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PRIORITISING SEARCH AREAS FOR WHITE-BELLIED HERON IN INDIA

WHITE-BELLIED HERON WORKING GROUP OF THE IUCN SSC HERON SPECIALIST GROUP

WHITE-BELLIED HERON
WORKING GROUP

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CONTENTS

HEADLINE INFORMATION

- This report provides guidance on sights for prioritisation for White-bellied Heron surveys and survey techniques.
- The current known White-bellied Heron population globally is extremely small and fragile.
- Little potential habitat within Arunachal Pradesh, India has been comprehensively surveyed yet large areas of potentially suitable habitat exist.
- 21 areas ('polygons') within Arunachal Pradesh appear potentially to be suitable for White-bellied Heron based on habitat features and current human-use patterns.
- Five of these 21 polygons have been identified as highest priority for survey because they have the highest likelihood of holding significant numbers of the species.
- The surveys required are of high intensity and lengthy (2–3 months per polygon) reflecting the nature of the species and landscape.
- Given the species's apparent rarity and array of potential and increasing threats, there is a great urgency to get these surveys underway.
- It appears, a much wider variety of forest streams and rivers is used by the species than was typically believed.

SUMMARY

The White-bellied Heron (*Ardea insignis*) has a small known global population of a few dozen individuals, with regular occurrence presently known in only three landscapes: central Bhutan; Namdapha National Park; and Kachin state, Myanmar, notably the Hukaung valley. None of these three populations can confidently be said to be secure. If there is the reasonable possibility that additional regularly used localities might exist, it is important to find them; the birds using them are likely to be threatened and in need of intervention to persist.

A vast amount of potentially suitable habitat remains. Two lengthy surveys in India in 2017–2018 found no new localities for the species, but neither spent significant time in areas remote from regular human activity. White-bellied Heron is very shy in India and it is plausible that remaining birds will be mostly or entirely in the most remote areas. Remote areas are considerably less widespread than is habitat intrinsically suitable for the species.

A three-day discussion meeting in February 2019 brought together 14 people with experience of surveying for the species and used aerial imagery to determine where in India the species is most likely to persist. The process involved intensive discussion of the sites where the species has recently been seen and those where observer effort is sufficient to conclude that a lack of records indicates that it is not regularly present, to determine what habitat and human use features discernible on the imagery would best predict where to look. The process did not consider conservation of White-bellied Heron populations once found, for which a different set of people would be required.

The examination and discussion of historical locality records from India and Myanmar, and currently occupied localities in Bhutan, suggested a number of insights on the species's natural history and threats. These are important in considering where to look for the species. It may well make regular use of streams much narrower than often assumed (down to 5 m width or so, and with some canopy closure), and evidently can use rivers with only occasional rockiness, in addition to the typically rock-dominated habitat of most recent sightings. Although there is little direct evidence of persecution of White-bellied Heron anywhere in its range, even very low levels might be catastrophic for the species, and such persecution is the only plausible explanation for the typical shyness of the species in India (which contrasts with its confiding nature in central Bhutan, where persecution is known not to occur other than, potentially, exceptionally). Adjacent land habitats seem to be of little if any influence directly: the association of White-bellied Heron with high-quality forest is likely to be a secondary effect of human activity in non- and degraded forest areas. This also explains the

location of most regularly used localities in rugged terrain.

Some potential correlates of current distribution were not visible on the aerial imagery, such as fish stocks; some sorts of past human activity; pollution; and cultural differences between ethnic groups in attitudes to wildlife. A number of short-stay records in well-watched localities indicate that dispersing White-bellied Herons can turn up in localities highly unlikely, in terms of habitat and human use, to support the species regularly. Such sites are unlikely to be of conservation value to the species. In total 21 landscapes ('polygons') were defined with some reasonable expectation of holding the species regularly (Fig. 1 in the main text). Of these, five were clear priorities for conservation assessment because of their potential to support relatively large populations. This was based primarily on size of remote area, absence of visible human presence, quality of stream habitat, and proximity to other known or likely White-bellied Heron areas. All the polygons are in Arunachal Pradesh, although the historical distribution in India was much wider. This reflects the, on average, much lower human population densities in Arunachal than in the other states. Some parts of the priority polygons are within protected areas but much polygon area is outside declared protected areas.

Given the perilous status of known White-bellied Heron populations across the global range, survey of the priority polygons is urgently required. For such a shy, low-density, somewhat cryptic species each of the priority polygons will require 2–3 months of intensive survey, the vast majority of which needs to be spent outside the areas familiar to typical local people. Each survey is therefore a major undertaking. Under-resourced surveys (e.g. too brief, insufficient penetration of the remote parts of the polygon, insufficiently motivated or experienced observers) have a high risk of overlooking the species and will prejudice later efforts to mount comprehensive surveys. Each polygon's survey requires a solid reconnaissance, careful map- and imagery-based planning, and supplementation of the mainstay method of direct searching (from viewpoints and, where feasible, walking along streams apparently suitable for the species) with other methods as locally applicable, such as camera-trapping and decoys. Safety of surveyors needs careful consideration: in most polygons surveys should occur in the dry season.

Historical records and the very limited information from tracking studies suggest the possibility that the species, perhaps only between fledging and selection of home range for breeding, may routinely use very wide, sandy rivers notably the Brahmaputra. There is a very large area of suitable such habitat and the most efficient way to understand its use would come from further tracking studies. These studies are an urgent priority also for informing various other aspects of effective White-bellied Heron conservation.

Participants agreed that it is important to search for White-bellied Heron in the priority polygons. If competent searches in all the five priority polygons fail to find the species, consideration should be given to abandoning further searches and focusing absolutely on the known localities and on captive conservation breeding.

INTRODUCTION

The White-bellied Heron has a small known global population of a few dozen individuals, with regular occurrence presently known in only three landscapes: central Bhutan; Namdapha National Park (Namdapha NP); and Kachin state, Myanmar, notably the Hukaung valley. None of these three populations can confidently be said to be secure. General discussions of the natural history, known status over the last 150 years, and the variety and intensity of various known or potential threats to the species can be found in BirdLife International (2001), Stanley Price & Goodman (2015) and WbHWG (2017). There is no captive insurance population, although a programme is being initiated in Bhutan. Thus, if there is the reasonable possibility that additional regularly used localities might exist, it is important to find them; the birds using them are likely to be threatened and in need of intervention to persist.

PROBLEM STATEMENT

In dry-season 2017–2018, two surveys looked for new localities for White-bellied Heron in India. These two survey programmes took different, but complementary, approaches. Samiran Patgiri selected a landscape including Mehao Wildlife Sanctuary (Mehao WS) and some surrounding rivers. This is close to Namdapha NP, similar in riverine habitats to the parts of Namdapha NP that are known to support the species regularly, and – in parts – has low levels of human use. He and his team explored a number of streams upstream to where access became difficult. Megha Rao and Rohan Menzies selected dozens of sites across Arunachal Pradesh and some in Assam for rapid survey at each; they necessarily did not allow more than a few days at any individual site. Both teams combined direct searches for the bird with discussions involving many local people. Both teams' survey sites will be mapped in their respective reports.

Neither team observed White-bellied Heron away from the known sites within Namdapha NP. Neither team had any respondent apparently seeing the bird on a regular basis; both were told of a few, specific encounters in the recent to further past of birds that plausibly were White-bellied Herons. While the survey at each site was insufficient to prove absence at any particular one of them, the large number of sites with no indication strongly suggests that the species is not widespread, if it occurs at all, in river stretches with habitat and human use similar to those visited on these surveys. Thus, unless there is a good reason to suspect the direct searches and discussions were flawed in methodology or biased in terms of selection, these results are profoundly disturbing.

Inspection of aerial imagery indicates that both teams' searches were in habitat-types visually consistent with localities known to be occupied presently or in the past. White-bellied Herons in NE India are typically shy, often flushing at hundreds of meters' distance. It is likely that the species is somewhat overlooked during general birding, because most observers tend to focus within 20-100 m around them. Early in their survey programme Rao & Menzies visited the known Namdapha NP sites to familiarise themselves with the species's appearance and behaviour in NE India. Patgiri has not seen the species but in discussion pre-survey was aware of the need to look at the limits of lines-of-sight given the likelihood the bird would flush as soon as it saw people. Both teams' lack of direct observation suggest rarity at, or absence from, other stretches of stream comparable in habitat and human activity levels to those they surveyed. This conclusion is corroborated by the absence of informants telling of regular encounters with the bird. Poorly executed discussions with local people are one of the banes of wildlife status assessment, but in this case the risk is of over-assessing White-bellied Heron prevalence, because there are various similarly shaped species in NE India, some of which are widespread and locally common although not, mostly, in habitats typically perceived as regularly used by White-bellied Heron. That informants were mostly disavowing any encounter with 'White-bellied Heron' suggests that they were not confounding other species into their answer, and that it is genuinely rare in (or absent from) the surveyed stretches. Many elementary errors are made by many interview survey teams, such as selecting inappropriate people for discussion, allowing insufficient time for rapport-building to encourage 'genuine' rather than expedient replies, handling issues of sensitivity over law-breaking, etc. In this case, White-bellied Heron has such a low profile that it is implausible that respondents would routinely have suppressed its occurrence, and the teams were sufficiently experienced in the basics to avoid common pitfalls.

In sum, it is implausible that White-bellied Heron was routinely being overlooked by these surveys' direct searches and local interviews. Deeper consideration of the implications of this leads to even further concern: informants typically answer for their entire area of regular activity. Thus, White-bellied Heron seems to be effectively absent from everywhere for which these interviewees were answering.

Based on this conclusion, particularly in the light of the geographic spread and sheer number of sites of the Rao & Menzies survey, there seems to be no point looking for new regular-use White-bellied Heron sites in India by asking around among local people or investing any serious direct search effort in places regularly visited by people. There may be case-by-case exceptions: in central Bhutan the species lives (and nests successfully) close to agriculture and even villages, likely because here the direct persecution of the species is negligible. The species is accordingly relatively

bold in central Bhutan compared with its behaviour in India and Myanmar, where, as inferred from its behaviour, it is presumably at much higher risk of being killed by people. Perhaps such 'benign' human communities exist somewhere in Indian White-bellied Heron range; and if they do, such areas may offer among the best opportunities for long-term in-situ White-bellied Heron conservation. But the onus should be on any future survey intending to look for White-bellied Heron in areas of regular human use to explain why it would be any more likely to find the species in such an area than were the two dry-season 2017-2018 surveys.

Under no conceivable scenario would resources be available for surveying all areas that hold superficially suitable habitat for the species. Any survey from now on in the name of WBH conservation must choose sites, methods and personnel with the highest likelihood of finding it. For comparison, in northern South-east Asia, there are multiple species (i) as low in population as (or even lower than) White-bellied Heron, and (ii) as or more difficult to locate in new areas, reflecting industrial-scale trade overlying cultural predisposition for hunting, which results in levels of offtake probably far higher than in any but a handful of places in India. Experience from these parts of northern South-east Asia shows that multiple, failed, attempts to find a species increase the difficulty of securing future funding and other resources to look in new areas for the same species.

OBJECTIVES

Over 16–18 February 2019 a small number of people gathered with the primary aim to prioritise spatially, within India, future survey for White-bellied Heron. It was apt also to review methodology and other aspects relative to maximising the effectiveness and efficiency of future White-bellied Heron surveys, wherever they would be located.

The geographic scope of the meeting was Arunachal Pradesh, Assam, West Bengal and Sikkim.

Claims of the species in India outside North-east India (including West Bengal) are likely to be in error, except potentially three claims from Odisha but even those sound dubious given that the birds were in rice paddies, and all stemmed from one observer (BirdLife International 2001), so they are here not considered further. The focus of discussion was on finding localities that hold White-bellied Heron regularly; there is little conservation value in finding one-off records of the species because it is unlikely that anything feasible can be done there to contribute to the species's conservation.

Except where explicitly indicated otherwise, statements in this document about White-bellied Heron, areas, threats etc. refer only to North-east India, not to the species's global range.

The meeting was not concerned with the vital topic of conserving the species where it is already known to occur; this would have involved a rather different set of people and considerably expanded the time necessary.

The meeting was held at the Indian Institute of Bank Management, Guwahati, Assam, India. Participants are listed in Appendix 1.

METHODS

The current distribution of localities with regular presence of White-bellied Heron presumably results from the interaction of (i) the distribution of intrinsically suitable habitat with (ii) human activity, with the latter preventing occupation of some of the former. A cursory look at topographic maps of North-east India shows an abundance of superficially suitable habitat for White-bellied Heron, with huge heterogeneity in human population density. There are various possibilities for how to propose where to look for White-bellied Heron within this vast area. Ecological Niche Modelling / Species Distribution Modelling approaches are now widely applied using a range of computer programmes, but were rejected because they would be likely to produce misleading predictions (Appendix 2).

The approach instead was to 'model' through thinking and discussion, using the combination of information and insight in the room. This allowed explicitly but subjectively to account for 'deficiencies' in the 'dataset'. Combining opinions with the information (facts) introduces the risk of error. This risk was reduced through discussion. All the risks and difficulties identified for computer modelling (Appendix 2) are relevant to this in-the-human-head approach as well, but they are more easily dealt with by this approach (provided the right heads are present in the room) than by computer modelling.

Google Earth was used as the primary source of spatial information, with occasional reference to other programmes such as Bing Maps. The first stage was to examine two landscapes known to hold the species regularly, with people in the group able to provide considerable context: Namdapha NP and central Bhutan. Similarly, an effort was made to define areas with no records but with observer coverage sufficient to allow reasonable confidence that they do not hold the species regularly. Distinguishing within the large 'white areas' of 'no records' between which are 'no information' (observer effort has been insufficient to determine whether the species is there or not) and 'absence' (observer effort has been sufficient to believe that the lack of records reflects a genuine absence of the species) is very helpful in the process.

The sites of occurrence and of presumed absence in these landscapes were examined on the aerial imagery, site by site, and the characters of river habitat, surrounding habitat, and human presence discussed as a group. Sequentiality of examination was flexible, with many cases of checking back at earlier examined sites. Apparent contradictions between the sorts of sites occupied in the two landscapes (Namdapha NP and central Bhutan) were discussed in detail. Next, the recent locality records from Myanmar were examined similarly, mostly without anyone in the room able to provide

deep insight, with a particular focus on any sites that seemed surprising in the light of what had been seen for Namdapha NP and central Bhutan. Following this, the historical records from across the range were examined. Most of these have considerably less spatial precision than the modern records, so for those in 'surprising' sites examination was made of the surroundings, to a distance appropriate for the era, for what might reasonably have been referred to under the locality name to see if there was any 'less surprising' habitat in the vicinity. Historical absence could rarely be inferred: indeed, the first records in the three main landscapes today were not made until the 1990s, even though, presumably, the species occupied them throughout the period of historical bird recording.

Intermixed with examination of locality records on aerial imagery, many topics were discussed in depth. These included the roles in determining current White-bellied Heron distribution of historical human pressure (which might leave little signature on Google Earth) versus current human presence; how to handle potentially serious factors leaving no obvious signature such as fish stock health (either 'natural' or depleted by overfishing); the plausibility, or otherwise, that various factors are relevant to White-bellied Heron current distribution; the inconsistent relationship, range-wide, between human activity-level as visible on aerial imagery and effects of human presence on White-bellied Heron, reflecting various factors, including major differences between ethnic groups in hunting traditions and the different consequences for White-bellied Heron; and, a particular aspect of this, whether anywhere in Indian White-bellied Heron range might there be an area comparable to central Bhutan where the species could live in close proximity to people.

The group then split into two. Most of the group discussed factors relevant to White-bellied Heron survey other than localities. R. J. Timmins (RJT), the process specialist, worked solo to examine most of North-east India by eye for areas where White-bellied Heron might plausibly still occur regularly (hereafter, 'WbH polygons'). These were defined as areas which contained inherently suitable river-channel habitat, and had within them minimal signs of recent human activity, over a large enough area, that plausibly they could support several pairs of White-bellied Heron, and that there was enough river length below 1400 m for such a population. Only Arunachal Pradesh, Assam, West Bengal and Sikkim were covered. Based especially on Myanmar localities, suitable habitat, with low enough human use for White-bellied Heron to persist, may well occur in other states of North-east India, but cursory inspection gives no obvious reason to consider that anywhere in these states would have areas of higher survey priority than those identified in Arunachal.

The group reconvened for RJT to present his predictive map and discuss, polygon by

polygon, the reasons for its selection and its possible priority for survey relative to other polygons, involving group discussion of the results. This led to the proposal of a small number of 'priority survey polygons'. Next, the various localities of recent North-east Indian White-bellied Heron records from the heavily human-used Brahmaputra plain were examined on the aerial imagery in the light of the foregoing, of historical records from this area, and of the indications from Bhutanese tagged young of dispersal from the natal area.

The process closed with some reprise of the earlier discussion about what would be needed for credible survey of the priority polygons, and a review of group opinion as to whether there seemed sufficient likelihood of finding White-bellied Heron in the priority polygons to warrant mounting surveys in them.

After the group dispersed, RJT reviewed and, where apt, modified the WbH polygons to reflect discussion during the group session, and the information received to reduce a number of information gaps that had become apparent during group discussion.

The process was experimental in that it was the first meeting-setting use of an informal approach developed since the early 1990s by RJT in Lao PDR and surrounding countries used to select survey areas and routes for a large number of little-known and rarely encountered species. Previously he has used it alone, for a variety of species, although taking copious input from people with experience and insight of the species and areas in question. Excellent ability to 'see' habitat and human activity levels from aerial imagery is essential.

RESULTS

Determinants of White-bellied Heron current occurrence in North-east India

Between them, people in the room were familiar with all written information on White-bellied Heron (notably WbHWG 2017), had seen and/or surveyed for it across much of its range, and had discussed with others not present at the meeting the latter's observations and thoughts of White-bellied Heron. All this insight was used during the process. Within broadly suitable rivers, human use was assumed to be far more important in determining current White-bellied Heron regular occurrence than was precise variation in channel habitat. No targeted hunting of White-bellied Heron is believed to occur but the markedly shyer behaviour of birds in India than in Bhutan indicates their awareness of risk from people. This presumably stems from occasional low-motivation, opportunistic shots. With the naturally low density of White-bellied Heron, even a low level of killing may threaten the population, yet people could honestly state 'we don't hunt White-bellied Heron [as a matter of course]'; the relevant question is 'has anyone here ever tried to kill a White-bellied Heron?' Essentially any path, patch of cultivation, or other sign of recent human incursion visible on Google Earth was assumed to lower the chance of White-bellied Heron occupation.

The species was assumed to occur from the plains readily up to 1400 m, potentially a little bit higher, but was assumed not to occur regularly much over 2000 m. The upper limit is speculative, with no hard information that higher altitudes are not used.
For regular presence, the species was assumed to require rivers, not merely standing surface water.

Totally non-canopy-breaking rivers are not proven to be suitable for regular use, but rivers alternating canopy-break with closure were presumed suitable. Minimum suitable river width was taken to be 5–7 m.

Very fast rivers were proposed as unsuitable but examination of Google Earth showed that even the rivers evidently fast in much of their length have reaches and margins where flow is slow enough for sandbars to form, indicating that it is unlikely that any river is everywhere too fast for White-bellied Heron. However, the higher the proportion of very fast water at depths suitable for White-bellied Heron to forage, the lower is likely to be the linear density of White-bellied Heron there.

Suitable in-channel habitat was expanded from the 'classic' rock-dominated channel, whether as exposed fixed rock or as mobile sediment up to boulder size, to include streams with merely some occasional rocky presence. Wholly sandy channels did not really occur within land-uses taken to be compatible with regular White-bellied Heron presence (see below).

Home range per pair (length of river required) was assumed to vary considerably between different types of river but to lie somewhere in the 2–10 km range, with birds assumed to be readily capable of flying between streams for up to 10 km or so.

Non-channel habitat was assumed to be largely irrelevant to White-bellied Heron suitability directly, but of high importance as a correlate of human activity: areas with substantial obvious recent forest encroachment were deemed unsuitable (see above). Ruggedness of terrain was not directly used as a factor, although all areas of minimal human use are in somewhat to highly rugged terrain.

Some potentially serious determinants of current occurrence are not visible on Google Earth, nor are any correlates of them: fish stocks (a product of natural potential and the extent, if any, of overfishing); many forms of human activity where they ceased a few years ago or earlier; pollution; and cultural differences between ethnic groups in attitudes to wildlife.

White-bellied Heron survey polygons

Overview

A total of 21 WbH polygons, where White-bellied Heron persistence was considered plausible, were defined. The overview map (Fig. 1) shows that they form an arc from Namdapha NP anti-clockwise up past the River Lohit, and a scatter west across Arunachal Pradesh. The 'Eastern Arc' polygons (Lohit 1 to Digaru) are listed first, followed by the remainder (Upper Siang to Subansiri). Despite the relative wealth of historical White-bellied Heron records from Assam (today's boundaries) and West Bengal, no WbH polygons were defined in them, reflecting their high human populations and only small areas of low human activity. This should not be taken to mean that the species no longer occurs regularly in these two states, merely that it is less likely that it occurs regularly enough and in large enough numbers at any localities in them for locality-based conservation implementation to be as worthwhile as in those WbH polygons found to contain the species. Similarly, the species might survive within the remaining states of North-east India: Meghalaya, Nagaland, Manipur, Mizoram and Tripura. These were not considered in full in this process, because rapid examination indicated a lack of large landscapes with minimal signs of human activity. If, however, there are regions with attitudes similar to wildlife of those in central Bhutan, or even those of the Lisu in Namdapha, White-bellied Heron could persist in these states: there is a lot of low-human-sign habitat. However, this process could not stratify across these states for likelihood because the main relevant factor (human attitude) does not show on aerial imagery. This same factor means that it is possible White-bellied Heron might survive in places outside WbH polygons of Arunachal Pradesh, Assam, Sikkim and West Bengal if there are large pockets of benign human behaviour.

Each polygon has an outer boundary of the 'maximal potential currently suitable WbH area', and most have an inner 'core search area', where occurrence is most likely and searching should be focused. The lowest priority polygons do not, because no area within them would be the equivalent to the core area of the other ones. Polygons to the west of Mouling NP were held to somewhat lower standards then were those to the east; none has an inner core search area. Polygon names are given merely as convenient, memorable, labels; for example those named after protected areas do not have a boundary congruent with that of the eponymous protected area. Fig. 2 shows a number of the polygons in greater detail than in Fig. 1.

Polygon details

Lohit 1 polygon

This polygon has a number of features strongly predicting the occurrence of White-bellied Heron. It has two long main branches each of over 15 km (and each with over 10 km in the core), and lots of length below 1000 m. Although it lacks broad, long gravel bars like on big 'typical' rivers, many White-bellied Heron locality records in Bhutan and Myanmar do not have those either. The polygon is very rugged: while this was perceived by some as hindering survey, it is the main reason to predict that it may genuinely be very little visited by people and thus be particularly likely to retain good numbers of White-bellied Heron. It is close to Namdapha NP and there may be exchange of birds. In April 2019, after the conclusion of this workshop, a camera-trapping project focused on monitoring tiger populations revealed a picture of a White-bellied Heron at a location within the Lohit 1 polygon (see https://timesofindia.indiatimes.com/city/itanagar/search-for-tigers-leads-to-critically-endangered-white-bellied-heron/articleshow/69110512.cms, https://www.synchronicityearth.org/lights-camera-heron/), which was an encouraging find.

Tidding polygon

Based on the River Tidding. The main Tidding valley has signs of people,which attenuate upstream, although people might also enter the valley from theBrahmaputra plains to the west. Broad, gravelly, boulder-strewn stretchessimilar to Namdapha NP show high channel suitability, although the proximity ofsigns of human use mitigates against continued White-bellied Heron occurrenceof the potentially most suitable main valley; hence this part is outside thecore area. The catchment is large, with two main core-area river stretches. Upto 1400 m it still looks really suitable. A major branch looks suitable even above1400 m: a broad, braided, relatively low-gradient section for 8.5 km betweenabout 1550 and 1750 m. This would increase even more the polygon's suitabilityfor the species, if it use areas at such altitude. Gentler terrain than Lohit 1in its lower reaches means that it is likely to be more entered by people. Itis close to Namdapha NP and there may be exchange of birds.

Kamlang polygon

Above 600–650 m this polygon loses the human influence that is obvious lower down. There are no very broad braided sections but an 8.5 km section over 1100–1600 m has an overall low gradient and an average width of around 25 m. Its catchment is broadly comparable in size to Lohit 1 and Tidding. Recently it has been included within a Tiger Reserve, which will help reduce human access. It is close to Namdapha NP and there may be exchange of birds.

Dibang 1 polygon

The big river valley well to the west of this polygon has a lot of human influence, as does a main river valley to the east which seems less likely to affect the upper reaches in this polygon. A broad and gentle valley emerges from the polygon but upstream in the hills, visible human signs disappear by 500 m. Channel habitat along the lower mainstream is broad and braided for 12 km (and there is additional similar habitat in the lowest reaches of three tributaries) and relatively low gradient; but because this might mean access is easy, it is excluded from the core area. The catchment area is similar to those of Tidding and Kamlang, and is probably larger than that for Lohit 1. The core area length is, conservatively, probably slightly less than in each of these other three polygons, although total suitable habitat is potentially highest of the four. However, the surroundings to the west and south are occupied by the Adi people, who are supreme hunters and fishers. This introduces uncertainty into predicting the polygon's suitability for White-bellied Heron. If the Adi go routinely 30 km through forest (as do many hunting groups in Lao PDR and Viet Nam), White-bellied Heron might already be absent from the polygon. Before White-bellied Heron survey of this polygon, further information is needed about where significant hunting might have occurred in the polygon, and which other hunting-sensitive species are known to persist in, and which are known to have been eradicated (or nearly so) from the area.

Dibang 2 and Dibang 3 polygons

These two smaller polygons, with considerably smaller catchments than, and lying one each side of, Dibang 1, seem lower priority for survey than Dibang 1. Their proximity to Dibang 1 further bolsters its potential, as providing an even larger area of potentially suitable habitat then does Dibang 1 alone. Dibang 3 is more likely to be seriously hunted than is Dibang 2 because it is closer to Adi communities; as with Dibang 1, careful reconnaissance is needed before deciding whether these polygons warrant survey for White-bellied Heron.

Talo polygon
From about 700 m for over 15 km there are only very sporadic signs of human occupation to 1200 m. Above this, in the core area, there appears to be no evidence of human occupation. The mainstream has a larger catchment than any so far, but this is largely all in the headwaters of the mainstream, and there is limited amount of suitable tributary habitat. At the lower altitudes assessed as typical for White-bellied Heron the tributaries are, mostly, small and steep. It holds at least 20–25 km of potentially suitable river including that outside the core area. There are no very broad braided sections, in contrast to Dibang 1 and Tidding. The core area has a wider channel than any of the streams so far outside braided sections. A stream to the southwest, outside the polygon, and flowing broadly parallel shows many visible human signs, despite a lack of obvious access-related reasons for this difference. The Talo polygon is not within known Adi range, but could possibly be hunted by them; presently it is believed that they are not in there. This needs to be checked carefully before committing to survey this polygon for White-bellied Heron. Google Earth shows several locality names within the polygon, but because none of these matches any signs of human occupation, these are assumed to be mis-located (which occurs commonly on Google Earth), or to be long abandoned. The few visible human signs within the polygon suggest at most a few very scattered and isolated households; nothing suggests actual hamlets, villages or other forms of 'settlements'. This needs specifically to be checked during reconnaissance.

Lithu 1 and Lithu 2 polygons
These two polygons might retain White-bellied Heron but are not survey priorities because each contains only short total lengths of superficially suitable river, mostly above 1000 m. If White-bellied Heron is found to make regular use of areas well above 2000 m, then Lithu 1 could have considerably more significance for the species, because this large catchment has a significant river length with good gradient and width characteristics from 1600 to 2400 m. Lithu 2 is a small catchment with a relatively narrow river all above 1000 m.

Digaru polygon
Of all the small catchments draining direct to the plains, this has the most suitability. Visible human signs drop off around 500 m, with river channel habitat superficially suitable for White-bellied Heron running up to 1400 m; however the low gradients of the lower reaches make it likely that the area is used by communities in the foothills on the edge of the plains. This reduces its survey priority. This is exacerbated by its small size: it could hold 1–2 pairs, whereas

the big polygons might have space for a dozen or more. Thus, if they hold the species at all, these bigger polygons are likely to offer greater conservation opportunities.

Upper Siang polygon

This polygon's suitable habitat starts at around 800 m and rises relatively rapidly thereafter, with the core area stretch starting around 1200 m. On the imagery, the polygon's main river is in shadow, hindering assessment of its characters. Its catchment is smaller than that of Lohit 1, but still big enough that it should be fully canopy-breaking. The headwaters of several other tributaries in the polygon create a larger habitat patch. There are no broad relatively low gradient stream sections, reducing its suitability for White-bellied Heron. Minorities in this area include Buddhists, which might suggest relatively low hunting, but a lot of others are there and, overall, hunting may well be high. The catchments to the south all have obvious human influence, even well upstream.

Mouling NP polygon

This polygon is comprises five catchments. Many flow east into the Siang, but one flows south-west to the Yanggang Chu. The northernmost, east-flowing, system has a large catchment significantly larger than that of Lohit 1; the west-flowing system is roughly comparable to Lohit 1; and the other three are much smaller. The main rivers west, south and east of this polygon are heavily settled. The polygon's rivers have visible human signs up to, mostly, 400–650 m, but to 700 m in the south-west one. The northern-most, east-flowing, system has at least 20 km below 1400 m and the west one at least 10 km, giving a large total length in the polygon. While the habitat is promising, there are Adi living to the east, and a recent bird survey overlapping the eastern part of the polygon, had only one hornbill record in the 70 km walked (suggesting bird hunting is heavy in the area), and few birds in general. This depresses the relative priority of this block, even though it is so big. Further details, preferably GPS track-logs of this recent survey would help assess the value of surveying the polygon for White-bellied Heron; if this recent survey went well into the block then it might be sensible to delete this as a WbH polygon.

Silon polygon

The Silon polygon is a small catchment with three main tributary valleys, with visible human signs up to 550 m. Its main river averages 20–30 m wide for much of its length below 1400 m. How far serious hunting extends in from margins is unclear but it seems unlikely to be as high as in Adi areas. It is rather isolated

from all other polygons and should be prioritised fairly low.

Kurung Kumeey polygon
Although a relatively large catchment, potential habitat does not start until 900 m and rises quite steeply thereafter, with relatively short lengths of stream below 1400 m. It is not close to any other polygon. Its small size and isolation give it a low priority. Because of the relative proximity of human occupation no core area is designated.

East Kameng 1, 2, 3 polygons
Each of these three polygons starts at over 1000 m, comprising three separate headwaters with the main and middle streams fairly settled by human communities. The catchment for East Kameng 2 is relatively large, but the other two are small, although all are canopy-breaking. Thus, if White-bellied Heron occurrence really does attenuate soon over 1400 m, the rather short total river length below 1400 m suggests that the cluster is rather marginal. Moreover, it is isolated, particularly given that in east Bhutan there is no evidence of regular White-bellied Heron occurrence. Communities here probably hunt fairly intensively. So, overall, these three polygons have a low priority.

The Pakke Tiger Reserve polygon
Pakke TR is one of the most surveyed and researched protected areas in Arunachal Pradesh. There is no evidence of White-bellied Heron occurrence. However, most of the observer activity to date has been in the southern part, adjacent to the Brahmaputra plain. Extensive suitable habitat in the protected area has apparently never been checked by anyone likely to identify a White-bellied Heron regularly given the observer effort there to date. Moreover, the lack of records perhaps suggests that the species does not now inhabit the interior, given that in Namdapha NP there are occasional records of White-bellied Heron in sites that have high observer cover but are not occupied consistently. Pakke TR has a number of options open to few other polygons. Camera-trapping has been intensive, but has covered only 40% of the area; it is believed unlikely that if White-bellied Heron had been camera-trapped it would have been overlooked. A map of camera-trap stations and GPS tracklogs of patrol routes would be useful in clarifying extent of coverage to date relative to potential White-bellied Heron streams, and thus the polygon's survey priority. There could be a role to give the patrol teams a major awareness drive over White-bellied Heron, coupled with compact zoom cameras to take on their patrols.

Subansiri Polygon
This polygon has a high total length of main river without evidence of people. It comprises several smaller catchments, mostly at low altitude. Even some tributaries exceed 50 m. Two rivers are about 25 km long within the polygon. West of the polygon human activity is high, but there is a surprisingly big block of forest in the polygon's central area with little visible evidence of people. Google Earth shows a village called Rotom in this 'non-degraded' area; a village of this name indeed holds recently immigrated permanent residents. They farm using slash-and-burn, but none of this is visible at the Google Earth location for the village, suggesting that the name may be mis-located. Recent expeditions have been made into the area for fixing tribal boundaries; tracklogs of people who have been in to these forest villages would be of great use in planning. Apparently, people go right throughout the forests hunting, so the polygon's western 'bulb' is probably not any sort of survey priority. The eastern part has similar ethnic groups, and while its lower and gentler terrain probably makes it intrinsically better for White-bellied Heron, it makes it more accessible to visiting people too.

Two polygons around Namdapha NP
Following the criteria used to define the White-bellied Heron polygons, two areas of Namdapha NP additional to those with White-bellied Heron records emerge as comparably suitable to the above polygons. To the knowledge of the group, these are seriously under-surveyed. In the course of conserving White-bellied Heron in Namdapha NP, they should be surveyed. But at this stage, resources for finding White-bellied Heron in new areas should look at other polygons.

Priority survey polygons

A polygon's relative priority for survey reflects its potential contribution to the species's conservation, including the likelihood of finding the species, the likely carrying capacity of the polygon, and its plausible population now. The process did not consider fully the differing practicalities of conservation in the respective polygons, because these are less easily predicted from the imagery, reflecting factors such as insurgency and local attitudes. These should be considered during reconnaissance before a polygon is searched (see below).

Features used to increase a polygon's survey priority were larger size; greater ruggedness; longer extent of superficially suitable rivers; greater proportion at lower

altitude (particularly below 1000 m); smaller human population in the neighbouring area; proximity to other polygons, especially large ones; and various polygon-specific factors. The overall priority of each polygon was assessed by subjectively weighting the factors. The extent of human access was not highly considered at this stage because the polygons had been defined already to include only areas of negligible visible human signs. Because considerable human activity, notably hunting, could occur without leaving signs visible on Google Earth, the prioritisation of polygons needs to be reviewed when such information is available, such as through reconnaissance visits.

The 'eastern arc' from Lohit 1 anticlockwise to Digaru comprise a relatively close-together set of polygons, close to Namdapha NP at one end, giving in total a large area of potential White-bellied Heron habitat with little visible human evidence. All the polygons west of the eastern arc are somewhat, to much, more remote from other polygons, and thus lower in survey priority. Even the large Upper Siang polygon is of lower priority than are all the big eastern arc ones including Talo. As well as the known regular presence in Namdapha NP, there are recent records from the eastern arc (or nearby) of two birds at Mehao Lake (13 May 2014) and a single at Maguri Bael (October 2015).

Within the eastern arc, five polygons stand out as particular survey priorities: Lohit 1, Kamlang, Dibang 1, Talo and Dibang 2. Lohit 1 is the top priority: large, rugged, long total river length, probably not visited frequently by Adi hunters, close to Namdapha NP and other polygons. Despite presence of WbH being confirmed in Lohit 1, it is still a first priority to establish a better understanding of the species status in that polygon. If Lohit 1 clearly supports a noteworthy local population of White-bellied Heron, then Kamlang is the next priority, but if unexpectedly few White-bellied Herons are found in Lohit 1, the priority to survey Kamlang needs to be reconsidered and additional factors evaluated to attempt to explain the divergence from predictions. Dibang 1 looks very good on Google Earth but may already have suffered hunting levels too heavy for White-bellied Heron: further information is needed to determine whether it is a priority survey polygon. Assuming that it is, the other two priority survey polygons, Talo before Dibang 2, offer somewhat less hope to hold the species than does Dibang 1. Fig. 2 shows a number of the polygons in greater detail than in Fig. 1, including all the priority five.This prioritisation is not intended to imply that the other polygons are unlikely to hold White-bellied Heron: that description fits the mass of land outside the polygons. Ifthere is any low-cost opportunity to search for White-bellied Heron in any of the polygons it probably should be taken. However, high-resource multi-month surveys specifically seeking White-bellied Heron should search the priority survey polygons first, because they are assessed on current

knowledge as having the best chance of a positive result. Even a few failed intensive searches for new localities regularly holding White-bellied Heron will hinder raising the resources for further such surveys, particularly in the same polygon. The prioritisation presented here is preliminary and new information may warrant change to it: the important thing is that intensive surveys select the polygons believed at the time to have the highest chance of holding White-bellied Heron and thus the highest chance of producing a positive result.

The rest of North-east India

If 'low-cost' opportunities for potential White-bellied Heron assessment anywhere in North-east India become apparent, they would be worth consideration, but it would be essential to communicate to all parties that these are opportunistic and a failure to find the species in such areas by such survey style should not prejudice the viability of full-scale searches (see below) in the identified WbH polygons. Continued highlighting to any surveyors, naturalists, protected area staff, research biologists, and indeed anyone capable of identifying a White-bellied Heron, in these areas to stay alert to the possibility of White-bellied Heron remains important. Indication of a substantial area inhabited by people potentially resembling those of central Bhutan in attitude to wildlife might urge for at least a reconnaissance even if habitat and human use look highly suboptimal on aerial imagery.


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Aspects of survey implementation

Scale of the survey and adaptive survey planning

The requirement to enter remote areas and spend considerable time within them (2–3 months for the larger polygons) requires an approach very different from White-bellied Heron searches so far, which have involved, at maximum, few-day forays into areas with which local people are familiar. To cover each WbH polygon properly, a full-blown 'expedition' is required, with many support staff and careful planning. Budgets need to be adequate that neither safety nor coverage are compromised. If a survey is poorly planned and it becomes clear that the whole polygon cannot be covered in the time available, it is vital to cover only a proportion of the polygon, but at the planned intensity. It is important not to rush to achieve complete spatial cover but at insufficient intensity because then if the specie is not found, it has plausibly been overlooked, and repeat visit will be needed.

Value of a reconnaissance visit

The typically rugged terrain and the fact that – by definition – few if any people are highly familiar with the polygons' interiors means that a separate reconnaissance visit to the area surrounding the polygon is essential. By discussing current levels of human activity across the polygon, checking possible security or other issues, selecting access routes, identifying suitable local people for support roles, agreeing a broad schedule and otherwise planning at the local level, it should be possible to increase the proportion of the survey time in parts of the polygon most likely to hold the species. If a reconnaissance shows the polygon to be consistently and widely visited by people for any purpose (that is, a situation contrary to that predicted from Google Earth), or one in which follow-on conservation activities would be difficult to undertake, it will probably be sensible to transfer the intended survey effort to a different polygon. If local people seem unfamiliar with the species this is not a negative sign because – by definition – they should not be particularly familiar with birds in the polygon's interior. Even the reconnaissance should use a GPS set of crucial river points and lengths to visit as assessed from aerial imagery and maps, to help discussion focus on the important sites within the polygon.

The reconnaissance should be preceded by detailed inspection of the polygon on Sentinel imagery. Although Sentinal 2's images are 10 m resolution (Google Earth is around 1m resolution), they allow current examination (typically within the last 6 months –or shorter) of human use patterns to complement the detailed but often outdated imagery on Google Earth. Use of Sentinel was considered during this meeting

but would have considerably lengthened the process if applied to all polygons. It seemed overall better use of resources to delay such intensive inspection until there is a clear commitment to survey a polygon, subject to no unexpected negative indications from inspection of Sentinel and a field reconnaissance.

The imperative to maximise time in the parts of the polygons most likely to hold White-bellied Heron

The polygons have defined the group's best prediction of where the most likely landscapes are in which to find regular presence of White-bellied Heron where it is not currently known. But the likelihood of finding the species is not uniform across the polygon in question. All other things being equal, the interior, being more remote from sources of people, is more likely to hold the species than are the parts of the polygon closer to its 'border', which, although shown as a line on the map is unlikely to represent a step-change in chance of seeing the bird in reality. Every effort should be made to maximise the proportion of time within the polygon that is spent in its core's most remote areas that hold suitable rivers. Using rivers for access into the polygon's core may be sensible (more time in rivers means more chance of finding White-bellied Heron), but if a through-forest route would allow substantially faster progress towards the interior, where chances of finding White-bellied Heron are higher, then it will usually be preferable to take it.


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Mobile surveying

Several surveyors made the point that walking along typical White-bellied Heron rivers is sometimes impossible, and frequently hazardous and slow: under such conditions so much time is spent looking down at one's feet that any White-bellied Herons in the area are likely to be flushed without being seen. Similarly, forest vegetation can be too dense for an observer walking along the stream to see the bird (at least, well enough

to be confident of identification). In these cases, viewpoint surveying is needed (see below). Whenever walking along streams, even in areas of low predicted likelihood of finding White-bellied Heron, the surveyor should go first, with all support staff following some distance behind. Relative fitness tends to result in support staff leading surveyors, unless continuous care is taken to prevent this. Himadri Sekhar Mondal observed sometimes that a White-bellied Heron flushed in Namdapha NP might not return to that stretch of river for two or three days. The negative consequences of allowing the wrong people to lead may therefore e profound.

GPS tracks should be collected for all mobile surveys so that survey effort is well understood during interpretation of results.

Viewpoint surveying

Where it is not sensible (unsafe, or poor viewing conditions) to walk along the river in areas where it is important to look for White-bellied Heron, static watches must be used. They should also be part of survey even where streams are readily walked along, given the species's shyness in North-east India. The observer should select a good viewpoint, suitable for all-day (dawn to dusk) watches for several successive days. It should have views along the channel as far as possible (at least 200 m) preferably in more than one direction (confluences may be particularly good, allowing potentially three directions) and wait observantly. Viewpoints can be any height over the water depending where the best view is obtained: they can be amongst river-level rocks, atop cliffs, or anywhere in between. Given the shyness of White-bellied Heron in North-east India, the surveyor should be camouflaged with branches and leaves, and all support staff should be within forest or otherwise invisible to birds in or over the channel; it is essential that they are not visible in the channel for several kilometers up- or downstream of the watchpoint. Sonam Tshering advised, based on experience in Bhutan, static watches should last five days before giving up and moving elsewhere. S. Patgiri's local informants around Mehao WS also suggested spending several days at such viewpoints. Considering White-bellied Heron territory size, viewpoints should ideally be spaced about 5 km apart but flexibility is needed given the scarcity of high-quality viewpoints for forest streams: it is better to move 3 or 8 km to a good viewpoint than to spend five days in an inferior position chosen because it is 5 km from the last. Plausible viewpoints should be selected (through clear potential to see along the channel a long way) from satellite imagery before beginning the survey, not through field searching or asking local people.

Given the resources necessary to survey in the interior of priority survey polygons, it may make sense to have two or even three surveyors active simultaneously at different

viewpoints rather than one surveyor covering them all sequentially and thus requiring the full team in the field for two to three times as long.Adding in other methods to boost chances of finding the birdSeeing White-bellied Heron where it is shy requires an element of luck. This is the more so, the shorter the survey. Lengthening the survey to reduce the element of luck costs concomitantly more. Therefore, it is worthwhile to experiment with ways of boosting the chance of an encounter, and with other methods that can be run simultaneously.

Camera-traps could be set looking along valleys, set to fire periodically (likely to be somewhere every 15 seconds to every few minutes, depending on the conditions). Camera-traps are usually set to be triggered to fire by a movement, but requiring a heron to trigger the camera would remove the chance of photographing the proportion of birds too distant to trigger the unit. To maximise battery life, the flash should be tuned off, and the camera set to photograph only during a clock window corresponding to daylight. Under such conditions the batteries are likely to last 4–5 days. Aiming the cameras along the streams would increase the chance of photographing birds over aiming them across the watercourses. Identification of flying large birds photographed will sometimes be impossible, but sometimes may be possible: the method has not been trialled yet.

White-bellied Heron is territorial in at least some of the breeding season. Placing a model White-bellied Heron at a readily visible place in suitable habitat could result in White-bellied Herons using that stretch coming to investigate. Effective use of decoys to bring down flocking birds (such as ducks, pigeons and non-breeding cranes) is commonplace, and L. Peske knows of success in situations comparable to White-bellied Heron, such as with breeding-season cranes; using sound playback to lure out territorial birds is also often effective. The decoy would need to be readily portable, relatively robust, and repairable. It could be placed by a static viewpoint, or coupled with a camera-trap.

White-bellied Heron makes various relatively far-carrying calls, particularly for breeding display and when aggressive. All surveyors should be familiar with these calls. Two recordings are held on Xeno-Canto (https://www.xeno-canto.org/species/Ardea-insignis) but are currently restricted access. The RSPN White-bellied Heron programme has multiple recordings of the species.
Drone use is currently restricted by two major factors, the need for permits and the weight of batteries needed for substantial flight time. During walking surveys a drone could come in useful for checking occasional small inaccessible parts of river, including complex braids as well as stretches where no access to the river is sensible. Drones could play some role in reconnaissance visits given that 10–15 km from the

observer could be achieved. There is also the risk that a drone, as an unfamiliar object, might flush a White-bellied Heron unseen by the observer that would not come back to the general area for 2–3 days.

Other ways to increase the chance of a positive record may well exist.

Survey season

Location of breeding White-bellied Herons would show particular value of a polygon. Surveying the polygons will be challenging and requires attention to safety. Wet-season survey, May to September, is particularly risky in remote areas. White bellied Herons tend to settle in breeding sites during February. This gives a good overlap of the possibility to see signs of breeding without wet-season survey risks: into April, even May in years with a late start to the wet season. Sightings of birds carrying sticks are not conclusive of nesting, because subadults may sometimes do this; however, such sightings should be followed up to establish flight line and destinations if possible. Provisioning the nestlings requires regular nest visits and is the easiest time to prove breeding, although it is typically most visible in the early wet season. It seems likely that birds may habitually bring food from 5 km or more from the nest. Many White-bellied Herons have a clear winter home range, within which threats can also operate. Hence, surveys during the early and middle dry season (November, even October in years with an early start to the dry season, to January) are also important. At least some reconnaissance visits could occur during the wet season, freeing up the dry season for interior survey.

With an estimate of 2–3 months to survey a large polygon effectively, a surveyor is likely to be able to cover only two large polygons per dry season. It is important to avoid the temptation to try to squeeze in more, by shortening the time per polygon.

Other avenues to maximise the potential for finding previously unknown White-bellied Heron localities

In addition to directed surveys of the identified polygons, to maximise the chances of finding new localities it is important to maintain continuous communication with protected area staff, birders, surveyors and research biologists going into North-east Indian forests. Crucially, this includes communicating the habitat insight from this meeting, showing that the species uses a much wider range of stream types than currently perceived as typical for it in India (see below). This understanding, based particularly the historical west Myanmar localities, indicate that it is highly likely that the species once occurred regularly throughout North-east India's forest rivers,

including south of the Brahmaputra.

Camera-trapping is intensive in parts of North-east India. Non-target species are often given little attention. As mentioned above, examination of a fresh set of camera-trap results just after the meeting revealed White-bellied Heron at a locality in one of the priority survey polygons, in a location that previously was not suspected to hold the species. Specifically checking the archived camera-trap images, particularly with and close to WbH polygons, could reveal other such photographs.

Where protected areas overlap WbH polygons, it is particularly important to alert patrol teams to the new insights on habitat use (see below), to encourage them to look or at least remain alert for the species on interior streams. Protected areas such as Pakke Tiger Reserve seem to have most management focus along the southern plains edge, but these might be the last likely parts of them to hold White-bellied Heron, based on the proximity of permanent settlement and the lower intrinsic suitability of rivers in this area than in the interiors.

Insights on White-bellied Heron natural history used in the process

Minimum stream width and river channel habitat

Those familiar with White-bellied Heron in only India and / or the Hukaung valley tend to see it as a species of very wide, typically braided, rivers with considerable rockiness in the channel, running over rocky 'outwash' plains in mountainous foothill country. Such habitat is, indeed, used.

In Bhutan, notably at Ada and Berti, White-bellied Heron habitually uses streams much narrower than it is known frequent to in Namdapha NP. Some reaches of these Bhutanese streams even lack a continuous wide canopy break. These streams are considerably higher gradient, running through narrow high mountain valleys, being what might be considered 'headwater streams': they are very different from the Namdapha NP and Hukaung sites. A recent record of a single bird from Kachin state, at Camp I (Hponyin) Hponkanrazi WS area (27°35'55N 97°59'55.2E; over 1500 m) in February 2011 (WCS Myanmar in Stanley Price & Goodman 2015) looks from Google Earth to have been from a very narrow headwater stream, not particularly rocky (this has been deduced from coordinates, rather than direct objective confirmation from the observer), and R. J. Tizard (in litt. 2019) observed the species nearby on 16 March 2017, in mixed evergreen – deciduous forest at 27°37'21"N, 97°53'25"E, considering that it feeds along the main stream and flies up the narrow tributaries.

Multiple historical records (given in BirdLife International 2001) come from west Myanmar (well south of Kachin state) from landscapes lacking any 'Namdapha-width' rivers and not on outwash plains. These streams are very different also from the 'headwater' streams in Bhutan. There are also modern records from such streams, both on the very southern edge of the Hukaung valley (perhaps just straying birds), but more convincingly from west of the main Hukaung valley; the geomorphology of these rivers might be termed 'foothill streams' where the rivers are overall much lower gradient than both those in the headwaters and outwash plains, and have long relatively gentle stretches with sedimentary features of 'finer' material, but also still have significant stretches of higher gradient 'rapids' with exposed bedrock. The 1950s Mizoram locality record from Sangau (see below) is also from foothill habitat, a long way from any sizeable headwaters and very far from ant outwash plain. The point is close to (and within a loop of) a 100-m-wide river, but whether the specimens were taken in river or tributary habitat is not known (such information might be on their labels or other associated material).

The bird seen at Manas National Park in February 1971 by T. P. Inskipp (in litt. 2000 to BirdLife International 2001) was on a "small, thickly forested stream", presumably over an outwash plain; a camera-trap record from Hukaung also fits this description. In sum, use of narrow streams may be a common, albeit hitherto little appreciated, aspect of White-bellied Heron natural history.

The absence of recent records from India in small-stream habitat could perhaps reflect a genuine difference from other countries/eras, but given patterns of observer effort to date, it could simply reflect observer bias away from narrower rivers. In Namdapha NP, there appears to have been no or at best minimal effort made to look for the species on small streams although these abound there. People may be disinclined to search such streams through a presumption the species does not use them. In addition, detecting the species on small steams would be very much more difficult because visibility along streams is typically much less than the species's flushing distance in India, confounded by the much greater total availability of small-stream habitat compared to large-river habitat. It is more surprising that in India there appear to have been no records from either 'headwater' or 'foothill' streams. This perhaps reflects observational bias, a history of early eradication from 'foothill' areas (discussion at the meeting indicated that many mountain minorities have longstanding traditions of heavy hunting), and a paucity of wildlife survey effort in 'headwaters' with low human pressure (surveys of the 'headwater' polygons should help clarify this). Most historical Indian records appear to be 'plains' records (see below) – different again from outwash, headwater and foothill streams – or adjacent 'outwash'. This fits quite well with a likely historical bias to observer effort focused on the plains.

Moreover, the localities of most of the historical west Myanmar records are far from any extensive outwash plains or river with Namdapha-style extensive in-channel rocks, whether fixed or mobile. All do have occasional exposed bedrock. Rivers in these areas predominantly show 'foothill' characters, although 'headwater' character is present in some areas. Perhaps not surprisingly, historical record locations (mostly imprecise) suggest that most were in the 'then' easier to access 'foothill' rather than 'headwater' areas. While some of these records could have been misidentifications, it is implausible that all are. The number and spread of localities indicate that White-bellied Heron must then have been reasonably regular in these habitats in this part of Myanmar, either as a breeder, or as a winter resident. There is insufficient information on these records' dates in BirdLife International (2001) to make a firm choice either way. One June record suggests local breeding, but for a large bird it might have been a subadult non-breeder remaining in the winter range. A record by E. C. S. Baker of a nest at Lemro, close to the southernmost record, would, if it could be accepted as reliable, prove nesting in this area; but the comments in Rasmussen & Anderton

(2005: 28–29) on the anomalies in the Baker information mean that such acceptance would be unwise. The lack of records for the Tenasserim range (running along the Myanmar – Thai border), at comparable latitude and as well covered by birdwatchers at that era as was the western range, perhaps suggests that these birds were not migrants from the north. In sum, it is certainly worth taking seriously the possibility that the species nests, or nested, over this wide swathe of Myanmar. There has been too little meaningful observer effort in this part of the country in recent decades to make a meaningful search for whether the species persists there. The area is not accessible for survey at present (R. J. Tizard in litt. 2019).

Additional records and corrections to localities

The following records were mentioned at the meeting, apparently additional to the records in Stanley Price & Goodman (2015) and WbHWG (2017):

- Basar Nalo camp, west of Itanagar, 1980s or 1990s, apparently a one-off; no information how much time the observer, who was then resident in Itanagar, spent in suitable habitat at that era (observer: Pratap Singh; reported by Tajum Yomcha). Habitat, although not the present levels of human use, looks highly suitable on Google Earth.
- Tippi (27d01m38sN, 92d36m37sE), 'historical', no further information but apparently published somewhere (reported by Tajum Yomcha). Habitat, though not the present levels of human use, looks highly suitable on Google Earth.
- Urpad Bael south of Goalpara, sight record of flying bird, 2000 (reported by Arnab Bose).
- Burha Chapori Wildlife Sanctuary, Assam (close to Kaziranga), 10 Dec 2013; one White-bellied Heron photographed on a sandbar standing somewhat distant from a Grey Heron (observer: Prasanta Bordoloi; reported by Rajan K Das, who found it on Facebook recently).
- In or near Kabua or Amatulla, W Kameng district, Arunachal Pradesh (very close to the Bhutan border, and close to Assam border too), about 1994; one record (observer: perhaps Pratap Singh).
- Kane Wildlife Sanctuary, one bird on the bank of the Siji river in West Siang district, Arunachal Pradesh, December 2005 (observer and reporter: Bhatt B. B.).
- Anini, upper Dibang valley, Arunachal Pradesh; reported to a bird guide by a villager who seemed competent, and described the habitat and behaviour well (reported via R. K. Das and although lacking photographic confirmation, plausible).
- Rungagora, a locality given in BirdLife International (2001), has probably been assigned the wrong coordinates there. The Rungagora "on the Dibru river" is at 27°34'25"N, 95°19'06"E. This is within 10 km of the modern (October 2015) single-record Maguri Bael locality. BirdLife International (2001) gave 27°30'N 95°20'E for

- (After the meeting) Three specimens, apparently in breeding condition, taken in February – March 1953 at Sangau (22.741dN, 93.057dE), Lawngtlai district, Mizoram, are held at the University of Michigan Museum of Zoology (Rasmussen & Anderton 2005, Choudhury 2016); these were overlooked by BirdLife international (2001) and Stanley Price & Goodman (2015).

Plains records

There are a number of records, historical and recent, of White-bellied Heron out on the Assam plain, sometimes in river channels but sometimes on the plain proper, in standing water, marshes or swamps. Some historical southern Myanmar records come from comparable habitat. There are too few records to produce a certain interpretation, but the following hypothesis is worth considering: dispersal from breeding areas into such habitat may be a normal part of White-bellied Heron behaviour, perhaps only or predominantly among birds in their first 12 months: a number of records involve certain juveniles, assessed as such on their plumage characters; it is unclear if any have involved certain adults. Precisely located such records tend to be around the confluences of tributaries leading from the known or safely presumed contemporary breeding areas; for example, the December 2013 Burha Chapori bird was right south of the downstream tributary (Kameng) flowing south from the Pakke area; and various of the historical plain localities mapped in BirdLife International (2001) are near the confluence of tributaries from WbH polygons. Dispersal downstream from the nest is consistent with the patterns shown by two tagged young Bhutanese White-bellied Herons in 2017 which left their natal area of Buri Chu and went downstream) from the nest; they were not recorded to reach the Assam plain, but tag function was erratic and it is unclear how far they went overall.

Recent Assam plain records have not seemingly involved birds known to stay more than one day, but the Brahmaputra mainstream comprises a massive complex of braided sandy channel (typically about 10 km wide) within which it would be very difficult to find a single White-bellied Heron. Flowing habitat would plausibly be where a White-bellied Heron would settle for a few weeks or months, rather than in the the sort of non-flowing spot from which modern plains records have tended to come. The well-watched autumn (October 2015) Maguri Bael bird certainly did not stay on the bael for more than a day, but the site is only a few miles from the main channel, into which the bird could have disappeared to spend the winter without ever having been seen by any birder again. Finally, and perhaps most persuasively that occurrence in these habitats is a normal part of White-bellied Heron behaviour, historical records were somewhat more numerous in the Assam plain, often near the main Brahmaputra, with two indications that contemporary observers recorded the birds with some regularity (as cited in BirdLife international 2001).

No WbH polygon was proposed in the Assam plain (or the adjacent West Bengal plain) because it was unclear what criteria would be used to select from within this vast area, and whether the species would be sufficiently predictable in occurrence in such habitat for the notion of a regularly used locality to make sense in conservation planning and implementation terms. But it is possible that if the Bhutan population makes regular use of the Assam plain, mortality there might limit population growth in Bhutan. Thus, it might be problematic to ignore the plain from White-bellied Heron survey and conservation. After the meeting R. J. Timmins, S. Patgiri and some Nature's Foster personnel made two half-day reconnaissances of the main Brahmaputra.
More thought needs to be given to whether searches in this area are sensible use of resources; this would be much easier to determine if even a few young White-bellied Herons were tracked for a solid six months or so after independence from their parents. In the interim, there may be merit in a pilot intensive 10–15 day survey of a 10–20 km stretch identified from remote imagery using river morphology and proximity to the mouth of plausible source areas. This would need to be in winter, if possible selected within the winter for when morning fogs would cause the least loss of survey time.

NEXT STEPS

Towards the close of the meeting, participants agreed, broadly, that the proposed polygons included the most likely places in India to find localities of currently unknown regular usage by White-bellied Heron. Similar broad agreement was given to the selection of priority survey polygons, and the factors used to assign this priority. By contrast, pressed on whether such surveys, if competently undertaken, stood a reasonable chance of finding the species, many participants wavered. For some, this seemed to reflect caution at making a 'bold' statement, but for one or two people there seemed a genuine pessimism that any additional White-bellied Herons remain to be found in India. It is probably impossible to secure complete consensus, but if there were a general feeling that competent surveys would be unlikely to find the species then such surveys would probably not be sensible use of conservation resources. Tajum Yomcha of Namdapha NP already expressed concern that if a focus on surveys now were to come at the expense of securing known populations, then this focus might actually increase the risk of extinction.

It is possible that the known Indian White-bellied Heron population is only a small proportion of that existing. It is very important to communicate to all stakeholders that no matter how many additional localities and birds are found in India, this does not mean that the species's conservation status is less dire than currently believed. This species has certainly undergone a major decline over the last century or so. Even if there are ten or twenty, or even fifty, times as many birds as are presently known about, the 2017–2018 surveys showed that it almost never persists in places showing even low levels of human use. This means that without specific attention to its conservation needs it is certain to go extinct: its low-density dispersal along water courses means that there is no way it will survive as an incidental beneficiary of conservation effort for other species or protected areas in general. Its conservation is challenging under any circumstances and the more localities are known that retain the species, the higher the chance that one or more of them will be sufficiently less challenging to give a markedly higher possibility of retaining it there.

It is urgent that the priority survey polygons, at least, are surveyed as soon as suitable surveyors are identified and resources found to mount surveys covering each of these polygons. If no White-bellied Herons are found in the priority polygons, careful consideration will need to be given to whether it is worth searching any more, given the cost of properly resourced surveys, and the need not to undertake under-resourced surveys.

Survey of a large to medium polygon will require 2–3 months in their interior

undertaking intensive, physically and mentally demanding, spatially complete searching, targeted absolutely at White-bellied Heron, using almost all the daylight hours. Such surveys can bring motivational challenges and would not sensibly be carried out by people, no matter how competent, believing the chance of finding the species in the polygon to be low.

A 10–15 day Brahmaputra main channel survey would be much cheaper than any polygon survey and should be seriously considered if no White-bellied Herons are tagged in the 2019 breeding season (or birds are tagged but transmission problems or early death prevent understanding of post-fledging movements).

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APPENDIX 1

Participants at the White-bellied Heron meeting, Guwahati, Assam, 16–18 February 2019

Process leader	
Dr Robert Timmins	Independent
Participants	
Dr B.B. Bhatt	Department of Environment and Forests of Arunachal Pradesh
Dr Ranjan Das	Tinsukia College
Samiran Patgiri	Nature's Foster
Tajum Yomcha	Namdapha Tiger Reserve
Himadri Sekhar	Bombay Natural History Society
Dr Gopinathan Maheswaran	Zoological Survey of India
Rohan Menzies	Nature Conservation Foundation
Megha Rao	Nature Conservation Foundation
Dr Lubomir Peske	Independent
Tshewang Lhendup	Royal Society for the Protection of Nature, Bhutan
Sonam Rinzin	Royal Society for the Protection of Nature, Bhutan
Sonam Tshering	Royal Society for the Protection of Nature, Bhutan
Takhe Bamin	Ashoka Trust for Research in Ecology and the Environment
Dr Anwaruddin Choudhury	Assam Government
Process support	
Chandan Bhuyan	Morigaon College
Dr J. W. Duckworth	White-bellied Heron Working Group
Rohit George	Ashoka Trust for Research in Ecology and the Environment
Dr Sarala Khaling	Ashoka Trust for Research in Ecology and the Environment

APPENDIX 2

Why Ecological Niche Modelling / Species Distribution Modelling is unlikely to produce a prediction useful for locating as-yet unknown localities of regular White-bellied Heron usage

One approach commonly used nowadays to predict a species's presence across areas where it has not been empirically assessed is computer modelling (Ecological Niche Modelling or Species Distribution Modelling). Various attributes shown by known localities are used to 'define' by the computer programme what correlates with the species's occurrence, and the entire region of analysis is then assessed against these correlates to produce a map showing the geographic variation in predicted probability of occurrence. A variety of programmes is available for this, such as MaxEnt. For any modelling programme to provide useful predictions, various things need to be assumed (or, even better, shown) to be true, or at least broadly true, for the dataset modelled. Most of these assumptions are problematic, some highly so, for White-bellied Heron in North-east India. Specifically,

- Identification accuracy. For 'presence-only' data input, even one or two incorrect identifications may cause major errors in the model's result – particularly if they are in atypical habitat.
- Sample size. The number of locality records should be into double figures, preferably several dozen. Not all sightings can be used as 'locality records'.
- Spatial independence. Records should be spread across the species's range within the area of analysis, not highly concentrated in one or two areas, or only in one half of the occupied area. Multiple records from nearby sites should be treated as one locality to prevent undue influence of that cluster's characters on the model results.
- Spatial precision. Records should be spatially precise, ideally to the pixel; this is particularly important if the species might be associated with habitat features that are small and dispersed, like cliffs or waterholes.
- Timing of records relative to locality information. For example, if the species is sensitive to human presence, than because that has changed greatly over the last century, records of presence 30-100 years ago compared with patterns in human use this year will mislead the model. By contrast, if it is sensitive only to geology, then records from all time may be useable.
- Status of the species at each locality record. Many bird species have distinct dispersal phases, both seasonal (e.g. long-distance, spring and autumn migration) and one-off (e.g. between leaving the natal area and settling in the first own home range). During these phases, for many species occasional individuals may drop down almost anywhere within the geographic range, and often somewhat outside it,

including in habitat and localities irrelevant for the species's conservation. If these records are used, then the model will 'confirm' that the species can occur almost anywhere – but it will not predict localities of regular occurrence and thus of potential conservation importance. If the aim is to help find areas of potential conservation importance, only records from regularly occupied localities should be used.

- The factors determining the species's distribution, or at least strong correlates of these factors, must be used as variables in the model. If they are not then the model cannot usefully predict likelihood of occurrence across the region of analysis.

Reviewing these factors for White-bellied Heron, there are indeed several dozen locality records, but many of them are ineligible for use in modelling today's distribution. Many are from decades ago and for a species clearly sensitive to human activity, in the light of major changes in human distribution, distribution and intensity and types of human activities and in total number of people, would mislead the model. Many records are not very precise, but these are largely the records too old for use anyway. There are multiple claims of White-bellied Heron known or suspected to be in error, and the requirement to avoid including any in error means that claims that cannot be meaningfully assessed (e.g. no photograph; claimed by observer of unknown reliability; etc.) should not be included; some good localities would doubtless be rejected. Some of these are recent enough that they would, if validated, be eligible for use. However, some or all of these would also be rejected on the likelihood that the presence was only transitory and of no value in determining where the species might occur regularly. Summing up these factors would reduce the allowable records to a cluster in central Bhutan, a cluster in Namdapha NP (India), a cluster in Hukaung Valley, Kachin state, Myanmar, and scattered records in Kachin state away from Hukaung. Furthermore, Namdapha NP and Hukaung are close enough to each other to constitute, for the purpose of modelling, one spatial complex. Depending on the variables used in the model, this would result in severe model bias towards the Hukaung–Namdapha NP complex and central Bhutan, with under-prediction for anywhere else in the historical range that the species still occurs and is far from these two centres of recording.

But probably the biggest challenge to modelling White-bellied Heron current distribution would be in the selection and availability of variables to use. Most of the commonly used modelling variables are probably non- or only weakly relevant to determining current White-bellied Heron distribution. Conventionally, modelling tends to use land cover, bioclimate, topographic features such as altitude and the watercourse layout, and various human features such as towns/villages, roads, and others for which global or at least regional data are available. Land species are at an advantage over river species because of the richness of land-cover data available. By

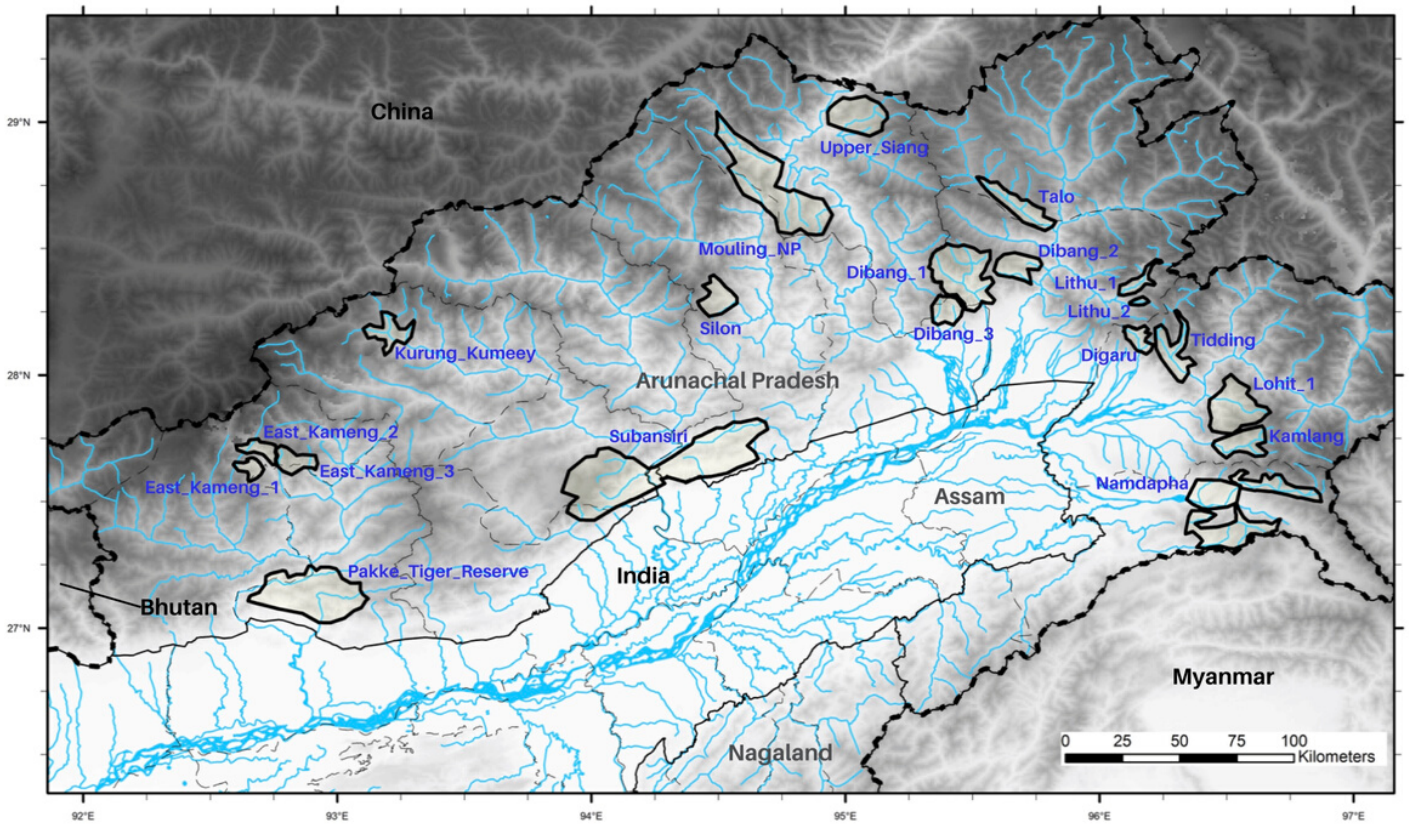
contrast, within-channel river habitats are not segregated; merely the presence of rivers is available. To some extent river channel habitats reflect factors that can be modelled such as topographic steepness, underlying geology, and the distribution of tributary mouths, but the more indirect is the factor in its influence on White-bellied Heron distribution, the more risks and uncertainties are introduced into the model. Similarly, in North-east India, it is clear that close proximity to roads and village rules out White-bellied Heron regular occurrence except in abnormal situations; the sort of measures of 'human footprint' needed for evaluating suitability for White-bellied Heron are likely to be those such as any presence of cultivation even at small and scattered scale, the distribution of even moderately used hunters' or others' paths across the landscape, the distribution of overfishing leading to prey scarcity, and other things for which GIS datasets are not available. While there is some correlation of distance from roads and villages (readily possible to model) and navigable rivers (not so) in these features, as or more influence as them in determining White-bellied Heron occurrence in any given locality comes from local human attitudes, for which, again, GIS datasets do not exist.

The defects in the datasets (White-bellied Heron and geographic variables) would not in any way prevent a model producing a map of startling intricacy and seeming perfection, and herein lies one risk: such a map's high precision has no necessary correlation to accuracy. Some maps may be simply aesthetically appealing works of fiction. Conventionally used measures of 'how well the model is doing' can sometimes help, but not always. For example the AUC (Area Under the Curve) is a measure of how well the model has explained the pattern of locality records using the factors available to it. If the localities fed in are highly biased, the model may do a magnificent job of explaining their layout (high AUC value); but this has no necessary relationship to its ability to predict occurrence in areas without any records, if what the model is in fact doing is explaining patterns in distribution of observer effort!

Thus, before the meeting, the use of computer modelling was rejected; the reasons were explained at the meeting, to no dissent. This is not a general rejection of the value of such modelling in conservation, merely recognising that in this particular case it would be unlikely to produce any useful insight.

FIGURES

Fig. 1: North-east India, showing the identified 21 'White-bellied Heron polygons' (areas not known to hold the species at present, but which have habitat and human use patterns suggesting they might retain it), indicating the five of highest priority to search.



Legend

- International borders
- Provincial borders
- WBH polygons
- District borders
- Upstream core area limit points
- Downstream core area limit points
- Towns/Villages/Hamlets (darker =roughly larger, paler =roughly smaller)
- Individual "houses" (darker =more substantial, paler =less substantial)
- Areas of cultivation (darker =more substantial, paler =less substantial)
- Namdapha WBH sighting records (not exhaustive)
- Road heads

Fig. 2a–2g. A selection of 'White-bellied Heron polygons' (areas not known to hold the species at present, but which have habitat and human use patterns suggesting they might retain it), showing greater detail than in Fig. 1. Between them, these show all the five of highest priority to search. Legend as for Fig. 1.

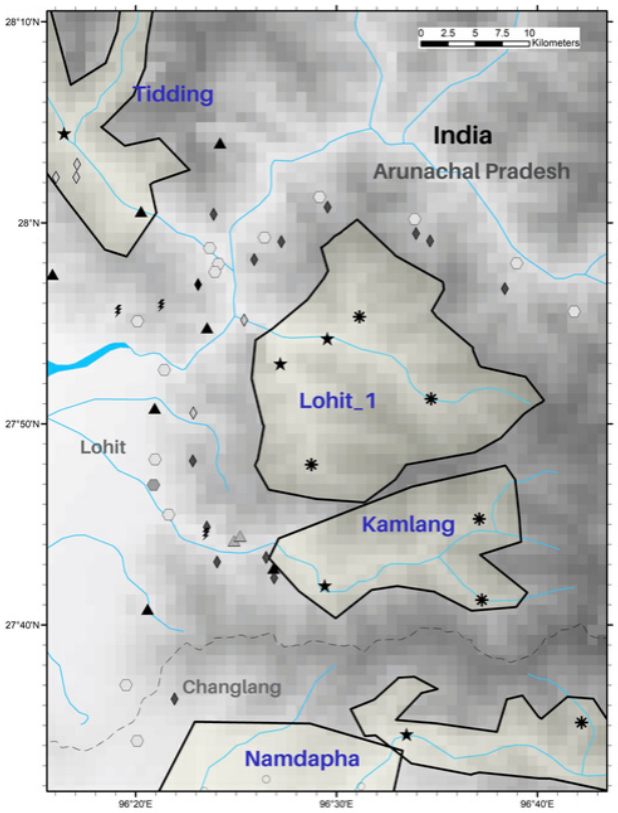


Fig. 2a

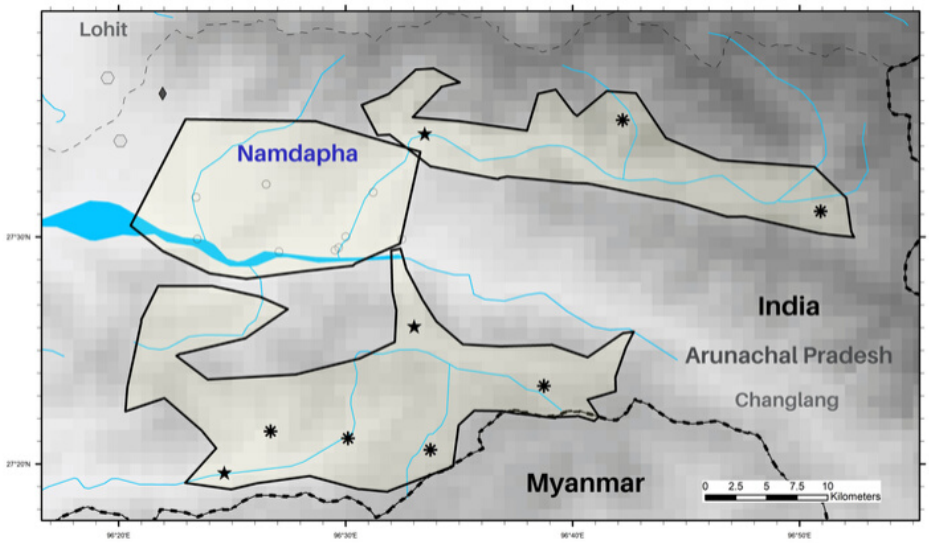


Fig. 2b

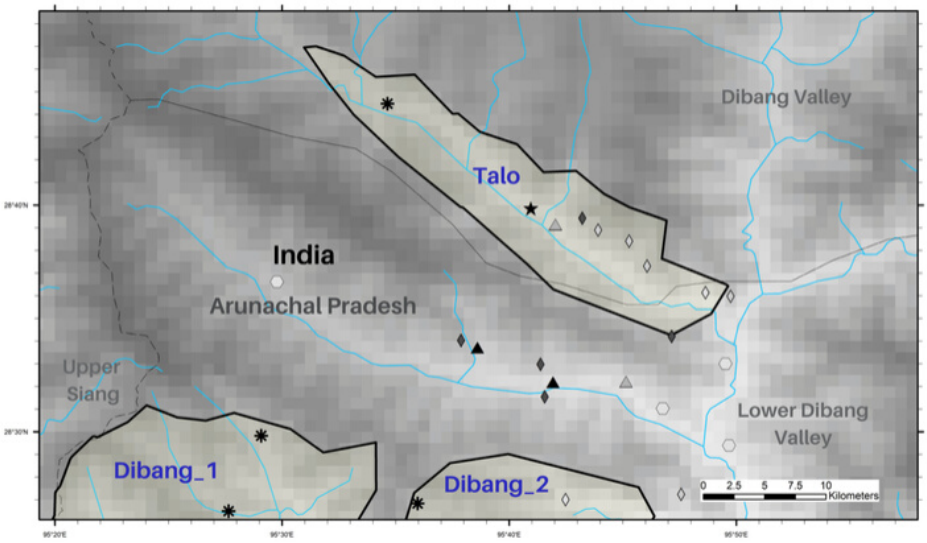


Fig. 2c

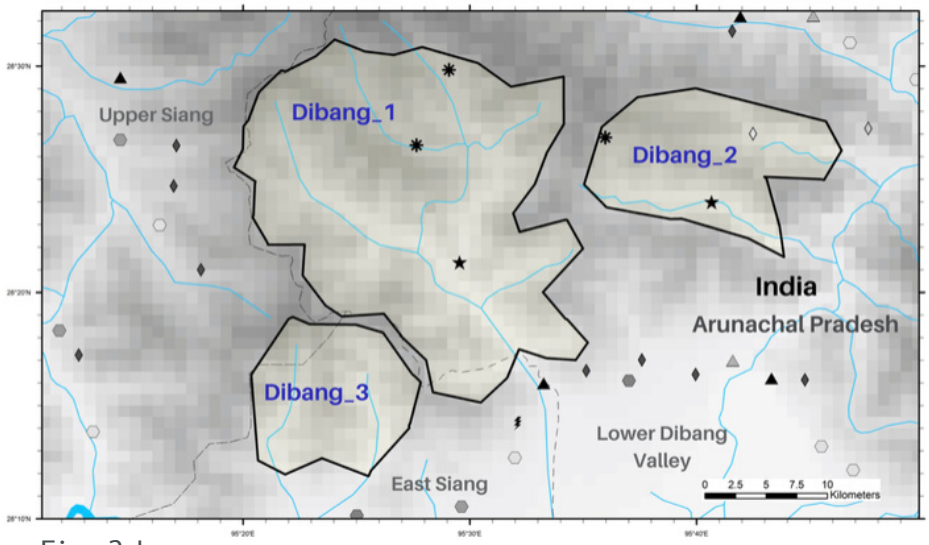


Fig. 2d

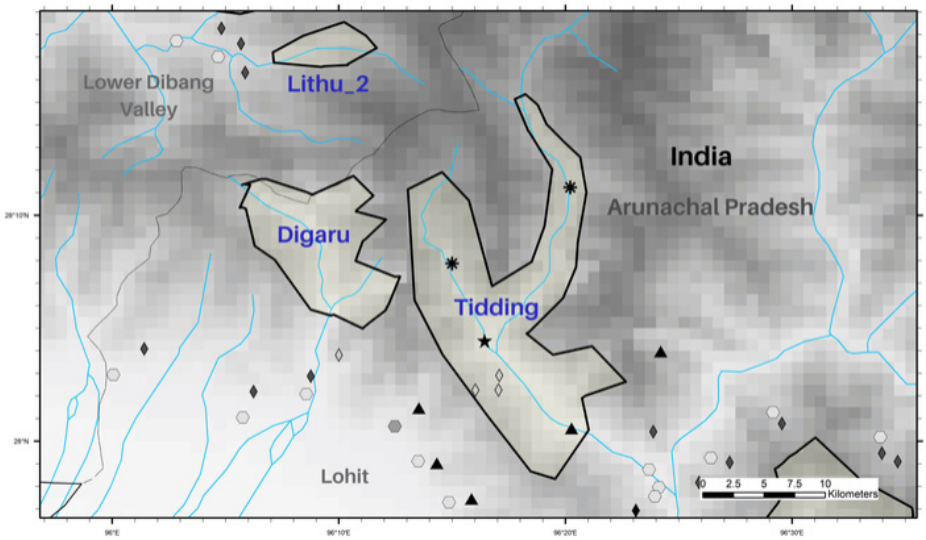


Fig. 2e

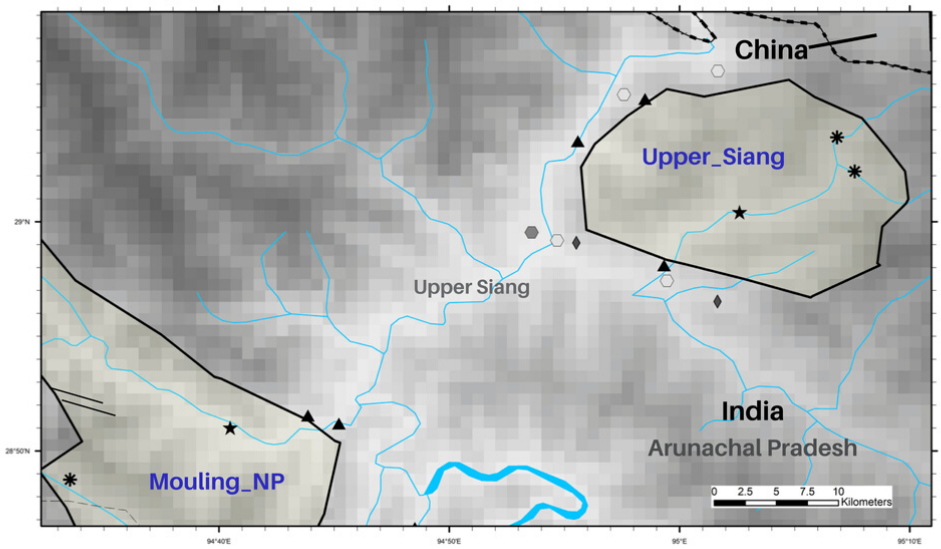

China
Upper_Siang
Upper Siang
India
Arunachal Pradesh
Mouling_NP
0 2.5 5 7.5 10
Kilometers

Fig. 2f

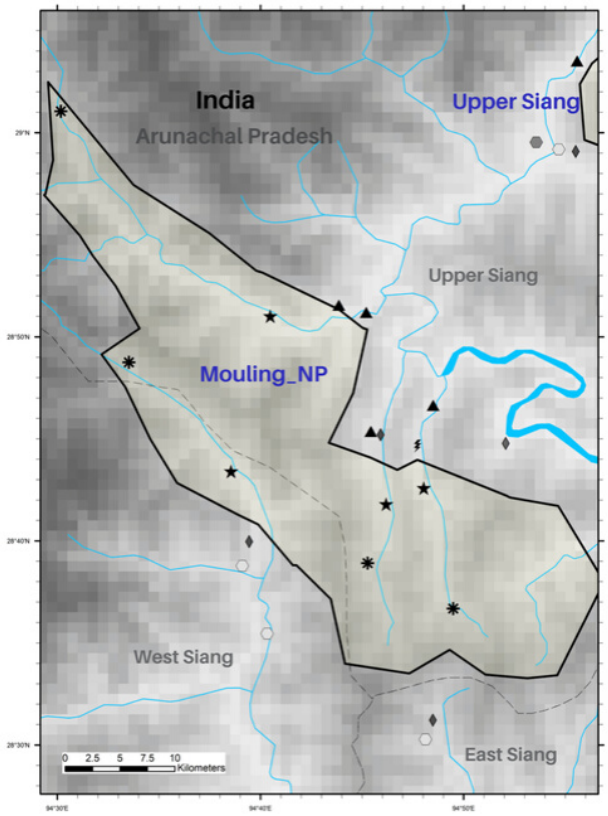

India
Arunachal Pradesh
Upper Siang
Upper Siang
Mouling_NP
West Siang
East Siang
0 2.5 5 7.5 10
Kilometers

Fig. 2g

WHITE-BELLIED HERON
WORKING GROUP