Potential geographic distribution of the Bugun Liocichla *Liocichla bugunorum*, a poorly-known species from north-eastern India

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The Bugun Liocichla *Liocichla bugunorum* is a recently-described species known from a minuscule area in north-eastern India. Based on the ecological characteristics of the three known occurrence points, we present three models of the species' possible distribution in surrounding regions. We present these models as maps of the region, in the hope that they might serve as a guide in the discovery of more populations.

Introduction

The Bugun Liocichla *Liocichla bugunorum* was described in 2006 based on observations, photographs, and feathers collected over 10 years of effort, representing an intriguing and distinct new species (Athreya 2006). The species, in addition to the remote situation of its range, is clearly not common—indeed, only a very small number of individuals were detected in spite of extensive searches. Given the extremely small known population, the decision was made not to collect a full scientific specimen to serve as a type, which will clearly be the object of controversy.

The technique of ecological niche modeling (ENM) is a means of reconstructing ecological and potential geographic distributions based on incomplete known point-occurrence data (Guisan & Zimmermann 2000, Soberón & Peterson 2005). The technique focuses on characterizing the ecological regime under which the species is known to occur, permitting an educated interpolation of likely presence or absence among known occurrence points. As such, ENM is a possible means of educating searches for elements of biodiversity, and offers hypotheses as to distributional areas of species (Soberón & Peterson 2004), and indeed has proven useful in applications to poorly-known species in the past (Raxworthy et al. 2003b, Bourg et al. 2005).

In this brief contribution, we analyze the known occurrences of the species in relation to digital, remotely-sensed data layers describing landscapes in the region. We use three ENM techniques to develop predictions of other possible occurrence sites for the species. Our hope is that these analyses may prove helpful in guiding future searches for the species, which may provide a more complete view of the geographic distribution of the species.

Methods

Ecological niche modeling is a technique that attempts to use known distributional information to build a hypothesis regarding the ecological requirements of species, at least at coarse spatial scales and as they relate to geographic distributions and limits (Soberón and Peterson 2005). The technique is based conceptually on early, geographic conceptualizations of ecological niches of species, effectively as the suite of environmental conditions within which the species is able to maintain populations without immigrational subsidy (Grinnell 1917). In a modern manifestation, known occurrences are related to digital electronic data layers summarizing relevant aspects of environmental factors, and complex computational algorithms used to detect nonrandom associations between occurrences and the environmental factors. Here, we use two evolutionary computing approaches (GARP & Maxent, see below), as well as a very simple, distance-based approach, to develop three predictions of the potential distributional area of this little-known species.

We used the three GPS-based occurrence records provided in the original description of the species (Athreya 2006) as representative of the little that is known of the species. To characterize environments across the region, we used 13 digital maps ("coverages") summarizing aspects of topography (elevation, slope, aspect, and compound topographic index, from the US Geological Survey's GTOPO30, native resolution 0.5 x 0.5 km, and Hydro-1K, native resolution 1x1 km, data sets) and remotely-sensed data layers as follows. We used 16-day composite images from every second month during 2005 of the Normalized Difference Vegetation Index (NDVI) from the NASA-MODIS / Terra data set (native resolution 500x500 m) (Justice et al. 1998), as well as difference maps between each consecutive pair of these coverages. NDVI vegetation indices are sensitive to photosynthetic activity (Tucker 1979), so these data sets provide an excellent description of spectral aspects of land cover and plant phenology, aspects of landscapes that should be relevant to bird distributions. All geographic data were resampled to 250 m resolution for analysis.

For ENM development, and given the vanishingly small sample sizes involved, we used three approaches. First, we used a simple approach based on distances in ecological space from known points of occurrence (Ferreira de Siqueira et al. Submitted). Here, in the 13-dimensional space described above, we calculated the Euclidean distance from all points in the region to the nearest (in ecological space) of the three known occurrence points. Appropriate landscapes, under this method, are taken as those areas showing shortest ecological distances from known occurrence points.

Second, we used the Genetic Algorithm for Rule-set Prediction (GARP) (Stockwell & Peters 1999) for ENM development. GARP uses an evolutionary computing genetic algorithm to search for non-random associations between environmental variables and known occurrences of species, as contrasted with environmental characteristics across the overall study area. In replicate GARP analyses, we input all three points, using two for model development and one for filtering best subsets of replicate models (Anderson et al. 2003). In particular, we produced replicate models until we had 20 that were able to predict the one filtering point as present; these models were summed to produce a final prediction of potential distributions.

Finally, we submitted the three occurrence points to the Maxent program, an evolutionary-computing approach based on the principle of maximum entropy (Phillips et al. 2004, Phillips et al. 2006). Maxent models produce output that takes the form of a probability surface with real-number values ranging 0–100. We used default settings and automatic feature selection in our analyses. To summarize the overall pattern of prediction of these three models, we averaged the predictions of the three—to balance their relative contributions, we rescaled Maxent predictions (0–100) to between zero and ten, and binned the Euclidean distances into ten categories of distance from known points of occurrence.

Because only three occurrence points were available for the liocichla, we did not attempt a validation of model predictions, nor did we attempt any data manipulations aimed at identifying key environmental dimensions in the distributional ecology of the species—sample sizes were quite simply too small to allow such analyses. Rather, we present this perspective on environmental similarity to known occurrences of the species on the species' native range, in the hope of guiding future efforts to encounter additional populations of this species. Because of the small sample sizes available, similarly, we have avoided extending our predictions broadly in space, as we are certainly obtaining models that have little predictive ability beyond the immediate vicinity of the known distributional areas.

Results

The three analytical methods each produced a somewhat different view of ecological similarity of the north-eastern Indian landscape to the known occurrences of the Bugun Liocichla (Figure 1). The sparsest picture of suitability was from the GARP model, which predicted most of the landscape of the region as unsuitable, and identified only a few areas as relatively similar ecologically to the known occurrence sites. The distance-based model was somewhat broader in its predictions, whereas the Maxent model showed a more homogeneously suitable picture of the landscape.

We then identified areas in which the three models agreed in predicting high potential for presence of the species (Figure 2). Here, we see relatively broad areas depicted as likely suitable for the species, including in particular areas north and west of the sites where the species was found. Suitable areas extend into neighboring Bhutan and China. Of particular interest for future searches would be the areas of Bomdilla, Dengan La, and between Poshing La and Lagam, as these are relatively extensive areas that apparently match the ecological profile of the sites where the species was encountered.

Discussion

This paper, using remotely-sensed imagery and high-end computing, may seem out of place in a regional bird journal. However, the recent description of the Bugun Liocichla as a bird species new to science (Athreya 2006) in this journal is similarly unusual, particularly given the unusual decision not to collect a full specimen to serve as a holotype and permanent documentation of this newly discovered element of biodiversity. In general, although we congratulate the describer of the Bugun Liocichla on the thoroughness of his description, we consider full, information-rich type specimens to be a critical part of taxonomy as a science, as do most members of the systematic ornithological community (Banks et al. 1993). As the decision not to collect a full specimen as a type apparently hinged on the rarity of the species and its apparent critical endangerment (Athreya 2006), we offer this analysis as a means of broadening the knowledge of the species' distribution.

ENM approaches have been explored previously for discovery of unknown elements of biodiversity. A previous analysis used ENM approaches to anticipate the existence of several previously unknown chameleon species in Madagascar (Raxworthy et al. 2003a), as well to guide discovery of unknown populations of rare plant species (Bourg et al. 2005; Ferreira de Siqueira et al. Submitted). Indeed, more generally, a broad suite of previous studies demonstrates the predictive ability of these methodologies (Guisan & Zimmermann 2000; Elith & Burgman 2002; Elith et al. 2006) in anticipating species' geographic distributions.

In the case of the Bugun Liocichla, we present our analyses and distributional predictions in the hope that they can assist in assembling a more complete picture of the geographic and ecological distribution of the species. Once additional populations are documented, we hope that the status of the species can be established more firmly, and that this description can be strengthened via the existence of a series of specimens to permit detailed scientific study. Surveys for more Bugun Liocichlas might, most profitably, be focused in the areas indicated in the maps provided herein.

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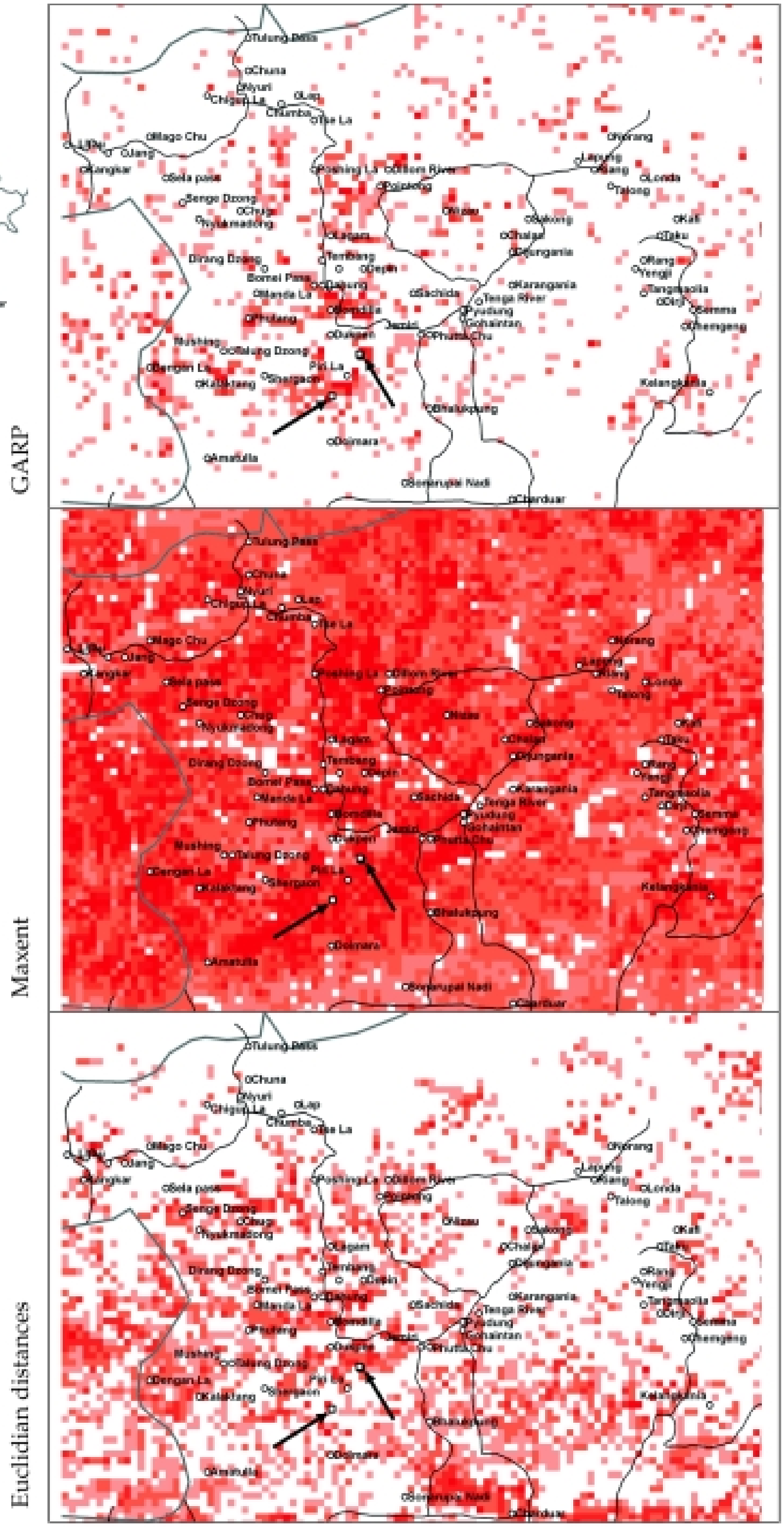

Figure Legends

Figure 1. Results of the three ecological niche modeling approaches for the possible distribution of the Bugun Liocichla. Known occurrences of the species are shown as white squares (black arrows), and populated places are shown as white circles. Thick gray lines indicate international boundaries (see inset map at upper left), and thinner black lines indicate roads.

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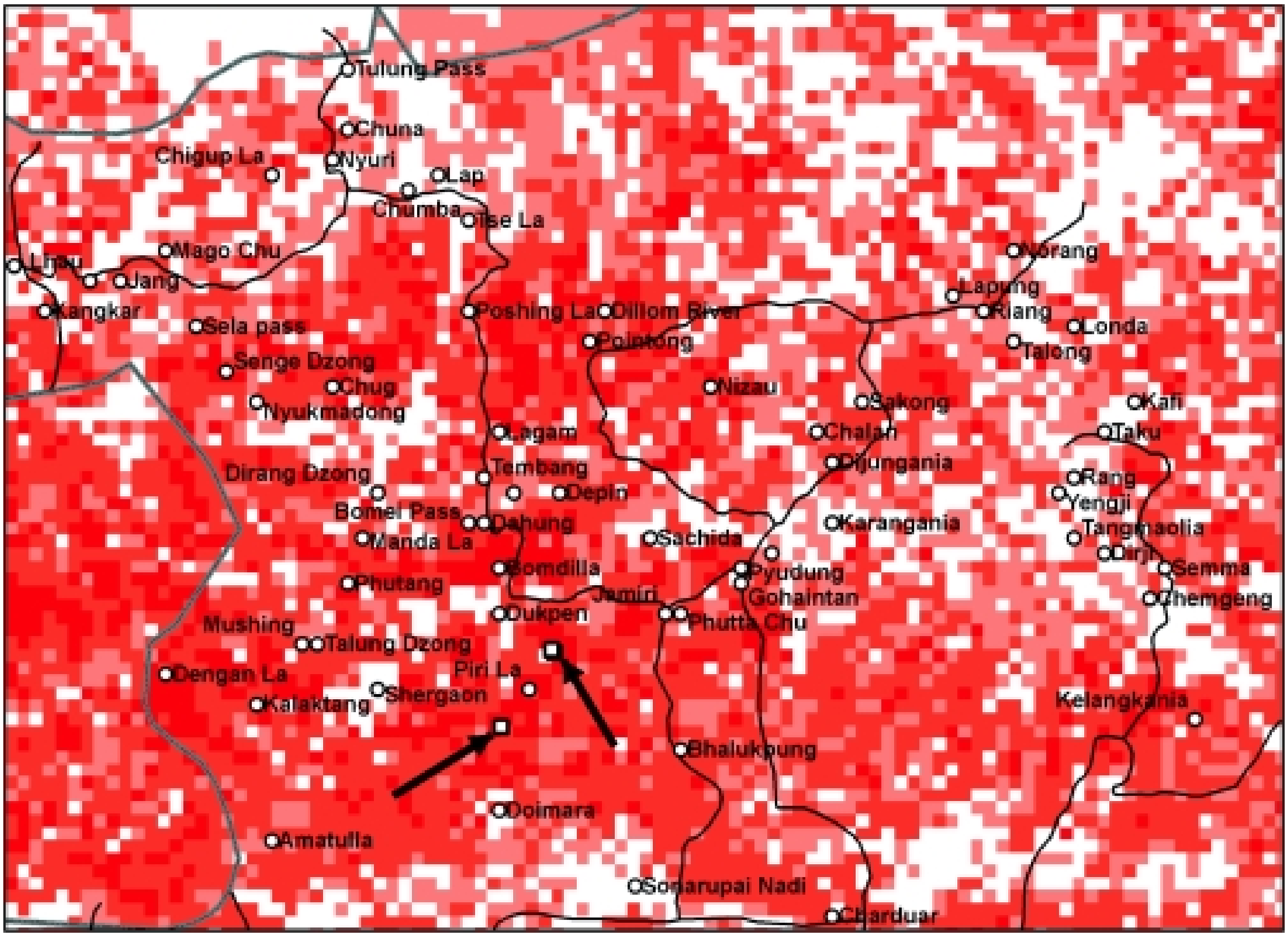

Figure 2. Consensus (average) of the three ecological niche modeling approaches for the possible distribution of the Bugun Liocichla. Known occurrences of the species are shown as white squares (black arrows), and populated places are shown as white circles. Thick gray lines indicate international boundaries (see inset map in Figure 1), and thinner black lines indicate roads.