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The distribution and conservation of Gurney's Pitta *Pitta gurneyi* in Myanmar

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Summary

Following a recent assessment of the distribution and habitat use of Gurney's Pitta in Myanmar (Burma), further extensive surveys were undertaken in 2010, 2011 and 2012. These have extended the species' known altitudinal limit to between 250 m and 300 m asl and its latitudinal limit to above 12.5°N, around 80 km north of the northernmost historical record, although the species was recorded far less frequently at higher altitudes and latitudes. Birds were recorded in a range of forested habitats, from intact primary forest to secondary and bamboo forest, with no significant difference between major forest types in the likelihood of occurrence. Niche envelope modelling (MaxEnt) suggested a total range size in Myanmar of 3,379 km^2, and did not identify any potentially suitable areas in adjacent parts of Thailand. The species' preference for warmer, wetter areas on flat ground, conditions ideal for growing oil palm and rubber, suggest that its distribution is likely to contract in the near future. The entire range of Gurney's Pitta in Myanmar falls within the part of the country most suitable for commercial oil palm production, although the projected yields within its range are low to moderate. Field surveys found evidence of rapid recent deforestation and high levels of hunting and trapping in many parts of the region. The species' range in Myanmar does not overlap with any protected areas. The protection of southern Myanmar's biodiversity will require substantial investment by foreign conservation interests, sympathetic land-use planning and the strengthening of environment legislation. Protection of extensive tracts of lowland forest within the range of Gurney's Pitta, particularly the proposed Lenya National Park and the adjacent Ngawun and Htaung Pru Reserve Forests, is urgently needed. Conserving these areas will also protect populations of other globally threatened bird and mammal species.

Introduction

Gurney's Pitta *Pitta gurneyi* is the only bird species endemic to peninsular Thailand and Myanmar (Burma) and is listed as 'Endangered' on the IUCN Red List (BirdLife International 2012). After a long absence of records, during which time it was thought possibly extinct, it was rediscovered in southern Thailand in 1986 (Round and Treesucon 1986) and in larger numbers in Myanmar in 2003 (Eames *et al.* 2005). It is associated primarily with lowland Sundaic forest and appears to be able to survive, or even benefit from, a degree of forest disturbance (Round and Brockelman 1998, Donald *et al.* 2009). While the future of the tiny population in southern Thailand remains precarious, surveys of southern Myanmar in 2003, 2007 and 2008 suggested that the species is relatively widespread and not uncommon in lowland Sundaic forests, although rapid forest loss in parts of the region means that the species' future there is far from secure (Eames *et al.* 2005, Donald *et al.* 2009). These surveys suggested that the species occurs at higher altitudes and latitudes than previously suggested (Collar *et al.* 1986, Round 1995, Collar *et al.* 2001), with no evidence of a decline in occurrence probability up to the maximum visited altitude of 226 m asl (Donald *et al.* 2009). From surveys up to 2008, the range in Myanmar was estimated to be 3,320 km^2 and the population, using assessments of density from the site in Thailand, at 9,300 to 35,000 territories (Donald *et al.* 2009). Accurate assessment of the range of the species in Myanmar is desirable. Although rates of forest loss in southern Myanmar were relatively low in 1990–2000 (Leimgruber *et al.* 2005) and in 2000–2005 (Hansen *et al.* 2010), and the country is unique in still harbouring extensive areas of lowland Sundaic forest (Lambert and Collar 2002), there are fears that the country's recent progress towards democratisation will lead to increased forest loss as the economy opens to international palm oil, rubber and timber interests (Fox and Castella 2013, Wang *et al.* 2013). Calls within the Burmese government to turn the extreme south of the country into the 'oil pot of Myanmar' (http://www.burmalibrary.org/docs13/AH-NLM2012-07-31-day17.pdf) and the suitability of the region for producing rubber (Fox and Castella 2013) suggest that external investors and local smallholders will be encouraged, or at least little hindered, to develop the region, a pattern that has led to the near extinction of the small Gurney's Pitta population in Thailand. This is therefore a crucial period in which assess and monitor the status of threatened biodiversity and to invest in biodiversity conservation in the country (BirdLife International 2003).

Here, we use data from extensive surveys undertaken throughout peninsular Myanmar in 2010, 2011 and 2012, informed by the assessment of distribution of Donald *et al.* (2009), to revise our assessment of the species' distribution using environmental niche modelling (MaxEnt) and to identify conservation priority areas for the species that may be at risk from development.

Methods

Field surveys

Field survey sites were identified using a previous distribution model (Donald *et al.* 2009), based upon survey data collected up to 2008 from 300 points. These field surveys were undertaken to validate the previous model by including data from throughout the modelled range, and in doing so provide data for another iteration of the modelling process to increase our knowledge of the species' distribution and clarify its altitudinal and latitudinal limits. At the end of each year, the distribution model was re-run (see below) and the results used to select the following year's study sites. Areas of high, medium and low modelled suitability were identified at each iteration, and we tried to visit a stratified random sample of areas spread across the gradient of predicted suitability, although the often severe limits dictated by the rapidly changing security situation in the area and difficulty of access meant that the target areas could often not be reached. In such cases, the nearest accessible areas were surveyed. We therefore attempted to avoid the pitfall of assuming that MaxEnt analyses are free of the constraints of normal sampling procedure (Yackulic *et al.* 2013).

Field teams established transects in selected areas along which point count stations were marked at intervals of at least 100 m. Playback was used to elicit a response from this notoriously cryptic species. Both "lillip" and "skew" calls (Round and Treesucon 1986) were played through loudspeakers from a Sony MP3 player at each point count station for at least 30 seconds and observers waited a minimum of 20 minutes for a response; responses generally occurred within 10 minutes of the first broadcast call. Since presence-only data were used in the models, failure to detect birds that were present was likely to have minimal effect on the predicted distribution, though may influence analyses of habitat selection (see below). Field surveys were undertaken from 24 March to 18 May 2010 (304 point counts along 37 transects), 28 March to 8 May 2011 (232 point counts along 21 transects) and 19 March to 12 June 2012 (701 point counts along 77 transects). These periods coincided with the period of maximum vocal activity recorded in Myanmar and Thailand (Gretton *et al.* 1993, Round 1995, Collar *et al.* 2001, Eames *et al.* 2005, Donald *et al.* 2009). The total number of points visited across all years (including 2003, 2007 and 2008) was 1,637. The distribution of point counts is shown in Fig. 1. At each point visited in 2011 and 2012, observers

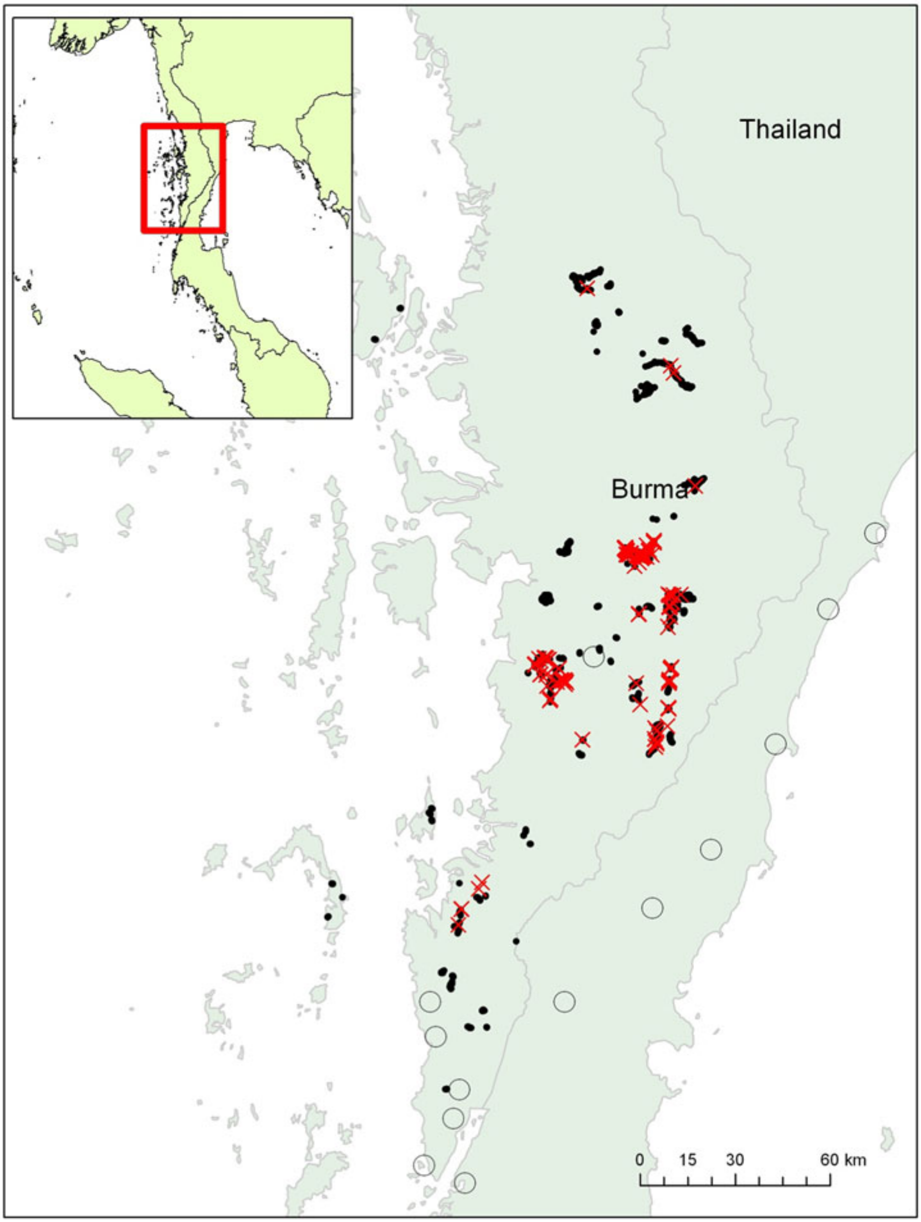

Figure 1. Distribution of the 1,637 point counts visited in 2007, 2008 and 2010–2012 (dots: Gurney's Pitta not recorded; crosses: Gurney's Pitta recorded). Large open circles indicate historical (pre-1952) records (from Collar *et al.* 2001); most of those in Myanmar were visited in 2003 and found to be entirely cleared of forest cover (Eames *et al.* 2005).

also recorded the broad habitat type which was later reduced to one of seven classes: bamboo forest, intact primary forest, degraded primary forest, degraded primary and bamboo forest, secondary forest, secondary and bamboo forest and 'other' (mostly clear-fell and cultivation). Other bird species were recorded incidentally during point counts. Direct (scats, pug marks etc) and indirect (through questioning local people) evidence of large mammals was recorded. Fieldwork was undertaken largely by LW, TDA, SM, SMZ, TTA and KNO, assisted by local guides.

Altitude at each point was recorded using a portable GPS in the field. However, because the accuracy of GPS estimates of altitude can vary, and may be low where reception is poor (e.g. under forest canopy), altitude was also extracted later for each GPS position from a digital elevation model (DEM). These in turn may provide inaccurate estimates of the altitude at a particular point since they are averaged over larger areas. We therefore assessed the correlation between altitudes derived from GPS and the DEM and assessed the species' altitudinal distribution using both.

Data extraction and analysis

All sightings (including those collected in 2003, 2007 and 2008) were used to model the distribution of Gurney's Pitta across an area 9.5–13°N and 98–99.70E (Fig. 1), an area encompassing all of southern peninsular Myanmar and adjacent areas of Thailand. This area was selected on the basis of what is known of the species' historical distribution (Collar *et al.* 2001), and is of a size and ecological homogeneity appropriate for the selection of pseudo-absence data for modelling the likely distribution of the species (VanDerWal *et al.* 2009, Anderson and Raza 2010). We used MaxEnt 3.3.3e (Phillips *et al.* 2006, Elith *et al.* 2011) to model the likelihood of occurrence of the species using presence-only locations as a function of land cover (using NDVI as a surrogate), altitude, slope and climate. Presence-only modelling was selected because, although "absences" were available, the famously cryptic nature of this species renders such absences ambiguous. MaxEnt has been found to perform well against other distribution models (Elith and Graham 2009) and produces models that have particularly high accuracy in the case of species with small ranges and limited environmental tolerance (Hernandez *et al.* 2006). However, concerns have been raised that it might underestimate distributions compared to presence-absence models and that, like presence-absence data, it requires a random distribution of presence locations (Royle *et al.* 2012).The latter concern is unlikely to be a problem, given the structured quasi-random sampling procedure used (see above).

We extracted NDVI data collected by the SPOT-Vegetation platform (1-km resolution; http://free.vgt.vito.be/) for the central decad (10-day period) in alternate months (January, March etc.) for 2008–2010, averaged them across years for each month and clipped them to the modelled area using VGT-Extract. Monthly averages were also averaged into an overall annual mean NDVI. Climate data were extracted from the WorldClim dataset, which offers 19 bioclimatic variables that are interpolated and modelled from observations and then averaged over the period 1970–2000 at a 1-km^2 resolution (Hijmans *et al.* 2005). From these we selected five variables: mean annual temperature, mean annual precipitation, rainfall seasonality (standard deviation of monthly averages *100), and mean temperature of the coolest and warmest quarters; most of the remaining variables are surrogates of these major climatic gradients. NDVI and bioclimatic layers were stacked and averaged to the same 1-km^2 grid. Altitude was assessed from the 90-m Shuttle Radar Topography Mission (SRTM) at 30 arc seconds (USGS 2004) and averaged across the same 1-km^2 grid as the NDVI and bioclimatic data. The ability of each model to discriminate between occupied and unoccupied areas was estimated from the area under the curve (AUC) of the Receiver Operating Characteristic (ROC) (Phillips *et al.* 2006). We used cross-validation to generate 10 folds of randomly-selected presence data and ran the model 10 times, excluding each fold in turn and using the fold to validate the model (Phillips and Dudik 2008). This uses all the data for validation and allows the standard deviation of the mean AUC to be estimated. The fit of each model to the data was assessed from the regularized training gain. Explanatory variables contributing less than 0.1% to the model were removed and the models were re-run. The regularisation multiplier was set to the default value of 1 and the graphed outputs checked for smoothness to assess the need for changing this default (Elith *et al.* 2010).

Observations made in the field suggested that much of the observed deforestation in the region was to clear land for palm oil and rubber production. To assess the overlap between possible future oil palm planting and the modelled distribution of Gurney's Pitta, we extracted the agro-climatically attainable

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yield for rain-fed (i.e. non-irrigated) oil palm production in tonnes per hectare estimated by Global Agro-ecological Zones (GAEZ) v3.0 (IIASA/FAO, 2012). Such data are not available for rubber, so we assessed rubber yields in adjacent parts of Thailand using data in Monfreda *et al.* (2008).

Results

Surveys in 2010–2012 visited 1,337 points, more than four times the number visited before 2010, although the detection rate was low because earlier surveys were concentrated in areas already known to be occupied by the species. Gurney's Pitta was recorded at 147 (9.0%) of the combined total of 1,637 point counts (Fig. 1). The highest GPS altitude at which birds were recorded was 259 m (the same point was measured at 219 m from the DEM), and the highest DEM altitude of an occupied point was 291 m (118 m from GPS) (Fig. 2). A large number of points surveyed above these altitudes failed to record any birds (Fig. 2), so it seems the species' altitudinal limit in Myanmar lies between 250 and 300 m. The most northerly record was made in 2012 in secondary forest near Bawsanwe village at 12.51°N, some 77 km north of the northernmost historical record from Thailand (Fig. 1) and 560 km north of the most southerly historical record from Thailand. However, the probability of recording Gurney's Pitta was low at higher and lower latitudes; 12.6% of the 1,099 points visited between 11°N and 12°N were occupied, compared to 3.4% of the 145 visited points below 110N and 0.8% of 396 points above 12°N. The same pattern was seen when the analysis was confined to points falling inside the area predicated as occupied by the model (see below): 13.6% of the 995 points visited between 11°N and 12°N were occupied, compared to 6.8% of the 145 visited points below 11° N and 0.6% of 155 points above 12°N. There was no significant difference between major forest types in the likelihood of occurrence ($\chi^2_6 = 7.56$, $P > 0.2$).

The average AUC of the 10 models was 0.951 (SD = 0.027). Within the model area, 3,379 1-km cells had an averaged modelled value exceeding the logistic threshold of equal training sensitivity and specificity (Fig. 3) and so were classed as being potentially suitable for the species. The most influential

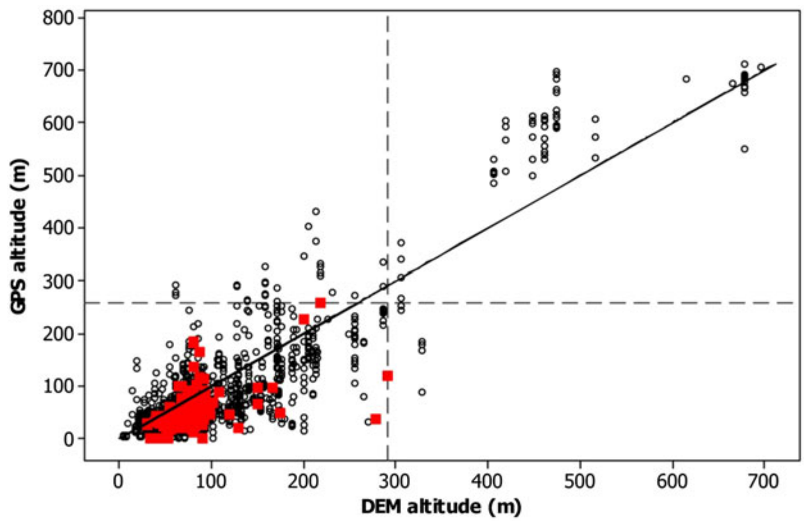

Figure 2. Altitude at 1,637 point count locations estimated from hand-held GPS and from a Digital Elevation Model at 1-km² resolution. Open circles indicate where Gurney's Pitta was not recorded, filled red squares where birds were recorded. The dotted lines indicate the highest altitude at which Gurney's Pitta was recorded by each method; the solid line indicates a 1:1 relationship.

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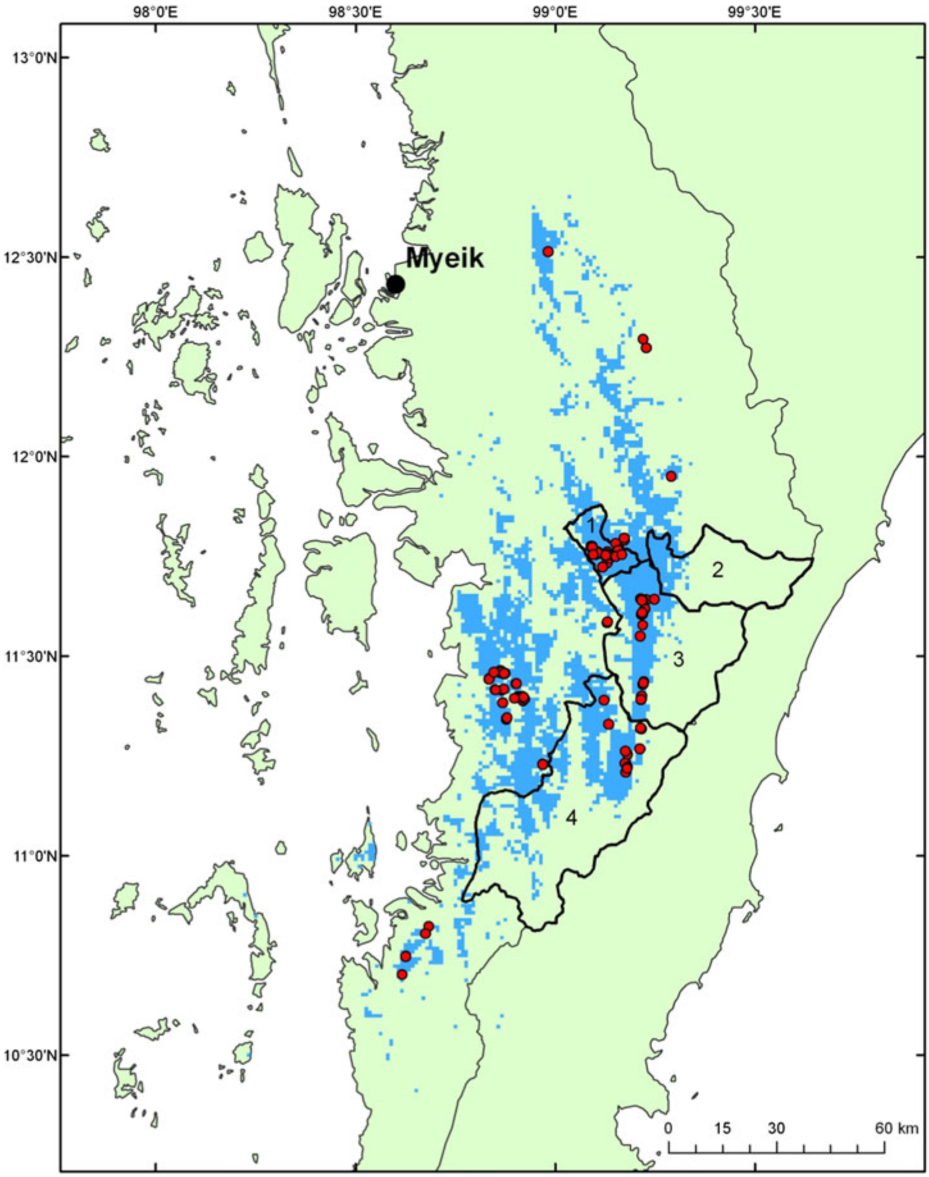

Figure 3. Modelled distribution of Gurney's Pitta, showing the 1-km cells for which the modelled value exceeded the logistic threshold of equal training sensitivity and specificity (blue). Point counts that recorded Gurney's Pitta are shown as red dots. Also shown are, from north to south, the borders of Htaung Pru Reserve Forest (1), Ngawun Reserve Forest Extension (2), Ngawun Reserve Forest (3) and the proposed Lenya National Park (4). The town of Myeik is the only major centre of human population in the region.

variables in the averaged model were, in descending order, rainfall seasonality (26.5% contribution), altitude (15.3%), rainfall (15.1%), temperature (13.0%), and slope (10.8%). Predicted likelihood of occupancy was highest with low values of altitude and slope, high temperature and intermediate values of rainfall and rainfall seasonality (Fig. S1 in the online supplementary materials).

Of the 3,379 cells with a modelled value exceeding the logistic threshold of equal training sensitivity and specificity, 19.04% fell in regions with a modelled potential oil palm yield of 1-3 tonnes/ha, 64.28% fell in regions with a modelled potential oil palm yield of 3–4 tonnes/ha and 16.66% fell in regions with a modelled potential oil palm yield of over 4 tonnes/ha. The species' range falls towards the northern limit of viable oil palm production in SE Asia, the highest potential yields in Myanmar being in the area of the proposed Lenya National Park (Fig. S2).

Discussion

Surveys since 2008 have increased the recorded latitudinal and altitudinal limits of Gurney's Pitta in southern Myanmar, in line with predictions made by the initial model. They have recorded the species over 70 km further north than any historical records (Collar *et al.* 2001), although the species is clearly rare at the northernmost limits of its range. Although the surveys recorded birds at higher altitudes than previously recorded, records above 150 m were rare, and were not necessarily of breeding birds; research in Thailand has shown that early in the breeding season, pittas (perhaps unmated males) can wander far from their usual habitats (P.D. Round *in litt.*). The surveys confirm that Gurney's Pitta is a species of a wide range of pristine and degraded lowland forests below 150 m, with small numbers recorded at higher elevations.

The range of the species falls at the northern limit of palm oil production in SE Asia, mainly in areas with low to moderate potential yields (1–3 tonnes per ha). These yields are lower than those in southern Thailand and Malaysia (> 4 tonnes per ha) and lower than the global average (3.5–5 tonnes per ha). However, potential yields are predicted to reach 4 tonnes/ha in the southern part of the species' range, and potential yields in Myanmar are highest within the boundaries of the proposed Lenya National Park. Furthermore, the GAEZ estimates should be treated with caution; oil palm is grown in Thailand at latitudes up to 15°N (P.D. Round pers. comm.), in areas predicted by GAEZ to be unsuitable for production. Potential rubber yields in Tenasserim are likely to be high as yields in adjacent parts of Thailand are among the highest in SE Asia (Monfreda *et al.* 2008). The whole range of Gurney's Pitta in Myanmar falls within areas identified by Phalan *et al.* (2013) as having high and currently unmet cultivation potential, and by Buchanan *et al.* (2011) as having globally high conservation value for forest birds. Oil palm and rubber plantations support very impoverished and functionally simplified bird communities in comparison to natural forest habitats (Donald 2004, Aratrakorn *et al.* 2006, Fitzherbert *et al.* 2008, Koh and Wilcove 2008, Danielsen *et al.* 2009, Azhar *et al.* 2013, Edwards *et al.* 2013, Senior *et al.* 2013) and Gurney's Pitta is not know to occur regularly within oil palm or rubber landscapes (Aratrakorn *et al.* 2006, Donald *et al.* 2009).

That the species has a slightly wider distribution within Myanmar than previously suggested is therefore of little comfort, since the recent democratisation of Myanmar, a process greatly to be welcomed for the social and societal benefits it will bring, is already bringing increased environmental challenges (Wang *et al.* 2013). Foremost among these is likely to be rapid loss of lowland Sundaic forest, already accelerating (Koh 2007), as the country opens its borders to international palm oil and rubber companies (Fox and Castella 2013); in 2012 and 2013, the field teams noted extensive forest loss in parts of the range of Gurney's Pitta, where areas sometimes in excess of 4,000 ha were being cleared for oil palm (pers. obs.). The teams also found evidence that the planting of oil palm plantations led to increased hunting of mammals and larger birds such as hornbills to provide food for estate workers, and evidence that many smaller birds such as Red-whiskered *Pycnonotus jocosus* and Straw-headed *P. zeylandicus* Bulbuls were being captured in large numbers for trade. In 2012, a visit to follow up sightings made the previous year of a bird at the species' northernmost limit found that the whole area had been cleared for oil palm in the interim. If unchecked, this rate of loss will result in the loss and fragmentation of the species' range as was recorded in Thailand, where the species is currently on the verge of extinction. This is likely to result in the loss of significant biodiversity. Although the area's biodiversity is poorly known, and much remains to be discovered, the field teams incidentally recorded a number of other globally threatened species, including Great Slaty Woodpecker *Mulleripicus pulverulentus*, Lesser Adjutant *Leptoptilos javanicus*, Large Green-pigeon *Treron capellei*, Plain-pouched Hornbill *Aceros subruficollis* and Wallace's Hawk Eagle *Spizaetus nanus*, and over 25 bird species listed as 'Near Threatened'. Evidence of tiger *Panthera tigris*, Asian elephant *Elephas maximus* and Asian tapir *Tapirus indicus* was recorded throughout the region (field teams pers. obs.).

As a minimum requirement, the loss of forest within the range of Gurney's Pitta needs to be monitored. The protection of southern Myanmar's important biodiversity, including Gurney's Pitta, will require substantial investment by foreign conservation interests, working both with Burmese authorities and international corporate agricultural interests, and the creation of a Ministry-level environment agency (BirdLife International 2003, Wang *et al.* 2013). Furthermore, a network of protected areas needs to be established to cover all the country's major biomes. The hitherto undesignated Lenya National Park, and the adjacent Ngawun and Htaung Pru Reserve Forests, both contain significant proportions of the range of Gurney's Pitta and their protection would greatly help to secure the future of this species. The creation of other protected areas further north, in the core of the species' range and where the pressure from oil palm may be lower, is also urgently needed. If the future economic development of Tenasserim is not to result in the environmental devastation that has taken place elsewhere in the Sundaic region, it must be underpinned by policies that include the conservation of key areas for biodiversity in all future land-use plans.

Supplementary Material

The supplementary materials for this article can be found at journals.cambridge.org/bci

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