Habitat associations of the Manchurian Reed Warbler *Acrocephalus tangorum* wintering on the Tonle Sap floodplain and an evaluation of its conservation status

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Sixty tape playback trials and 17 net rides were used to investigate the habitat associations of Manchurian Reed Warbler *Acrocephalus tangorum* at what is potentially its most significant wintering site, the Tonle Sap floodplain in Cambodia. Fieldwork in March 2006 concentrated at three sites within the inundation zone during the dry season when floodwaters are at their lowest. This corresponds with the non-breeding season, when Palearctic migrant *Acrocephalus* warblers visit. We analysed cover of different habitat types at two scales: close to and broadly surrounding playback locations. Detections within broad habitat types differed significantly from random ($c^2 = 32.8$, d.f = 5, P <0.001) with an apparent bias towards grass habitats represented in the study area by tall (>1.0 m) grassland. A principal component analysis (PCA) of the proportionate abundance of different habitats within 10 m of playback locations generated just two PCA axes, correlating strongly with the abundance of grassland and wet habitat features (PCA1) and woodland and scrub (PCA2). Logistic regression with both axes as predictor variables revealed a significant effect of PCA1 (z = –2.566, P = 0.010), but no significant effect of PCA2 (z = 0.088, P = 0.419). All sites with detections had a low loading on PCA1, suggesting a strong association with grasslands. Capture rates were extremely low compared with one wintering location in Thailand, so while our study suggests the Tonle Sap is of global importance for the species, we cannot find sufficient evidence to warrant revising the species's IUCN Red List status from Vulnerable to a lower category of threat.

INTRODUCTION

The Manchurian Reed Warbler *Acrocephalus tangorum* is a migratory passerine listed as Vulnerable on the IUCN Red List (BirdLife International 2012) because it is inferred to have a small and declining population. The species is only known to breed at a few sites in extreme south-east Russia and north-east China. It is considered rare or threatened in north-east Asia by Gluschenko (1989) and of the three sites in the Chinese breeding range (excluding Inner Mongolia), Alström *et al.* (1991) reported that two did not appear to have much suitable habitat remaining and they 'doubt that significant numbers of *tangorum* remain', but it remained 'locally common' at Zhalong.

The species's status in, and even the extent of, its wintering range remains particularly poorly understood. The wintering grounds were unknown until a population was found in *Phragmites* reedswamp at Khao Sam Roi Yot, Thailand, in 1981 (Round 1993, Round & Rumsey 2003). Subsequently, it has been found wintering in sedge beds within deciduous dipterocarp forest at a number of sites: Champasak province, southern Lao PDR (Round 1998), Preah Vihear province, northern Cambodia (Clements *et al*. 2005) and southern Mondulkiri province, eastern Cambodia (Bird *et al*. 2007). In 2000 'at least 20' Manchurian Reed Warblers were recorded at Krous Kraoum, Kompong Thom province, on the Tonle Sap floodplain in Cambodia (Robson 2000, Davidson 2001), and more records have since followed in Kompong Thom and Siem Reap provinces, Cambodia. These observations originated from a variety of habitats, particularly tall grass stands (away from water), sedge beds (both wet and dry), scrub-fringed lotus swamps, and heterogeneous scrub/grass mixes away from water (BirdLife International 2012).

To date, the only study examining winter habitat use by the species was conducted within the least disturbed part of a c.50 km^2 marsh in Khao Sam Roi Yot National Park, Thailand (Round & Rumsey 2003). This demonstrated a strong positive association of Manchurian Reed Warbler with stands of mature *Phragmites*. Because *Phragmites* is rare elsewhere in Thailand, and because a moderate increase in mist-netting in South-East Asia and an improved knowledge of the species's identification failed (at least before 1997) to produce many records, the Red Data Book asserts that Manchurian Reed Warbler should be considered truly scarce and locally distributed with a small global population (BirdLife International 2001). However, more recent records at wintering sites away from Khao Sam Roi Yot demonstrate that other wetland vegetation is widely used in the absence of *Phragmites*, and it remains undetermined whether this is truly suboptimal habitat (Round & Rumsey 2003). The extent of potentially suitable habitat in the Tonle Sap Lake inundation zone, South-East Asia's largest freshwater wetland, is vast (P. Davidson *in litt*.) and therefore, even if population densities in floodplain habitats other than *Phragmite*s should prove to be lower, Manchurian Reed Warbler may be more widespread and numerous than previously considered.

At Khao Sam Roi Yot, the best documented (and formerly only known) wintering site for the species, the extent of *Phragmites* is declining owing to illegal encroachment with plantations of casuarinas, eucalyptus and coconut palms established around the margins of the area, while major prawn farms have been established in the centre, pumping salt or brackish water into previously freshwater areas (BirdLife International 2001). There is now very little *Phragmites* habitat in Thailand and wetlands in the country are imminently threatened by reclamation and urbanisation (Round 1993). The Tonle Sap Lake floodplain supports large areas of natural and semi-natural seasonally inundated grassland (Evans *et al.* 2005) that are currently under intense pressure from land-use change, with grassland cover declining since the late 1990s owing to scrub encroachment and, since 2004, an extraordinary intensification of rice cultivation (Gray 2006, Gray *et al*. 2007). Gray *et al.* (2009) documented losses of 27% of grassland cover on the Tonle Sap floodplain within 10 grassland blocks between January 2005 and March 2007, primarily as a result of land conversion for intensive dry season rice cultivation. Bengal Florican *Houbaropsis bengalensis* was uplisted to Critically Endangered in 2007 as a direct result of these land-use changes in the Tonle Sap floodplain (BirdLife International 2012). The impacts of land-use change on Manchurian Reed Warbler remain unknown but, based on the above, a population decline has been inferred in assessing its current IUCN Red List status (BirdLife International 2012).

We used tape playback and mist-netting to investigate the habitat associations of Manchurian Reed Warbler on the Tonle Sap floodplain. Our results are discussed in the context of the species's likely abundance and trends, in order to review its assessed extinction risk.

METHODS

Study area

The Tonle Sap Lake in Cambodia is the largest freshwater lake in South-East Asia (Gray *et al*. 2009). The lake floodplain system is characterised by notable seasonal differences in water level and surface area (Kummu & Sarkkula 2008 in Västilä *et al.* 2010). The lake expands from some 2,500 km^2 in the dry season (December to June) to between 12,500 km^2 and 15,000 km^2 during the wet season (Campbell *et al.* 2006). The floodplain landscape is a complex mosaic of flooded forests, wet and dry scrub, cropped grasslands, tall grasslands structurally similar to *Phragmites* reedbeds, and areas of rice cultivation radiating out from the lake in roughly concentric rings. During March 2006 we conducted surveys on the northern boundary of the Tonle Sap Lake inundation zone around the Siem Reap and Kompong Thom provincial border (Figure 1) in natural and semi-natural habitats and areas of dry season rice production (headponds for irrigation and rice paddy). The study area experiences annual flooding up to 4 m depth for 4–7 months a year (Gray 2007). Three relatively distinct sites were studied during the dry season (Figure 1): (1) an area of seasonally inundated grassland and short tree scrubland near Stoung (dry at the time of field visits), (2) natural and semi-natural seasonally inundated grassland at Kruos Kraom (fields were dry at the time of fieldwork but headponds remain inundated year-round for irrigation) and (3) permanently flooded forest and seasonally flooded bankside scrub at Boeung Tonle Chhmar, one of the core areas of the Tonle Sap Biosphere Reserve.

Tape playback

Manchurian Reed Warbler has previously been shown to respond to playback (Alström *et al*. 1991). To investigate habitat preferences of the species, relative abundance was compared in seven broad habitat types using 60 separate playback trials. A series of random playback positions was generated and a representative sample chosen for each habitat type. At each playback position, five minutes of continuous vocalisations by Manchurian Reed Warbler was played on a portable Sony CD player through a pair of Philips SBA220 speakers at equivalent volume to reed warbler vocalisations (judged by ear). The vocalisations included song and calls alternating for a minute each for the total five minutes. During the following ten minutes, two observers standing back-to-back recorded all Manchurian Reed Warblers seen and heard from the position of the speakers. An estimation of the total number of individuals was made.

Parameters recorded at each playback position were site number, date, time, cloud cover and precipitation. Broad habitat type was subjectively assigned by eye to dry scrub (which is inundated by shallow water during the wet season), permanently flooded forest, wet/flooded scrub (potentially submerged in the wet season), scrub-island within paddy (inundated in the wet season), grass-island within paddy (inundated within the wet season), tall dry grass (>1.0 m average height, inundated in the wet season), or tall wet/flooded grass (>1.0 m average height, artificial headponds and natural). Percentage cover within a 10 m radius (measured with a measuring tape) of playback positions of sedge, floating vegetation, cultivated rice, *Mimosa* sp., tall grass (>1.0 m), scrub, flooded forest, water and mud was estimated by eye. A radius of 10 m was selected by default: no comparable studies were found to indicate the attractant radius of playback on individual reed warblers; to maximise the number of playbacks completed, a manageable radius was selected; and because isolated habitat islands were part of the trial and these pockets were small, a 10 m radius was optimal. Surveys were carried out from 06h00 to 10h00 and again from 14h00 to 18h00, periods of maximum bird activity, between 4 and 24 March 2006.

Using R version 2.13 (R Core Development Team 2011), we applied principal component analysis (PCA) to data on the proportionate cover of habitat features within 10 m of each playback location in order to isolate key components of habitat variation. Using ordination plots classified according to the presence or absence of Manchurian Reed Warbler detections, we then performed a visual assessment of the relationship between habitat variation and warbler detection. We used logistic regressions with presence/absence as a response variable to test for significant relationships with extracted values from habitat principal

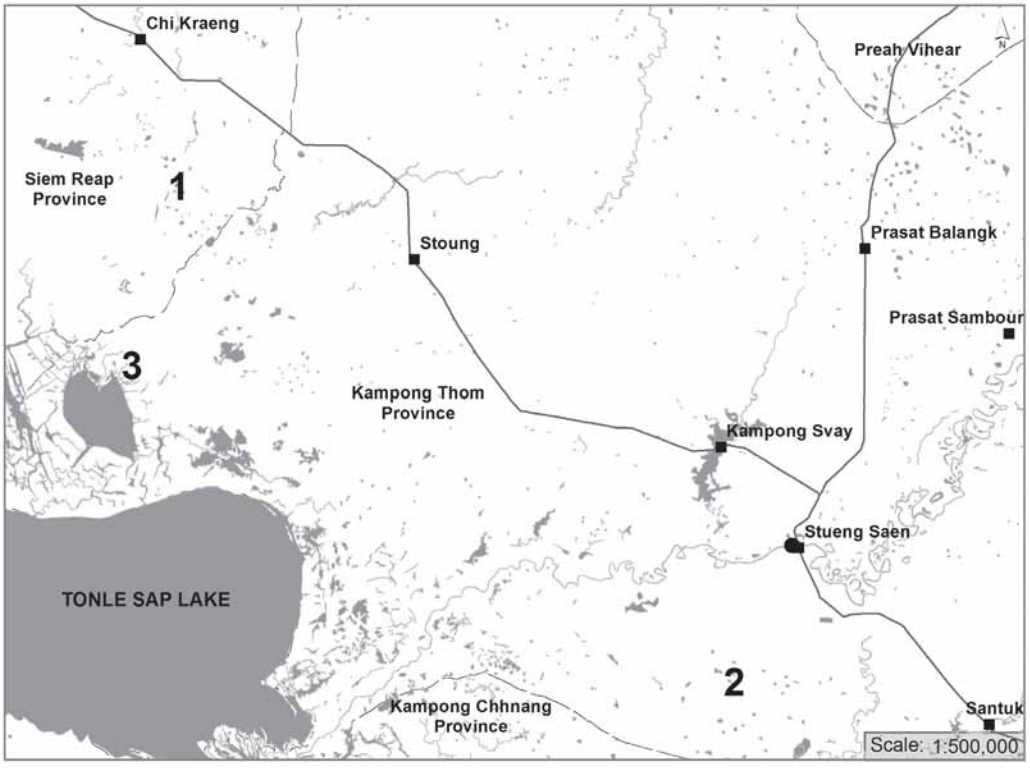


Figure 1. Study sites where playback was performed around the Tonle Sap, Cambodia.

components, as well as overall habitat classes. We also compared detection rates across the broad habitat types at playback sessions using a Chi-square test.

Mist-netting

Birds were caught during 14 mornings of netting and ringing sessions on 17 separate net rides, each of which was classified under a broad habitat type. Only where there was relatively extensive homogeneous habitat of the same type were net rides established.

Nets were operated for up to four hours, mostly between 06h00 and 10h00. All birds caught were identified, ringed, measured and examined for moult and feather wear. Birds were weighed to the nearest 0.1g using Pesola spring balances before being released. Capture rates allow comparison of relative abundance of Manchurian Reed Warbler between sites and with other species. The number of Manchurian Reed Warbler caught per metre-hour (mh) of mist-netting was calculated for different habitat types.

Owing to the difficulties of mist-netting in flooded scrub and forest, the survey of Manchurian Reed Warbler was limited to playback in the maze of channels and streams linking Boeung Chhmar and the Tonle Sap Lake.

RESULTS

An estimated 35 Manchurian Reed Warblers were recorded (based on both calls and direct sightings) during 60 playback sessions. Overall densities of Manchurian Reed Warbler appeared to be relatively low, with detections being made at just 16 playback locations (27% of total). Detection rate across different habitat types was significantly different from random (Table 1, $c^2 = 32.8$, d.f=5, P<0.001), with most detections occurring in grass habitats (Table 1). Tall grassland habitats, both wet and dry, appeared to be the main vegetation types supporting Manchurian Reed Warblers within the study area. Multiple encounters also occurred in man-made habitats, mostly in tall grasses surrounding artificial wet headponds (used for dry season rice irrigation—an estimated 12 individuals encountered in 6 playbacks), as well as from small 'islands' of tall grass habitat in and along the edges of rice fields (an estimated 7 individuals encountered in 10 playbacks). Detection rates in forest and scrub habitats, both flooded and dry, were very low, and no detections were made in extensive areas of permanently inundated scrub and flooded forest in the Boeung Chhmar/Moat Khla IBA. However, logistic regression with habitat type as an explanatory variable revealed no significant differences between habitat types, potentially owing to the small sample sizes in each habitat.

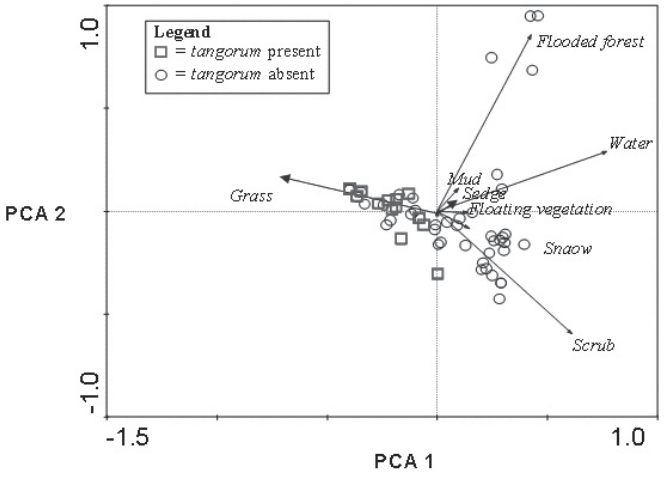
Table 1. Broad habitat classifications of playback locations, together with the numbers of Manchurian Reed Warblers recorded in each habitat type and numbers that would be expected if habitat selection was random. The distribution of records was significantly different from random ($\chi^2 = 32.8$, d.f = 5, P <0.001). 'Tall wet grass' includes man-made head-ponds.

	tangorum numbers		
Habitat	**Playback locations**	**Observed**	**Expected**
Dry scrub	4	2	2.3
Flooded forest	6	0	3.5
Flooded scrub	9	0	5.2
Small grass island in paddy	11	7	6.4
Scrub island in paddy	10	0	5.8
Tall dry grass	10	14	5.8
Tall wet grass	10	12	5.8
Sum	60	35	

Table 2. Factor loadings for each variable in a principal component analysis of habitat variation across playback locations, showing the first two principal components (proportionate eigen values: PCA1 69.2%, PCA2 23.7%).

Variable	PCA1	PCA2
Sedge	−0.030	−0.026
Floating vegetation	−0.008	0.001
Rice	0.011	0.073
Mimosa sp.	−0.017	0.017
Tall grass	0.824	−0.171
Scrub	−0.305	0.511
Flooded forest	−0.231	−0.794
Water	−0.416	−0.262
Mud	−0.032	−0.065

Figure 2. Ordination plot showing playback locations, classified according to the presence or absence of Manchurian Reed Warbler in relation to principal component axes explaining variation in habitat characteristics. Axes PCA1 and PCA2, collectively, explain 93% of variation in the habitat characteristics shown. NB 'snaow' is *Sesbania* spp.



PCA of the proportionate abundance of different habitats within 10 m of playback locations revealed that habitat variation was rather simple (Table 2), with 93% of variation being explained by just two PCA axes, correlating strongly with the abundance of grassland and wet habitat features (PCA1) and woodland and scrub (PCA2). Logistic regression with both PCA1 and PCA2 as predictor variables revealed a significant effect of PCA1 (z = −2.566, P = 0.010), but no significant effect of PCA2 (z = 0.088, P = 0.419). Figure 2 shows an ordination plot of playback sample locations against both PCA axes, with sites classified according to the presence or absence of Manchurian Reed Warblers. All sites at which the species was recorded have a low loading on PCA1, suggesting a strong association with locations dominated by grasslands. Manchurian Reed Warblers were absent from all locations which received a high loading for PCA1, suggesting avoidance of habitats associated with wet features such as floating vegetation, open water, mud and sedges. Figure 2 also shows that locations with a high or low loading on PCA2 did not produce detections, suggesting avoidance of wooded or scrub-rich sites. This analysis underlines the importance of tall grassland for Manchurian Reed Warblers within the study area. Grasslands, structurally similar in height and density to *Phragmites* reedbed, also tended to be the dominant habitat at playback locations at which detection rates were high. Tall grass comprised 76% habitat cover within 10 m of playback locations where Manchurian Reed Warbler was detected versus just 26% at locations where none was detected.

The sample of Manchurian Reed Warblers from mist-netting was too small to test statistically, but their distribution was heavily

Table 3. Habitat types and capture rate for Manchurian Reed Warblers (MRW) netted in Kompong Thom and Siem Reap provinces.

Broad habitat type	No. of net rides	Metre-hours netted (mh)	No. of MRW caught	No. per hundred metre-hours netted (n/100mh)
Grass/scrub	2	391	1	0.26
Dry scrub	4	1,719	0	0.0
Wet/flooded scrub	3	975	0	0.0
Tall dry grass (>1.0m)	5	1,914	6	0.31
Tall wet grass (>1.0m)/scrub (headpond)	1	819	2	0.24
Tall wet grass (>1.0m) (natural)	2	825	0	0.0
*Pure mature *Phragmites*	6	2,706	60	2.2

*Data from captures at Khao Sam Roi Yot, Thailand, from Round & Rumsey (2003)

skewed towards grassland. All eight of the net rides where individuals were caught were dominated by grass (Table 3). Capture rates (n/mh netted) for the species were very low in comparison to those recorded by Round & Rumsey (2003) in pure *Phragmites karka* stands at Khao Sam Roi Yot (Table 3). During 6,643 mh of mist-netting, captures of all *Acrocephalus* warblers involved 9 Manchurian Reed Warbler, 73 Black-browed Reed Warbler *A. bistrigiceps*, 3 Blunt-winged Warbler *A. concinens*, 118 Oriental Reed Warbler *A. orientalis* and 1 Thick-billed Warbler *A. aedon*.

DISCUSSION

Habitat association and abundance

A strong positive association of Manchurian Reed Warbler with grassland was demonstrated using playback. The species has been observed in a wide variety of wetland habitats in Cambodia, but within the Tonle Sap inundation zone areas of tall grass (possibly a *Saccharum* sp.), similar in appearance to *Phragmites* reedbed, appear to be strongly favoured over alternative habitats. It remains unclear whether the species is wintering in suboptimal habitat on the Tonle Sap floodplain, as no *Phragmites* reedswamp could be located for direct comparison with earlier studies (e.g. Round & Rumsey 2003).

Densities of Manchurian Reed Warbler on the floodplain were low relative to other *Acrocephalus* species and locations. Despite 6,643 mh mist-netting effort, just nine individuals were captured at a rate of 0.0013 individuals per metre hour, whereas Round & Rumsey (2003) recorded a capture rate of 0.022 in stands of mature *Phragmites* at Khao Sam Roi Yot, capturing 60 different individuals during April 1995. The high levels at Khao Sam Roi Yot might partly be explained by influxes of migrant individuals and a concentration effect in limited habitat area, but this is conjecture.

Inundated grasslands within the Tonle Sap floodplain are of exceptional importance for conservation (Gray *et al.* 2009). It has been suggested that Manchurian Reed Warbler might have a large wintering population in Cambodia given the extensive available habitat in the Tonle Sap floodplain (Round & Rumsey 2003, P. Davidson pers. comm. 2005). Our findings support this assertion: although densities throughout the floodplain are likely to be low given the habitat associations and densities we observed, the available area of tall grass stands remain vast (but needs quantifying). Furthermore, with a spate of new wintering records in the late 1990s and 2000s redefining the species's non-breeding range to include much of Cambodia to southern Lao PDR and the Vietnamese border, the availability of tall grass within this range is unlikely to be a limiting factor considering its prevalence in human modified landscapes on the floodplain. Although Manchurian Reed Warbler is now known to be more widespread in the non-breeding season, the Tonle Sap lies at the core of its wintering range, and as South-East Asia's largest permanent freshwater wetland it probably represents a stronghold for the species. Continuing destruction of wetland habitats in Thailand may further increase the global significance of this population (BirdLife International 2001, Round & Rumsey 2003).

Potential threats

Alluvial grasslands have been cleared preferentially for agriculture in most parts of East and South-East Asia, so the large areas remaining around the Tonle Sap Lake are of outstanding regional importance (Evans *et al*. 2005). Drainage and conversion of natural wetlands and grasslands, primarily for rice agriculture, have resulted in a significant decline in the area of available habitat for conservation priority species in Cambodia (Seng *et al*. 2003) and expansion of dry season rice is probably the most serious threat to the biodiversity of the Tonle Sap grasslands (Evans *et al*. 2005). It is possible, however, that Manchurian Reed Warbler has been less heavily impacted than other species. The major land-use changes occurring around the floodplain, particularly the shift from traditional wet season rice cultivation to dry season rice cultivation (Chan *et al*. 2004, Evans *et al*. 2005), may influence habitat availability for the wintering population. Manchurian Reed Warbler appears to persist around headponds created for dry season rice irrigation, as well as in small blocks of tall grass within paddyfields themselves. This implies that the influence of these land-use changes will not necessarily be negative. It is also likely that traditional management systems are beneficial to the species, as regular grazing and burning help maintain grasslands (both tall and short swards) by preventing successional reversion to scrub and forest (BirdLife International 2006).

Despite the availability of apparently suitable habitat within Cambodia, it is important to emphasise that population densities are likely to be low in most areas. The continuing degradation and inadequate habitat protection at Khao Sam Roi Yot, the only other relatively large area of known habitat to support this species in South-East Asia, highlights the need for conservationists to ensure the maintenance of suitable habitat for this species in Cambodia. Management measures such as retaining tall grass margins may be relatively simple and cost-effective to implement, and should be considered in mid- to long-term management objectives for inundated grassland areas around the floodplain.

Another potential threat to the species, not reported in the IUCN Red List account, is trapping. Trapping is widespread in South-East Asia for food and for merit release (the practice of releasing caged wild-caught birds for religious purposes). Trapping has been implicated in rapid declines in Yellow-breasted Bunting *Emberiza aureola* populations: roosting flocks in reedbeds are disturbed and then caught in mistnets, and are cooked and sold as 'sparrows' or 'rice-birds' (BirdLife International 2012). This practice has now become widespread and, although it is illegal in some areas, over a million individuals are reportedly killed annually to be sold as snacks (BirdLife International 2012). While Manchurian Reed Warbler is unlikely to be a focus of trapping effort it may well be caught as a bycatch species. We observed passerine trapping while conducting fieldwork. Merit release is now also widespread at tourist sites. JPB observed a tail-less individual of either *A. bistrigiceps* or *A. tangorum* in central Phnom Penh that was presumably a merit-released bird.

Red List implications

The IUCN Red List criterion that has been triggered to qualify this species as Vulnerable, C2a(ii), states that the population is estimated to number fewer than 10,000 mature individuals and is undergoing a continuing decline, with all mature individuals in one subpopulation (IUCN 2001). The population estimate for Manchurian Reed Warbler of 2,500–9,999 mature individuals

(BirdLife International 2012) is derived from the original Red Data Book assessment that it 'must be presumed to have a fairly small world population' owing to the scarcity of wintering records and its restricted wintering range (BirdLife International 2001). We recommend revising the text that accompanies the Red List account to reflect that the wintering range is now known to be much larger than when the Red Data Book account was compiled. Based on our findings it seems unlikely that wintering habitat is population-limiting and it should not be used as the basis for the current population estimate.

However, it would be premature to revise the population estimate upwards and downlist the species to Near Threatened or Least Concern as a consequence, for two reasons. First, although the species has a broad non-breeding range we cannot definitively say its population is larger than the current estimate. It is possibly noteworthy that increased mist-netting in *Phragmites* in central Thailand (Bung Boraphet), during which several thousand *Acrocephalus* warblers were ringed in 2007–2012, yielded fewer than ten Manchurian Reed Warblers (PDR unpubl. data), and very few have been caught on migration in Hong Kong, suggesting the global population is indeed relatively small. Second, the Red Data Book provides sufficient justification for a cautious approach: various problems exist at the three best known breeding grounds of the species, Khanka Lake in Russia and Zhalong and Dalai Hu National Nature Reserves in China, while the two other reported breeding sites in China (excluding Inner Mongolia) are regarded as no longer suitable for the species (Alström *et al.* 1991, BirdLife International 2001). We are unaware whether updated information exists from these sites in the Russian or Chinese literature. If it does, it could provide valuable insights into the conservation status of the species. If not, gathering this information should be a priority for further research. It is also clear from the Red Data Book account that assessing the species's status in Inner Mongolia is important.

After small population size, the second assertion of the current IUCN Red List assessment is that the species's population is declining. Despite conversion and degradation of habitat in some wintering sites (notably Khao Sam Roi Yot), the Manchurian Reed Warbler's ability to exploit a variety of habitats throughout its non-breeding range suggests that habitat conversion may not be causing declines on the wintering grounds, and this should be reflected in the Red List text account. However, again we feel it is premature to recommend changing the Red List status owing to uncertainties on the breeding grounds, where habitat conversion may well be causing the population to decline.

While the population consequences of documented threats remain unquantified, there is insufficient evidence to infer a rapid population decline (>30% over 10 years or three generations) that could qualify the species as Vulnerable under the A criterion of the IUCN Red List (IUCN 2001). Furthermore, now that the wintering range has been increased substantially through improved knowledge, the species's estimated extent of occurrence, 490,000 km^2 (BirdLife International 2012), is much larger than the threshold triggering the B criterion. Overall we recommend that the status quo, listing the species as Vulnerable under criterion C2a(ii), be maintained.

CONCLUSION

This study is the first to investigate the wintering habitat associations of Manchurian Reed Warbler in Cambodia since records revealed the country encompasses the majority of its known non-breeding range. While the findings deserve further scrutiny and ideally more prolonged research, they go some way towards outlining Cambodia's importance for this threatened species. Preliminary evidence suggests Cambodia, and the Tonle Sap Lake floodplain in particular, probably supports a substantial proportion of the global population. Establishing more reliably what that population is likely to be requires considerably more study, and is probably best achieved by concentrating on the breeding sites. Currently there is little evidence that the species is unduly threatened by habitat conversion in Cambodia but we must stress that this conclusion requires confirmation. Additionally, the unregulated trapping of small birds (including reed warblers) through the use of nets is widespread within the species's non-breeding range and its impacts at the population level warrant further investigation.

ACKNOWLEDGEMENTS

We thank Pete Davidson for helpful advice and information before undertaking fieldwork, Tom Evans and colleagues at the Wildlife Conservation Society in Cambodia for providing essential help and support throughout, and the many donors for sponsoring the research: the Astor of Hever Trust, British Ecological Society, British Ornithologists' Union, Chris and Liz Shepley, IdeaWild, Opticron, Oriental Bird Club, People's Trust for Endangered Species, Robert and Elaine Dawson, Royal Geographical Society, Sevenoaks RSPB members' Group, Sir Phillip Reckitt Educational Trust, University of East Anglia Travel and Expeditions Committee, The Wetland Trust and Wexas International. Also, thanks to Santhosh Kurian for his assistance with the map. Finally we thank two anonymous referees for helpful comments that greatly improved the manuscript.

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