

Research Article

Cite this article: Savini T, Gale GA, Sukumal N (2023). Is there any suitable habitat left for the Critically Endangered Gurney's Pitta's in Thailand? Implications for species management. *Bird Conservation International*, 33, e28, 1–7
<https://doi.org/10.1017/S0959270922000235>

Received: 22 February 2021
Revised: 31 March 2022
Accepted: 27 April 2022




Keywords:

Hydrornis gurneyi; Species reintroduction;
Range collapse

Author for correspondence:

*Niti Sukumal,
E-mail: niti_230@hotmail.com

Is there any suitable habitat left for the Critically Endangered Gurney's Pitta's in Thailand? Implications for species management

Tommaso Savini , George A. Gale  and Niti Sukumal* 

Conservation Ecology Program, King Mongkut's University of Technology Thonburi, 49 Soi Thian Thale 25, Bang Khun Thian Chai Thale Road, Bangkok 10150, Thailand

Summary

Severe habitat loss has been widely suggested as the main cause for the near disappearance of Gurney's Pitta across its range, with the species having been functionally extirpated from Thailand, and heavily reduced in Myanmar. Here we provide an overview of the decline in available habitat in the Thai portion of the range and the species prospects for reintroduction anywhere in Thailand. Little suitable habitat for the species has remained in the Thai part of its range since 1986, when the species was rediscovered and it has since declined to a level where viable populations cannot be found. Lowland forest (<150 m asl) has been heavily fragmented with most remaining habitat found in patches smaller than 1 km² and only 13 ranging between 1 and 5 km². Under current conditions, viable populations of the species cannot be reintroduced into the wild. However, maintaining a free-ranging, captive population may be possible as several of the remaining small habitat patches are legally protected, although they would require substantial management.

Introduction

Over the past 20 years much of the level lowland forest of Southeast Asia has been lost (Namkhan *et al.* 2021). Particularly hit by this destruction is the biodiversity-rich transition zone between the Indo-Burma and Sundaic regions (Isthmus of Kra; Hughes 2017) where most of the forest has been lost on the Thai side of the border (Leimgruber *et al.* 2005) and is under extensive and intensive threat on the Myanmar side (Donald *et al.* 2015). One such species endemic to the region, the Gurney's Pitta *Hydrornis gurneyi*, is restricted to level lowland Sundaic moist evergreen forest, almost entirely below 150 m elevation (Shwe *et al.* 2020), ranging between 7° and 12.5°N (Donald *et al.* 2014). First described in 1875 from Tanintharyi (Hume 1875) and in 1877 in southern Thailand (Hume and Davison 1878), it went unrecorded since 1952. It was rediscovered in southern Thailand in June 1986 (Round and Treesucon 1986, Gretton *et al.* 1993). In southern Myanmar (Tanintharyi region) the species was rediscovered in 2003 (Eames *et al.* 2005). While subsequent surveys estimated this latest rediscovered population to be quite large (Donald *et al.* 2014) the Thai population has been declining, mainly due to habitat loss following lack of protection, and by 2014 considered “functionally extinct” (Round 2014). Unfortunately, in recent years the species has declined dramatically in southern Myanmar for the same reason, ongoing rapid loss of suitable habitat due to lack of legal protection (Shwe *et al.* 2020, Savini *et al.* 2022).

Downlisted from ‘Critically Endangered’ to ‘Endangered’ by BirdLife International as recently as 2008 following the rediscovery of a large population in southern Myanmar, Gurney's Pitta was returned to ‘Critically Endangered’ status in 2019 (BirdLife International 2019) following the rapid decline of its habitat, which is expected to continue into the foreseeable future. Due to a lack of legal protection and with the establishment of a key proposed protected area being stalled for a decade (Donald *et al.* 2015), remaining suitable habitat in southern Myanmar is under immediate threat of conversion from the expansion of agricultural plantations and smallholdings. This habitat has undergone a decline of over 80% in the last 20 years (Shwe *et al.* 2020). The remaining habitat has been reduced to merely five suitable patches (>20 km²) located in three remaining strongholds, which remain under sustained threat of encroachment (Savini *et al.* 2022). Like Myanmar, the main cause of the disappearance of the species in Thailand was linked to habitat loss due to limited, and weakly implemented legal protection (Round 2014). It was rediscovered in 1986 in a 30 km² patch of extreme lowland, closed-canopy forest dominated by *Dipterocarpus* sp. trees, and bamboo *Dendrocalamus* sp. with a palm (*Licuala peltata*, *L. spinosa* and *Salacca rumphii*) understorey in southern Thailand (Round and Treesucon 1986) including secondary forest, not older than 50 years (Donald *et al.* 2009). Following its rediscovery, part of this patch (Khao Nor Chuchi), was designated as part of the Khao Pra-Bang Khram Non-Hunting Area in

1987 and then as a Wildlife Sanctuary in 1993, which primarily included the hillsides while excluding the lowland forest on which the Gurney's Pitta depends (Round 2014). However, the commercial value of this lowland, as well as limited enforcement, has perpetuated the species' decline (Round 2014). Throughout this period the species in Thailand was the subject of an intensive, but ultimately unsuccessful management effort and the population shrank to such low numbers that it was considered functionally extinct by 2014 (Round 2014).

Nevertheless, in recent years in Thailand, several projects have been initiated to assess the current status of the species by extensively surveying the species range in order to develop plans for a potential reintroduction of captive-bred birds (Wildlife Research Division 2009). However, up to now, no recent quantitative work has been undertaken to assess in detail the availability of suitable habitat, as was done for southern Myanmar (Shwe *et al.* 2020; Savini *et al.* 2022), and to assess if any forest patch (or patches) large enough remain(s) available for possible reintroduction and long-term management of the Gurney's Pitta in Thailand.

Assuming the availability of a captive Gurney's Pitta population for reintroduction or a wild population for translocation (issues beyond the scope of this paper), the aim of this study was to assess the status of the remaining suitable habitat in southern Thailand to understand the level of possibility for reintroducing/translocating and managing the species in the near future. First, we estimated the status of suitable remaining habitat using habitat variables based on recently published work from Myanmar for which relatively large numbers of detections for the species were available (Donald *et al.* 2014, Shwe *et al.* 2020) and estimate how much habitat has been lost since the species was rediscovered in 1986. Second, we identified remaining habitat patches and assessed whether they were large enough to possibly maintain a long-term viable Gurney's Pitta population. Following what is known about the species, we assessed whether there was sufficient habitat anywhere to maintain a Gurney's Pitta

population for the mid- to long-term. Third, we estimated how much suitable forest habitat is currently located within the Thai official protected area system. Finally, we provide recommendations for possible areas as well as discuss limitations to where reintroduced/translocated populations could be managed.

Methods

We defined the Thai range of the species based on confirmed records both recent, after its rediscovery in 1986, and historical records back to when it was first described in the country in 1875-1877, as available in Collar *et al.* (1986) and Gretton *et al.* (1993). Despite the species having been recorded in southern Myanmar up to 291 m DEM (digital elevation model) elevations following an extensive survey (Donald *et al.* 2014), a detailed analysis of the available location data showed that only 3.4% of the detections were above 150 m (Shwe *et al.* 2020). Therefore, this upland habitat should be considered marginal for viable populations in Thailand (P. D. Round pers. comm.). We therefore focused on level lowland forest (<150 m with slope <10 degrees, following Shwe *et al.* 2020) ranging from southern Prachuap Khiri Khan to northern Trang (following Round 2014), between 11°50'N and 7°30'N (see Figure 1A and Table 1 for details of observation records).

Lowland forest maps for 1987, 1998 and 2018 were produced from satellite images and digital elevation maps. Landsat 5 Thematic Mapper (TM) and Landsat 8 Enhanced Thematic Mapper (ETM) images (30-m resolution) were downloaded from <https://earthexplorer.usgs.gov> to classify forest cover and non-forest (i.e. all other land-cover types). The initial classification was assessed by detailed manual editing using images from Google Earth where both the crown pattern and the vegetation colour were used to distinguish natural forest from plantations. Further checking, when needed, was done using Google Street View which proved to be effective, as Thailand is extensively covered by roads. Shuttle Radar Topography Mission (STRM) DEM maps were downloaded

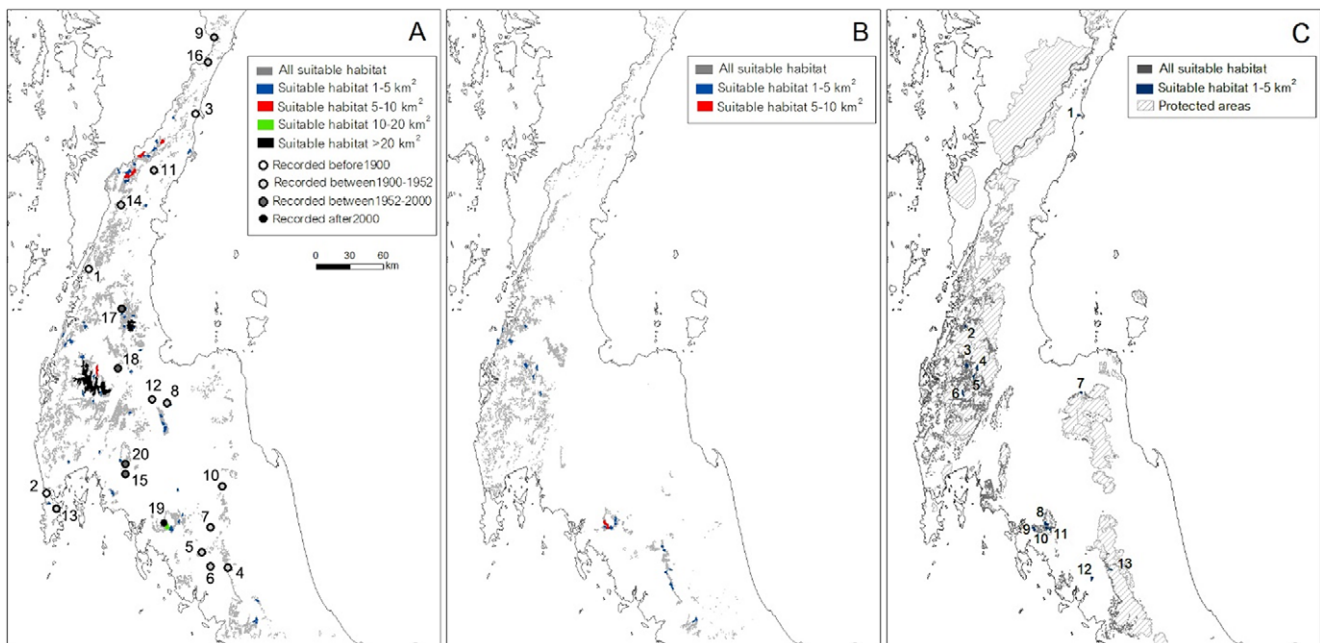


Figure 1. Remaining suitable Gurney's Pitta's habitat in Thailand for (a) 1987, (b) 1998 and (c) 2018. Numbers in (a) represent the sites where the species has been detected following details in Table 1. Numbers in (c) indicate the 13 remaining patches of suitable habitat larger than 1 km².

Table 1. Details of site records where Gurney's Pitta was observed in Thailand since its discovery (spelling of site names follow those in Collar *et al.* 2001). References cited in the table: (1) Hume and Davison 1878, (2) Hume 1879, (3) Robinson and Kloss 1911, (4) Robinson 1915, (5) Gyldestolpe 1916, (6) Robinson and Kloss 1918, (7) Robinson and Kloss 1924, (8) Meyer de Schauensee 1946, (9) Deignan 1963, (10) Collar *et al.* 1986, (11) Round and Treesucon 1986, and (12) Gretton *et al.* 1993.

ID	Site	X_utm	Y_utm	Detection period	Note	References
1	Ranong	462196.51	1101824.13	1877		1 (in 10)
2	Ban Suan Maphrao	424239.41	901857.97	1879	From skin specimen	2
3	Ban Saphan	556401.57	1239985.80	1893	From skin specimen	10
4	Khao Kachong	585668.99	835546.38	1909	Four birds collected	11
5	Ban Lamphu La	562495.64	849324.91	1910	Eight birds collected	11
6	Ban Khuan Khan	569858.83	836425.49	1910		11
7	Klong Muan	569885.45	871437.93	1910		11
8	Ban Kok Klap	531152.34	981965.27	1913 & 1929	Defined as "very common"	4; 10
9	Koh Lak Paa	572620.21	1308199.02	1914	Immature male observed	5
10	Klong Wang Hip	577430.40	909439.37	1915	Nesting pair found	10
11	Klong Bang Lai (Ban Salui)	519650.94	1189727.11	1916		10
12	Ban Han Not	518323.20	985640.66	1916		10
13	Klong Tung Sai	433153.00	888115.89	1917	One male observed	6
14	Ban Tha San	490880.86	1158851.98	1919		7
15	Khao Phanom Bencha W.S.	494662.21	919243.12	1936; 1987 until 1992		8; 12
16	Ban Khlua Klang, Huai Yang	567100.46	1286130.77	1952		9
17	Tha Chana, Khlong Yan	491372.50	1066060.49	1987 & 1988	One pair and one male observed	12
18	Khlong Yan Vallyay	487848.85	1012916.65	1988	Two pairs found in a 20 ha forest	12
19	Khao Nor Chuchi	528669.33	875483.72	1986 until 2013	Several breeding pairs observed	11; 12
20	Khlong Phraya W. S.	494425.64	927724.16	1936; 1987 until 1992	Recorded at 4 locations outside the sanctuary	8; 12

from <https://earthexplorer.usgs.gov> and we selected elevations from 0 to 150 m to produce a lowland shapefile. Areas with slopes less than 10° were defined from elevation maps to produce a shapefile of the level lowlands. The forest cover shapefile and the elevation shapefile were overlaid. The output map of forest cover at elevations 0–150 m and slopes <10° was used to define suitable habitat for Gurney's Pitta as described above, following Shwe *et al.* (2020) and P. D. Round (pers. comm.).

A forest patch of 20 km² was estimated to be of sufficient size to maintain a Gurney's Pitta population for the mid- to long-term in mildly degraded habitat, potentially accommodating a population ranging between 140 and 200 pairs (Savini *et al.* 2022). However, due to extensive deforestation in the region (Hughes 2017), we predicted that no such large patches of lowland forest remain within the Thai range of the species. We therefore only excluded fragments smaller than 1 km² and then grouped the remaining forest into four size categories: 1 to <5 km², 5 to <10 km², 10 to <20 km² and ≥20 km². Finally, we estimated how much remaining suitable habitat is currently under legal protection by overlaying the boundaries of the Thai protected area system (UNEP-WCMC & IUCN 2014).

Results

As expected, suitable forest habitat steadily declined between 1987, soon after the species was rediscovered, and 2018, the year

of our most recent forest cover map. Lowland forest declined from 928 km² in 1987 to 273 km² currently within the known range of Gurney's Pitta in Thailand. However, at present, suitable forest cover is highly fragmented with most of it represented by fragments <1 km². After these fragments were removed from consideration, only 27 km² of suitable habitat remained, declining from 313 km² in 1987 (see Figure 1A and Table 2 for details on forest loss since 1987).

Most of the remaining suitable forest cover is found in only 13 small patches, all of which are less than 5 km². The three patches larger than 10 km² disappeared after 1987 and only one patch between 5 and 10 km² remained in 1998 (see Figure 1B and Table 2 for details on forest fragmentation since 1987).

A total of seven suitable habitat patches larger than 1 km² lie inside five protected areas: from north to south following Figure 1C, patch number 2 in Khlong Naka Wildlife Sanctuary, patches 3, 4 and 5 in Khlong Saeng Wildlife Sanctuary, patch 6 in Khao Sok National Park, patch 11 in Khao Pra-Bang Kham Wildlife Sanctuary and patch 13 in Khao Bantad Wildlife Sanctuary (see Figure 1C for details). Three additional patches are found overlapping the boundary of a protected area just inside and outside Khao Pra-Bang Kham Wildlife Sanctuary (patch numbers 8, 9 and 10), where Gurney's Pitta was last recorded in Thailand (record 19 in Table 1). Finally, three patches were found outside of the current protected area system (patches 1, 7 and 12). Number 1 is located within Pa Klang Ao Forest

Park in Prachuap Khiri Khan Province, and number 12 is located within the Peninsular Botanical Garden (Thung Khai) in Trang Province.

Discussion

Our data indicate an almost complete clearance of Gurney's Pitta habitat in its Thai range since the species was rediscovered in 1986.

The remaining level lowland forest is highly fragmented with no patches even reaching 5 km². Suitable forest cover was already greatly reduced in 1987, soon after the species was rediscovered in Khao Nor Chuchi (Round and Tresucon 1986), when only two patches larger than 20 km² and one just over 10 km² were recorded (Table 2).

In contrast to southern Myanmar, most of the remaining suitable habitat patches (seven out of 13) are within existing protected

Table 2. Total suitable habitat cover and patch size details for the remaining forest cover measured in 1987, 1998 and 2018, over the Thai part of the Gurney's Pitta's range.

	1987		1998		2018	
	cover (km ²)	n of patches	cover (km ²)	n of patches	cover (km ²)	n of patches
Total forest cover	928	80,260	274	42,773	273	26,537
Forest cover after removing patches < 1 km ²	313	59	46	22	27	13
Forest cover patches between 1-5 km ²	92	51	37	21	27	13
Forest cover patches between 5-10 km ²	32	5	8	1	–	–
Forest cover patches between 10-20 km ²	12	1	–	–	–	–
Forest cover patches > 20 km ²	177	2	–	–	–	–

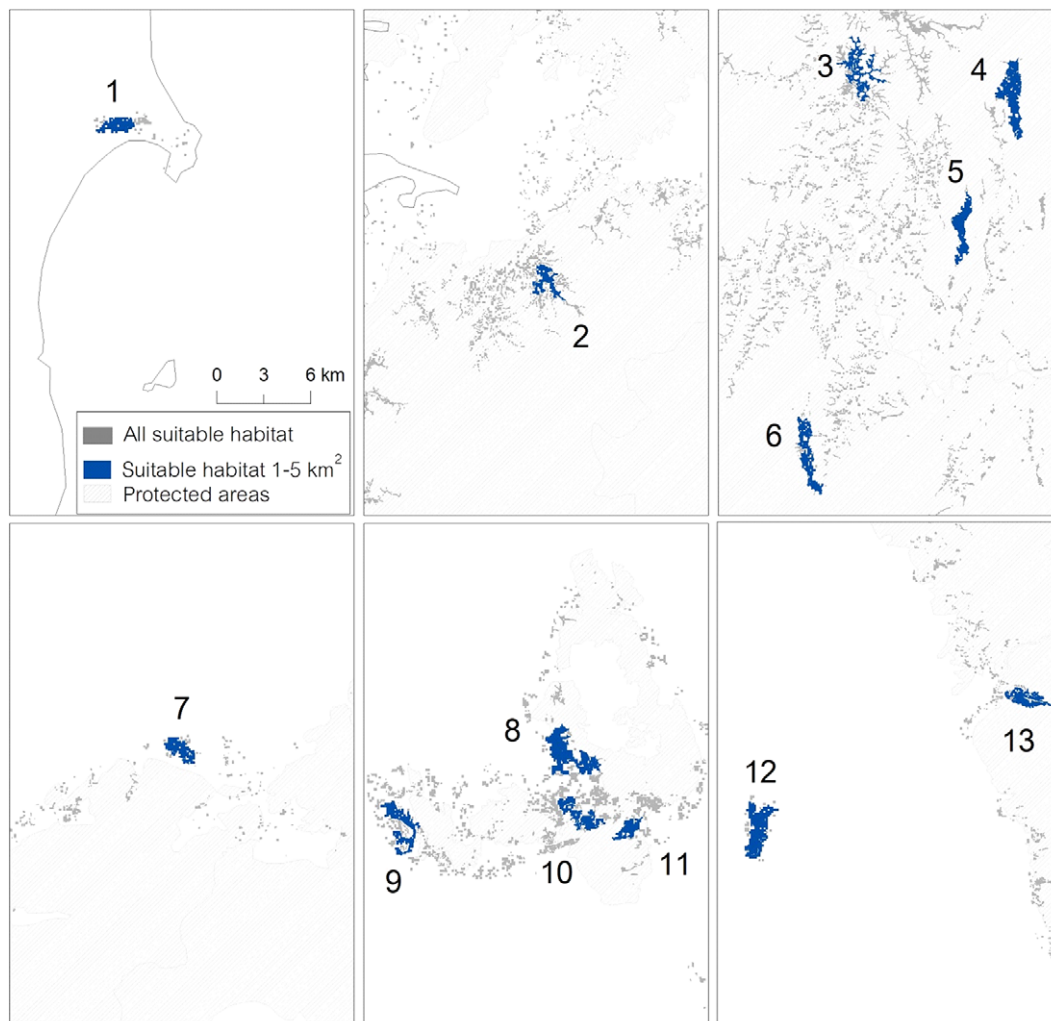


Figure 2. Details of the remaining 13 fragments, larger than 1 km², of Gurney Pitta's suitable habitat in the Thai range of the species in 2018.

areas (2, 3, 4, 5, 6, 7, 8, 9, 10, 11 and 13 in Figure 1C and Figure 2) and one within a forest park (1 in Figure 1C and Figure 2). One patch appears only in 2018 (patch 7 in Figure 1C and Figure 2) and may be the result of land patches previously cultivated as an orchard and subsequently abandoned, resulting in some secondary forest regrowth. In addition, a small patch was also found in a botanical garden (12 in Figure 1C and Figure 2) which however falls just outside the known southern limit of the species range.

The largest single patch was found in what is now the Klong Saeng – Khao Sok forest complex and disappeared almost immediately when the Chiew Larn reservoir inundated the remaining lowland forest in 1987 (Woodruff 2013). What is left in the whole forest complex are four fragments smaller than 5 km² (3, 4, 5 and 6 in Figure 1C and Figure 2), mere leftovers from the reservoir formation. Although several lowland species were recorded in the area (Irving *et al.* 2018) there are no records of Gurney's Pitta inhabiting the area prior to reservoir formation or subsequently. A second patch larger than 20 km² was found near Tha Chana, Surat Thani Province, where the species was recorded in 1988 (record 17 Table 1). However, none of the lowland forest in the area remains, as it never appears to have been included in any protected area. The last large patch of lowland forest, less than 20 km², recorded in 1987 was found in Khao Nor Chuchi where the species was rediscovered in 1986 (Round and Tresucon, 1986). Despite being protected and included in the Khao Pra-Bang Khram Wildlife Sanctuary, the 150 km² protected area established to protect Gurney's Pitta after it was rediscovered in the area in 1986 (Round 2014), habitat disturbance and its small population size have led to the demise of the pitta at this location. The degradation of the area has continued since then and now only four fragments smaller than 5 km² remain (8, 9, 10 and 11 - Figure 1C and Figure 2). Several birds were also recorded at four sites outside Khlong Phraya Wildlife Sanctuary between 1988 and 1992. Furthermore, by 1992 a large portion of the protected area was deforested leaving only few fragments smaller than 1 km² (Gretton *et al.* 1993).

Options for possible reintroduction and/or translocation

Although it was hoped that Gurney's Pitta in Thailand could perhaps be restored through intensively managing semi-wild sub-populations, for which there is still a lot to be learned (i.e. how to do this practically and how to breed the species in captivity), our results show that currently no sufficiently suitable habitat is available in southern Thailand to provide to any reintroduced population a chance of long-term survival. Consequently, assuming a captive bred population will be available for any management programme, broadly speaking, two possible scenarios are suggested to recover the species in its Thai range.

In the short-term, the small remaining patches of suitable habitat might at most allow the establishment of managed free-ranging colonies utilizing the remaining small patches, similar to programmes successfully used for species such as the Kakapo *Strigops habroptilus* (Clout and Merton 1998). Following our results (patch size, elevation, and habitat quality), six sites could be potentially used for this purpose: one area is in Khlong Naka Wildlife Sanctuary (patch 2 in Figure 2), where Gurney's Pitta was recorded in 1992 although outside the Sanctuary boundaries (P. D. Round pers. comm.). Other second choice sites could also be found in Khao Sok National Park (patch 6 in Figure 2), Khlong Saeng Wildlife Sanctuary (patches 3, 4 and 5 in Figure 2) and Khao

Bantad Wildlife Sanctuary (patch 13 in Figure 2), however, all these sites were surveyed in the 1980s, at which time they did not hold any Gurney's Pitta. This might suggest either their unsuitability for the species or these pittas were long gone prior to the surveys. Despite not being optimal, four of these areas have also been identified by the Department of National Parks, Wildlife and Plant Conservation, based on mostly different criteria (although the details were not available), as potential sites for reintroduction (Wildlife Research Division 2009) further suggesting their potential to assist in the species' survival.

For the long term, sufficient suitable habitat could be generated by connecting existing small fragments. Reconnecting existing patches to establish a sufficiently large forest patch to secure mid- to long-term survival of Gurney's Pitta has been suggested for southern Myanmar (Savini *et al.* 2022). Although reconnecting protected areas is a substantial undertaking, several countries have done so including Bhutan and Taiwan in Asia (Saura *et al.* 2019). When assessing where this could be done in southern Thailand the primary focus should fall on the Khao Nor Chuchi area, which includes Khao Pra-Bang Khram Wildlife Sanctuary and the largely encroached 30 km² of the Bang Khram National Reserve Forest lying in the Khlong Thom Basin (Collar *et al.* 2001), where its presence was confirmed until recently (Round 2014). However, we also note that in spite of the long-term management programme implemented in the area since 1986, the conservation of sufficient suitable habitat was not realized, but instead much of the forest was cleared for high-value crop production, mainly rubber and oil palm. Nevertheless, despite having been extensively fragmented by agricultural expansion, the area still holds four patches (patches 8, 9, 10 and 11 in Figure 2) totaling 8.97 km², to which extra habitat could be added if patches smaller than 1 km² are included, specifically connecting patches 8, 10 and 11 (grey area in Figure 2), reaching a total of 17.18 km² potentially forming a single protected area complex. The management of the area could be simplified due its particular topographical characteristics. The lowland area within the Khlong Thom Basin is ringed on three sides by the higher hills of the Khao Pra-Bang Khram Wildlife Sanctuary leaving only one side, on the west, which could facilitate access. The possibility of controlling access to the area where the species could be reintroduced, will assist the management of the area to control further deforestation and perhaps hunting. This could be achieved by including the remaining lowland forest of the Khlong Thom Basin inside the boundaries of the Khao Pra-Bang Khram Wildlife Sanctuary, as already suggested (Collar *et al.* 2001).

Since 2005 a reforestation project has been developed in the area under the supervision of the Forest Restoration Research Unit (FORRU), Chiang Mai University (Thailand), which has successfully demonstrated the concept by restoring nearly 15 ha of lowland forest (S. Elliott pers. comm.). However, local and government agencies will need to ramp-up the project to scale, which is still lacking. The process and key tree species for habitat restoration are understood and have been tested around the Khao Nor Chuchi area for Gurney's Pitta (Elliott *et al.* 2008), and a tree nursery was created. Despite having been achieved successfully at other sites (northern Vietnam; Meyfroidt and Lambin 2008, Chazdon and Guariguata 2016), the difficulty remains as to how to conduct such restoration over large scales where small size patches are relatively far apart, as is the case here. Furthermore, commitments required for such a project from local stakeholders might be still difficult to guarantee.

Including the whole area under the protected area system, as suggested by Collar *et al.* (2001), would provide legal tools to

reduce the expansion of land clearance, both for the remaining patches as well as for future restored ones, and may also limit the persecution of the species. Both of these issues were the primary reasons for the species' disappearance from the area since its rediscovery. However, difficulties remain as to how to acquire the needed land, currently under cultivation, for restoration. This has proven to be rather complicated here and elsewhere in Thailand where villages have been left within protected area boundaries to be monitored by park staff. As the species has been suggested to inhabit mainly secondary forest (Donald *et al.* 2009), closely managing it in areas surrounding agricultural areas could provide an initial solution.

Yet, in these small fragments of secondary forest, nest success was suspected to be low, as a consequence of intense predation pressure, particularly from snakes (Donald *et al.* 2009). However, recently published work from the region, including a major (>1,500 nests), long-term (9-year) study of nesting success and nest predators in a large (>2,100 km²) relatively undisturbed forest, as well as a similarly large 7-year nest predation study in a moderately sized (~160 km²) secondary forest patch in Thailand, indicate that nest success for most understorey bird species is naturally low (1.9–43.0% depending on the species) (Khamcha *et al.* 2018, Pierce *et al.* 2020). Furthermore, snakes are typically the most important or second-most important nest predators depending on the species of bird (Pierce and Pobprasert 2013, Khamcha and Gale 2020). Thus, despite the naturally high nest predation rates in the region, managing nest predators and/or protecting birds and nests from predators, is recommended because reintroduced birds appear more vulnerable to predation pressure compared to those born in the wild (Collar 2020).

Acknowledgements. We are grateful to Philip D. Round and two anonymous reviewers for providing extensive comments on the manuscript and Maliwan Namkan for helping in measuring forest cover.

References

- BirdLife International (2019) *Hydrornis gurneyi*. The IUCN Red List of Threatened Species 2019: e.T22698628A157110021. <https://doi.org/10.2305/IUCN.UK.2019-3.RLTS.T22698628A157110021.en> [accessed 14 February 2020].
- Chazdon, R. L. and Guariguata, M. R. (2016) Natural regeneration as a tool for large-scale forest restoration in the tropics: prospects and challenges. *Biotropica* **48**: 716–730.
- Clout, M. N. and Merton, D. V. (1998) Saving the Kakapo: the conservation of the world's most peculiar parrot. *Bird Conserv. Internatn.* **8**: 281–296.
- Collar, N. J. (2020) Preparing captive-bred birds for reintroduction: the case of the Vietnam Pheasant *Lophura edwardsi*. *Bird Conserv. Internatn.* **30**: 559–574.
- Collar, N. J., Round, P. D. and Wells, D. R. (1986) The past and future of Gurney's Pitta *Pitta gurneyi*. *Forktail* **1**: 29–51.
- Collar, N. J., Andreev, A. V., Chan, S., Crosby, M. J., Subramanya, S. and Tobias, J. A. (2001) *Threatened birds of Asia: The BirdLife International Red Data Book*. Cambridge, UK: BirdLife International.
- Deignan, H. G. (1963) *Checklist of the birds of Thailand*. Washington, DC: U.S. National Museum. (Bulletin 226).
- Donald, P. F., Aratrakorn, S., Thura Win Htun, Eames, J. C., Htin Hla, Thunikhorn, S., Sribua-Rod, K., Tinun, P., Sein Myo Aung, Sa Myo Zaw and Buchanan, G. M. (2009) Population, distribution, habitat use and breeding of Gurney's Pitta *Pitta gurneyi* in Myanmar and Thailand. *Bird Conserv. Internatn.* **19**: 353–366.
- Donald, P. F., Hla, H., Win L., Aung, T. D., Moses, S., Zaw, S. M., Ag, T. T., Oo, K. N. and Eames, J. C. (2014) The distribution and conservation of Gurney's Pitta (*Pitta gurneyi*) in Myanmar. *Bird Conserv. Internatn.* **24**: 354–363.
- Donald, P. F., Round, P. D., Thiri Dawei Aung, Grindley, M., Steinmetz, R., Shwe, N. M. and Buchanan, G. M. (2015) Social reform and a growing crisis for southern Myanmar's unique forests. *Conserv. Biol.* **29**: 1485–1488.
- Eames, J. C., Hla, H., Laimgruber, P., Kelly, D. D., Aung, S. M., Moses, S. and Tin, U. S. N. (2005) Priority contribution. The rediscovery of Gurney's pitta *Pitta gurneyi* in Myanmar and an estimate of its population size based on remaining forest cover. *Bird Conserv. Internatn.* **15**: 3–26.
- Elliott, S., Kuaraksa, C., Tunjai, P., Polchoo, T., Kongho, T., Thongtao, J., and Maxwell, J. F. (2008) *A technical strategy for restoring Krabi's Lowland Tropical Forest*. Chiang Mai, Thailand: Forest Restoration Research Unit.
- Gretton, A., Kohler, M., Lansdown, R. V., Pankhurst, T. J., Parr, J., and Robson, C. (1993) The status of Gurney's Pitta *Pitta gurneyi*, 1987–1989. *Bird Conserv. Internatn.* **3**: 351–367.
- Gyldenstolpe, N. (1916) *Zoological results of the Swedish zoological expeditions to Siam 1911–1912 and 1914–1915*. IV. Birds II. Kungl. Svenska Vetenskapakad. Handl.
- Hughes, A. C. (2017) Understanding the drivers of Southeast Asian biodiversity loss. *Ecosphere* **8**: e01624.
- Hume, A. O. (1875) Novelty? *Stray Feathers* **3**: 296–303.
- Hume, A. O. (1879) A first tentative list of the birds of the western half of the Malay Peninsula. *Stray Feathers* **8**: 37–72.
- Hume, A. O. and Davison, W. (1878) A revised list of the birds of Tenasserim. *Stray Feathers* **6**: 1–524.
- Irving, G. J., Round, P. D., Savini, T., Lynam, A. J. and Gale, G. A. (2018) Collapse of a tropical forest bird assemblage surrounding a hydroelectric reservoir. *Global Ecol. Conserv.* **16**: e00472.
- Khamcha, D. and Gale, G. A. (2020) Predation behaviour of the bridge snake (*Lycodon cf. davisonii*) on Asian tropical evergreen forest bird nests. *Raffles Bull. Zool.* **68**: 803–809.
- Khamcha, D., Powell, L. A. and Gale, G. A. (2018) Effects of roadside edge on nest predators and nest survival of Asian tropical forest birds. *Global Ecol. Conserv.* **16**: e00450.
- Leimgruber, P., Kelly, D. S., Steininger, M. K., Brunner, J., Muller, T. and Songer, M. (2005) Forest cover change patterns in Myanmar (Burma) 1990–2000. *Environ. Conserv.* **32**: 356–364.
- Meyer de Schauensee, R. (1946) On Siamese birds. *Proc. Ac. Nat. Sci. Philadelphia* **98**: 1–82.
- Meyfroidt, P. and Lambin, E. (2008) The causes of reforestation in Vietnam. *Land Use Policy* **25**: 182–197.
- Namkhan, M., Gale, G. A., Savini, T. and Tantipisanuh, N. (2021) Loss and vulnerability of lowland forests in mainland Southeast Asia. *Conserv. Biol.* **35**: 206–215.
- Pierce, A. J. and Pobprasert, K. (2013) Nest predators of southeast Asian evergreen forest birds identified through continuous video recording. *Ibis* **155**: 419–423.
- Pierce, A. J., Sankamethawee, W., Powell, L. A. and Gale, G. A. (2020) Patterns of nesting and nest success in an evergreen forest in Southeast Asia. *Emu-Austral Ornithol.* **120**: 46–55.
- Robinson, H. C. (1915) On a collection of birds from the Siamese province of Bandon, N.E. *Malay Peninsula*. J. Federated Malay States Mus. **5**: 83–110.
- Robinson, H. C. and Kloss, C. B. (1911) On birds from the northern portion of the Malay Peninsula, including the islands of Langkawi and Terutau; with notes on other rare Malayan species from the southern districts. *Ibis* **9**: 10–80.
- Robinson, H. C. and Kloss, C. B. (1918) On a collection of birds from the province of Phuket, Peninsular Siam. *J. Nat. Hist. Soc. Siam* **3**: 87–119.
- Robinson, H. C. and Kloss, C. B. (1924) The birds of South-west and peninsular Siam. *J. Nat. Hist. Soc. Siam* **5**: 1–397.
- Round, P. D. (2014) Gurney's Pittas in Thailand—from rediscovery to extinction in just 28 years. *Nat. Hist. Bull. Siam Soc.* **60**: 3–8.
- Round, P. D. and Treesucon, U. (1986) The rediscovery of Gurney's Pitta. *Forktail* **2**: 53–66.
- Savini, T., Shwe, N. M., and Sukumal, N. (2022) Suitable habitat for the critically endangered Gurney's pitta continue its drastic decline. *Oryx* **56**: 202–208.
- Shwe, N. M., Sukumal, N., Grindley, M. and Savini, T. (2020) Gurney's Pitta on the brink of extinction! *Oryx* **54**: 16–22.
- Saura, S., Bertzky, B., Bastin, L., Battistella, L., Mandrici, A., and Dubois, G. (2019) Global trends in protected area connectivity from 2010 to 2018. *Biol. Conserv.* **238**: 108183.

- UNEP-WCMC and IUCN (2014) *Protected Planet: The World Database on Protected Areas (WDPA)* [On-line], [accessed 16 April 2015], Cambridge, UK: UNEP-WCMC and IUCN. Available at: www.protectedplanet.net.
- Wildlife Research Division (2009) *Meeting report: Distribution and population status of Gurney's Pitta from the past, present, to management in the future (In Thai)*. Bangkok, Thailand: Department of National Parks, Wildlife and Plant Conservation.
- Woodruff, D. S. (2013) Wildlife conservation in protected areas in Thailand: lessons from Chiew Larn, Khao Sok and Khlong Saeng. *Nat. Hist. Bull. Siam Soc.* **59**: 91–107.