and the future scenario model outputs.

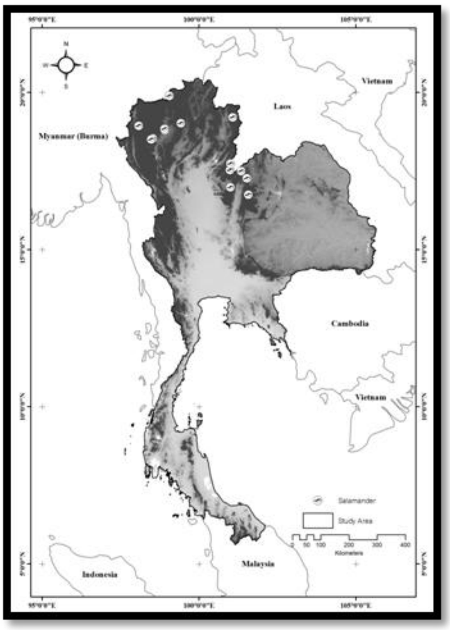

Figure 1. Present of localities of *Tylototriton verrucosus* in Thailand based on literature data.

Table 1. Variables used to build models of potential distribution of *Tylototriton verrucosus* in Thailand and their contribution to the models.

Variable	Percent contribution
Annual mean Temperature X Elevation (The WoldClim database and The Shuttle Radar Topography Mission (www2.jpl.nasa.gov.srtm/))	90.1
Annual Precipitation (The WoldClim database)	5.7
East UTM	2.9
Normalized difference vegetation index (Acquired from Landsat TM imagery)	0.8
Normalized difference water index (Acquired from Landsat TM imagery)	0.4
North UTM	0
Distance to Stream	0

Results and Discussion

The model of potential distribution for *Tylototriton verrucosus* was the occurrence locations all fell within the estimate distribution. Under current conditions the MaxEnt model performed reasonable well (AUC_{test} = 0.992, AUC_{model} = 0.994). The variable with highest gain was annual mean temperature and elevation for predicting a potential distribution**.** Other less significant variables were annual precipitation, East UTM, NDVI and NDWI respectively.

We used three variables with highest percent contribution annual mean temperature and elevation, annual precipitation and East UTM, distance to predict future habitat suitability of the *T. verrucosus* for 2020, 2050, and 2080. The predicted habitat suitability maps for *T. verrucosus* (Figure 2) in 2020, 2050, and 2080 yielded the $AUC_{(model)}$'s of 0.992.

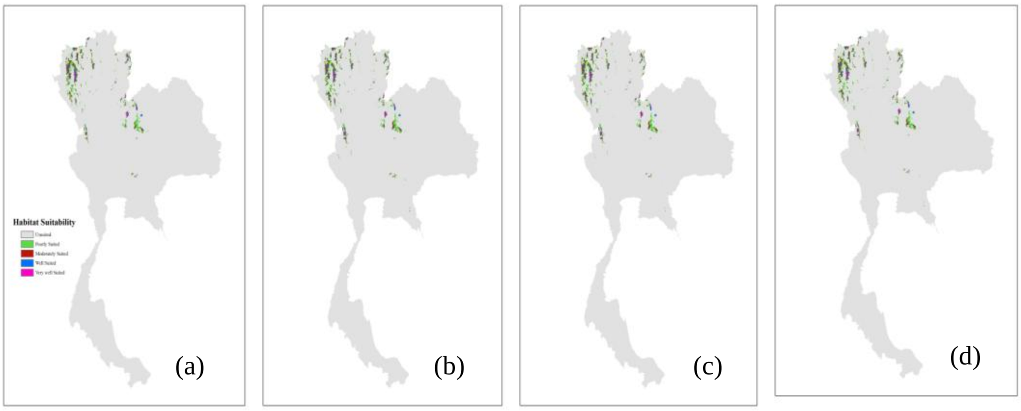

Figure 2. Predicted habitat suitability classification for *Tylototriton verrucosus* in Thailand in the current year (a), 2020 (b), and 2050 (c) and 2080 (d).

We reclassified the most predictive map into five habitat suitability classes and summarized the changes in *Tylototriton verrucosus* distributions under the future scenario models (Table 2). Very well suited habitat for *T. verrucosus* increased slightly for 2020 and decreased under the future climate conditions scenarios for 2050 and 2080.

Table 2. Changes in area of different habitat suitability classes for *Tylototriton verrucosus* under current, 2020, 2050 and 2080 models.

Habitat Suitability Classification	Current Area	2020		2050		2080	
		Area	2020-current	Area	2050-2020	Area	2080-2050
Unsuited	498795	497,831	-964	498,268	437	498,415	147
Poorly Suited	8188	8,717	529	8,548	-169	8,414	-134
Moderately Suited	3624	3,854	230	3,746	-108	3,702	-44
Well Suited	1928	2,104	176	1,971	-133	2,004	33
Very well Suited	496	525	29	498	-27	496	-2
Total	**513031**	**513,031**		**513,031**		**513,031**	

Our results indicate that climate change may cause remarkable change even in the distribution of *Tylototrition verrucosus.* The *T. verrucosus* is a specific ecological niche species. Thus a direct threat arising climate change is high susceptibility of anurans to climatic change. Including such as land use, expansion of agriculture and urban areas, habitat fragmentation would probably indicate even faster. The reflect not only the impacts on *T. verrucosus*, they also indicate effects that can be extrapolated to many species. The generated species distribution models and habitat suitability maps could also be a promising tool for conservation decision of those threatened species and their natural ecosystems to current and future climate.

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