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Habitat use by Siberian warbler species at a stopover site in Far Eastern Russia

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Knowledge of the routes and habitat use of Siberian songbird species during migration is very limited. The goal of our study was to describe the autumnal habitat use of seven Siberian warbler species in the genera *Phylloscopus*, *Acrocephalus*, *Iduna* and *Locustella* in Far Eastern Russia. A total of 2283 individuals were trapped in mist nets placed within different habitat types between 2012 and 2014 as part of the Amur Bird Project at Muraviovka Park in Far Eastern Russia. We studied the effect of habitat type and vegetation height on the occurrence of each species, and compared our results to published information on habitat use on the breeding grounds. Our results demonstrate that most species exhibit species-specific preferences for habitat type, and that these stopover habitats were similar to habitats used on the breeding grounds.

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Most long-distance migrant songbirds migrate nocturnally (Winkler 1989, Liechti & Bruderer 1998) and they make several stopovers in daytime to replenish their energy stores and water reserves for the next bout of flight (Schaub & Jenni 2000, Fuchs *et al* 2006). Passerine migrants are known to use a range of habitats at stopover sites that is wider than those occupied during breeding season (Bairlein 1983, Bilcke 1984, Chernetsov 2006), although there are still often species-specific habitat preferences (Bairlein 1983). In some species, dominance hierarchies are established, whereby males and adults outcompete females and juveniles for the best habitats (Catry *et al* 2004, Schaub *et al* 2004, Tellería & Pérez-Tris 2004, Gyurácz *et al* 2012, Gyimóthy 2012).

Migrants regularly land in unsuitable habitat after nocturnal movements, often moving within the habitat in the early morning, this manifesting itself as a peak in captures at this time (Brensing 1989, Titov 1999b). Such local movements may be an attempt to establish a defined home range or territory within preferred habitats, and may also be related to increased energy demands after a long flight (Titov 1999a, Chernetsov *et al* 2004, Chernetsov 2005).

There are many studies dealing with the habitat use and preference of European songbird species, especially warblers (Bairlein 1983, Pambour 1990, Cantos &

Tellería 1994, Chernetsov 1998, Schaub & Jenni 2000, Preiszner & Csörgő 2008, Vadász *et al* 2008a, b, Mérő *et al* 2016). Previous studies of Siberian songbird species have concentrated on identifying habitat preferences on the breeding grounds (Forstmeier *et al* 2001, Egorova *et al* 2009, Alström *et al* 2011, Bozó 2015) or wintering areas (Round *et al* 2014, Ayat & Tata 2015), however, and knowledge of habitat use during migration at stopover sites is limited. This lack of knowledge is caused partly by uncertainty over the species' migration routes, but also by a lack of ringing stations in eastern Asia where such studies could be conducted. Information on bird migration at a stopover site in Far Eastern Russia has been collected within the Amur Bird Project since 2011, for species including several Siberian warblers (Heim *et al* 2012, Bozó & Heim 2015, 2016, Bozó *et al* 2016, Sander *et al* 2017). The variety of vegetation at the ringing station provides an opportunity to examine the habitat use of migratory species.

Using three years' ringing data, our study aimed, first, to identify which habitats were used by seven species of warbler in the genera *Phylloscopus*, *Acrocephalus*, *Iduna* and *Locustella* at an autumn stopover site in Far Eastern Russia and, second, to compare the stopover habitats with published information on habitat use on the breeding grounds.

Material and methods

The study was carried out, as part of the Amur Bird Project, at Muraviovka Park along the middle stream of the Amur River in the Russian Far East (Heim *et al* 2012). The study site (49°55'08"N 127°40'20"E) is located 60 km southeast of the city of Blagoveshchensk.

Daily ringing activities were carried out in 2012 (29 August to 16 November), 2013 (25 July to 23 October) and 2014 (25 July to 29 September). Twenty one mist nets (216 m in total length) were set up in a variety of habitats (with the dominant plant species in parentheses): deciduous forest (*Quercus mongolica*, *Lespedeza bicolor*), pine forest (*Pinus sylvestris*), homogeneous reed beds (*Phragmites australis*), shrub (*Salix* sp., other unidentified bushes), and sedges and grassy swamps interspersed with willows (*Carex* sp., *Poa* sp.). For the analysis we assigned each mist net to one of the following habitat types: deciduous forest (42 m of mist nets), pine forest (24 m), reeds (24 m), shrub (42 m) and swamp (84 m). Mist nets were checked every full hour from sunrise to sunset. Rings were supplied by the Moscow Ringing Centre. Species identification was based on Svensson (1992) and Brazil (2009).

We also studied the potential effects of vegetation height on the birds' use of habitat. In 2014 we mapped the vegetation types and recorded the average height of the vegetation around the nets.

The data analysis was based on 2283 individuals of seven species: Dusky Warbler *Phylloscopus fuscatus*, Radde's Warbler *P. schwarzi*, Pallas's Leaf Warbler *P. proregulus*, Yellow-browed Warbler *P. inornatus*, Black-browed Reed Warbler *Acrocephalus bistrigiceps*, Thick-billed Warbler *Iduna aedon* and Pallas's Grasshopper Warbler *Locustella certhiola* (Table 1).

Linear models were fitted for each species, with the number of birds trapped at each mist-net site (per net-m per day) as response variable, and habitat type and vegetation height as factors. Significant variables were selected with the help of backward stepwise model selection (Crawley 2013) using the likelihood-ratio test ($P < 0.05$). Data analysis was performed in Microsoft Excel 2017 and R version 3.4.2 (R Development Core Team 2017).

Results

No relationships between the number of birds (per net-m per day) and vegetation type or height were found for Thick-billed Warbler or Radde's Warbler. Significant relationships between capture rates of birds and both habitat type and vegetation height were found for

Table 1. Annual capture totals for the study species.

Species	2012	2013	2014	Total
Dusky Warbler	275	82	233	590
Radde's Warbler	49	41	47	137
Pallas's Leaf Warbler	141	21	136	298
Yellow-browed Warbler	396	202	455	1053
Black-browed Reed Warbler	13	13	61	87
Thick-billed Warbler	42	9	19	70
Pallas's Grasshopper Warbler	7	7	34	48
Total	923	375	985	2283

Yellow-browed Warbler: this species preferred higher vegetation and the 'shrub' habitat type. Significant relationships with habitat type but not with vegetation height were found for Dusky Warbler, Pallas's Leaf Warbler, Black-browed Reed Warbler and Pallas's Grasshopper Warbler. Whereas the latter two species preferred reeds, Dusky Warbler preferred swamp and Pallas's Leaf Warblers both types of forest (deciduous and pine) as well as shrub (Table 2).

Discussion

Our results show that most of the species studied have specific patterns of habitat use, which are likely to be related to food preferences and foraging methods.

The Thick-billed Warbler breeds in dense thickets, bushes, tall grass, the edges and clearings of forests and other wetlands (Dyrzcz 2017a). Our results revealed that neither habitat type nor vegetation height can explain the pattern of occurrence of the species in the study area. The same was found for Radde's Warbler, which breeds in taiga forests with dense undergrowth (Clement 2017a). This result may stem from these species using a variety of habitat types on migration.

The Black-browed Reed Warbler breeds in sedges with clumps of willows and other bushes, tall grass and reed beds (Dyrzcz 2017b) and was also found to use reed beds during migration stopovers at our site. Our results show that this species is more associated with reed beds than the other warblers studied. This shows that the wetlands are very important for the species both in breeding and migratory periods.

Pallas's Grasshopper Warbler breeds in tall grass with tussocks and riverbanks, valley meadows, moist taiga woodland and shrubby steppes (Pearson 2017) and was found to use reed beds during stopover on migration. Therefore, we can say that the species uses wetland habitats both on migration and when breeding.

The Yellow-browed Warbler and Pallas's Leaf Warbler breed in taiga forests and feed within the canopy (Alström *et al* 2018, Clement 2018). Both species feed on insects, which are hunted in forest canopy. However, significant correlation between species occurrence and vegetation height was found

Table 2. Parameters and statistics of the final species-specific models (call: number of birds ~ habitat type + vegetation height + vegetation height²).

Species	Parameter	Estimate	F	P	r ²
Dusky Warbler	habitat type		2.5149	0.0826	0.3860
	deciduous forest	0.00631		0.5360	
	pine forest	0.01736		0.5623	
	reeds	0.02318		0.3798	
	shrub	0.01888		0.4136	
	swamp	0.04438		0.0086**	
Radde's Warbler	none				
Pallas's Leaf Warbler	habitat type		5.3543	0.0062**	0.5724
	deciduous forest	0.00945		0.0172*	
	pine forest	0.02746		0.0155*	
	reeds	0.00194		0.2753	
	shrub	0.02254		0.0259*	
	swamp	0.00707		0.6064	
Yellow-browed Warbler	vegetation height	0.00301	4.6428	0.0479*	0.6468
	habitat type		4.6471	0.0111*	
	deciduous forest	-0.00474		0.7877	
	pine forest	0.03739		0.0970	
	reeds	0.00401		0.6985	
	shrub	0.56532		0.0052**	
	swamp	0.01855		0.1470	
	Black-browed Reed Warbler	habitat type		7.3478	
deciduous forest	0.00002		0.9616		
pine forest	0.00006		0.9529		
reeds	0.00364		0.0001***		
shrub	0.00002		0.9955		
swamp	0.00027		0.6232		
Thick-billed Warbler	none				
Pallas's Grasshopper Warbler	habitat type		3.8665	0.0220*	0.4915
	deciduous forest	0.00019		0.9304	
	pine forest	0.00000		0.9628	
	reeds	0.01467		0.0025**	
	shrub	0.00000		0.9536	
	swamp	0.00247		0.4203	

only for Yellow-browed Warbler. When feeding, both species often hover and snatch insects from the edges of leaves; this foraging method can be used easily in the canopy but would be very difficult in denser vegetation (Forstmeier & Keßler 2001). Pallas's Leaf Warbler was also found in large numbers in the pine forest on migration, indicating that they use the same habitat in both breeding and migratory periods.

The Dusky Warbler breeds in bushes, taiga forests, and wetlands bordering bushes, and feeds in lower vegetation (Clement 2017b). Our results indicate that on migration this species prefers sedges and grassy habitat, unlike the habitats used during the breeding season.

Usually migratory passerines seem to use wider habitat preferences during stopovers than in the breeding period, behaving as generalists in their habitat selection (Bairlein 1983, Vega Rivera *et al* 2003, Chernetsov 2006, Preiszner & Csörgő 2008). Among other species, Wrens *Troglodytes troglodytes* (Hawthorn 1971, 1975) and Blue Tits *Cyanistes caeruleus* (Gyurácz *et al* 2012) use a variety of habitats during migration. In contrast, six of the seven species in our study use the same or similar habitats as in the breeding season, highlighting the importance of protecting a wide

variety of habitats – as different species use different habitats. Three of the seven species associate with wetlands on migration as well as when breeding but, unfortunately, wetlands are among the most endangered habitats of eastern Asia. If the extent of these habitats (reed beds, marshes and other wetlands) were to decrease drastically in future, the population of these species might decrease as well. A recent study estimated that Yellow-browed Warblers need to stop at least six times during autumn migration before reaching their wintering grounds (Sander *et al* 2017), highlighting the importance of abundant habitat availability all along the route.

In eastern Asia the number of sites with natural habitats (particularly wetlands and woodlands) has been drastically reduced and illegal trade and hunting of birds poses a serious threat even to once-common species (Kamp *et al* 2015, Edenius *et al* 2016). Thus, knowledge of year-round habitat use of migratory species is crucial to their future conservation.

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