HABITAT CHARACTERISTICS OF WINTERING WOOD WARBLER (*Phylloscopus sibilatrix*) IN CENTRE REGION OF CAMEROON: CONSERVATION IMPLICATIONS

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ABSTRACT

Populations of many Afro-Palearctic birds have declined, with those wintering in sub-Saharan Africa, such as Wood Warbler *Phylloscopus sibilatrix*, particularly affected. In this study we investigated the relationship between habitat characteristics on Wood Warbler presence/absence in Centre Region of Cameroon. A total of six transects were established in three habitat types (forest, forest-savannah transitional zone and savannah). Call playback surveys were conducted monthly from November 2015 to April 2016 to determine Wood Warbler presence / absence. Detailed habitat measurements were also recorded in each transect. A total of 86 responses were recorded: 33 (mean 6.6 ± 2.3) in forest habitat, 47 (mean 9.4 ± 3.36) in forest-savannah transitional zone, and 6 (mean 2 ± 1.1) in savannah habitat. Wood Warbler presence increased significantly with the number of trees between 3 - 7 m in height, and decreased significantly with the number of shrubs between 0.5 - 3 m in height. Anthropogenic disturbance such as agriculture cycle and burning were not found to have an effect on Wood Warblers presence / absence. We conclude that Wood Warblers

overwinter in forested habitats with a relatively low canopy and an open understorey, supporting a similar study in West Africa. Forest clearance in sub-Saharan Africa potentially threatens wintering habitat for Wood Warblers.

Keywords: Wood Warbler, Wintering habitat, Habitat characteristics

INTRODUCTION

Biodiversity conservation and environmental sustainability have become global priorities that shape international policy (United Nation et al. 2000). Biodiversity faces multiple threats ranging from agricultural expansion, overexploitation, forest fires and habitat fragmentation (Laurance et al. 2009). In many cases, species are particularly vulnerable if their geographic range spans multiple habitats or even continents (Grendelmeier 2011), as is the case with migrant birds.

There is increasing evidence from Europe suggesting that many migrant birds from the African - Palearctic region (Afro-Palearctic migrants) are undergoing population declines (Evans et al. 2012). This decline is more marked in long distance migrants that overwinter in sub-Saharan Africa and breed in Eurasia than short distance and sedentary species (Heldbjerg and Fox 2008). However, the mechanisms leading to the decline of these species are poorly understood (Evans et al. 2012). Moreover, almost nothing is known of the wintering ecology of many species (Hobson et al. 2014).

The Wood Warbler (*Phylloscopus sibilatrix*) is one of such migrants that have undergone a striking population decline (PECBMS 2011). Wood warblers breed in Europe and Central Asia, and winter in Equatorial Africa (Urban et al. 2007). Natural and semi-natural broadleaved as well as coniferous woodland is the preferred breeding habitat, with densities highest where Oak Quercus is dominant (Wesołowski and Bazaars 2009; Mallord et al. 2012a). Wood Warbler populations declined significantly in Europe and between 1990 and 2006 (Vořišek et al. 2008), but it remains obscure whether this pattern of change is due to events in the breeding areas or on wintering grounds, or both. Preliminary data from Great Britain (Mallord et al. 2012a, 2012b) and Switzerland (Gerber 2011; Grendelmeier 2011), do not indicate that changes on the breeding grounds are implicated in declines. Thus, events occurring outside the breeding grounds are likely more important (Hobson 2014). Despite this, the information about their ecology on their wintering ground is poorly known, particularly in Central Africa (Evans et al. 2012; Mallord et al. 2016). In a review of the potential factors that are driving migrant bird declines, Vickery et al. (2014) highlighted the urgent need for detailed studies on the wintering grounds to inform conservation management, where there is a paucity of ecological information for most species. Such is the case with Wood Warbler wintering habitat use which is poorly understood, making it difficult to identify potential threats and hindering conservation efforts. In particular, no studies to date have quantified habitat use throughout the entire wintering period, which could change in response to resource availability and environmental cues.

This paper presents the first systematic study carried out to investigate the relationship between habitat characteristics on Wood Warbler presence/absence in Central Africa. Based on work from West Africa (Mallord et al. 2016), we expected that (1) Wood Warblers would prefer the forest savannah transitional zone, and (2) that anthropogenic activities such as agricultural practices and burning would negatively influence Wood Warblers presence.

MATHERIALS AND METHODS

Study area

The study was conducted in the Centre Region of Cameroon, at three sites that differed in broad vegetation characteristics identified from satellite imagery and assessments on the ground: Batschenga (4°16'60" N 11°39'0" E) characterized by its forest cover, Nachtigal (4°20’48.01″ N 11°38’5.99″ E) characterized by its forest savannah transitional zone cover and Ntui (4°27'0"N 11°37'60" E) characterized by its savannah cover (Figure 1). The study area holds a high diversity of floral species such as Ebony (*Diopyros spp*), Sapelli (*Entandrophragma cylindricum*), Moabi (*Baillonella toxisperma*), White Doussie (*Afzelia pachyloba*), Ayous (*Triplochyton sceroxylon*) and Fraké (*Terminalia superba*). The area has no legal protection status. Two transects of 2 km of length were established in each of the study sites (forest, forest savannah transitional zone and savannah) by non - random sampling based on homogeneity of habitat.

Wood Warblers presence / absence

The data was collected in repeated manner from November 2015 to April 2016 and a day per month was devoted to the visit of each transect. Surveys began at 06:20 am and were completed at 11:00 am; since birds are more active during this period and their detectability is high (Bibby 2000). Along each transect we established 20 listening points at intervals of 100 m measured using a handheld GPS. Given that Wood Warbler have a small size (Hobson et al. 2014) and are easily overlooked when not singing or calling, we used call playback (Sutherland et al. 2004) to increase Wood Warbler detectability. At each station along the transect, the advertising call of Wood Warbler (recording taken from Chappuis 2001) was played using an mp3 player connected to a “Radio Shack” mini Amplifier-Speaker, alternating in all directions during 30 seconds (short period to minimize disturbance) and 10 seconds (to avoid attracting a bird from outside afar). Presence/absence was recorded on a data sheet alongside the GPS position. This method is described by RSPB / BTO in collaboration with Naturama and Ghana wildlife society, in their migrant project (*unpublished*).

Habitat characteristics

Habitat characteristics within 50 m of each point were described with variables referring to habitat structure and anthropogenic activities. Data were collected at all bird survey points, and additionally at 200 m intervals between points. Table 1 below shows the different variables recorded.

Statistical analysis

The effects of habitat structure and land management practices on Wood Warbler presence / absence at a listening point were modelled using a Generalised Linear Mixed effects Model (GLMM) with a binomial error structure. There was no multicollinearity between predictors (r = < 0.6). Continuous fixed effects in the model were *n* trees 3-7 m, *n* trees 7-14 m, *n* trees> 14 m, *n* shrubs 0.5-3 m, *n* shrubs 3 – 5 m, vegetation density (mean of four measurements taken at the cardinal points). Burning period, wood removal and agricultural cycle were included in the model as categorical factors. Continuous fixed effects were mean centred and scaled by 1 standard deviation to compare coefficient effect sizes (β). Point ID nested in transect was included as a random intercept to account for pseudo replication. The minimum adequate model was selected using likelihood ratio tests, and 95% confidence intervals were bootstrapped.

After selecting the minimum adequate model for habitat structure and land management practices, we then tested if there was a seasonal effect on wood warbler presence/absence. This was done by re-running the minimum adequate model with the addition of month as a fixed effect, and also including a two-way interaction between month and each of the remaining habitat structure / land management variables. All analyses were conducted using R (R Core Team 2014) and the lme4 package (Bates et al. 2014).

RESULTS

During the six month survey, a total of 86 responses were recorded. Respectively, 33 (mean 6.6 ± 2.3) responses were recorded in forest habitat, 47 (mean 9.4 ± 3.36) responses were recorded in the forest-savannah transitional zone, and 6 (mean 2 ± 1.1) responses were recorded in savannah habitat (Figure 2).

The maximum number of responses were recorded in January, and by April no birds were detected (Figure 3). In other words, few responses were recorded in November and this gradually peaked over time until the maximum number of records in January, with no responses recorded in April.

Habitat Preferences

The best minimum adequate GLMM (Table 2) for Wood Warbler presence included only the fixed effects of *n* trees 3-7 m and *n* shrubs 0.5-3 m. The probability of Wood Warbler presence was positively correlated with *n* trees 3-7 m ($\beta = 0.45$, $p = 0.014$; Figure 4), and negatively correlated with *n* shrubs at 0.5-3 m ($\beta = -0.66$, $p = 0.019$; Figure 5). Based on β effect sizes, *n* shrubs at 0.5-3 m had a greater influence on Wood Warbler presence. Marginal R^2 for the minimum adequate model was 13%. The number of responses did not vary significantly during the season, and there was no evidence of seasonal changes in habitat preferences based on the interactions tested ($P > 0.05$)

Conditional modes of the intercept for the random effect of study site (Batschenga, forest; Nachtigal, forest-savannah transition; Ntui, savannah) showed that the probability of detecting Wood Warblers was, on average, greatest in the forest-savannah transition zone (Figure 6).

The various anthropogenic activities recorded as potential threat on Wood Warbler habitat in the study area are agricultural activities dominated by perennial cultures (100% in forest, 33,33% in forest-savannah transitional zone and 83,33% in savannah), pasture (5% present only in forest-savannah transitional), bush fires (55% in forest-savannah transitional zone, 45% in savannah and absent in forest), wood removal (40% in forest, 29% in forest-savannah transitional zone, 47% in savannah).

DISCUSSION

This study is the first to investigate Wood Warbler habitat preferences in Central Africa. The majority of responses were recorded in forest-savannah transitional zone with a greater probability of Wood Warbler detection in its two transects (NAT1 and NAT2) than those of others habitats. Our results are consistent with those of Mallord et al. (2016) in similar study in Burkina Faso and Ghana, and Evans et al. (2012) using stable isotope for declining avian migrants wintering habitat investigation. These could be due to the proximity of our forest-savannah transitional zone (in Nachtigal) to Sanaga River, which provide a micro climate, suitable for abundance of a broad insect’s diversity, principal food resources of Wood Warbler. Miguel and Aide (2008) found in Puerto Rico that, Migratory species were mostly abundant in habitats situated near a river. This abundance could be due to the availability of nutritive resources (Lefebvre et al. 1994; Lefebvre and Poulin 1996), characterized by a broad specific insects richness and abundance (Meades et al. 2002), considered as the main food resources of a large number of these migratory species (Russell, 1980; Lefebvre et al. 1994). Also, bioavailability of insects in this habitat could reduce competition between Wood Warbler and others insectivores of the same or different taxa (Moreau, 1952; Miguel and Aide 2008). Furthermore, more than one response was recorded at some listening points, mostly in forest and forest-savannah transitional zone habitats. This observation is similar with those found by Mallord et al. (2016) and suggests that, Wood Warblers are not territorial on the wintering grounds, and forms ephemeral intra- and inter-specific feeding flocks (Mallord et al. 2016).

Effect of wintering period on Wood Warbler presence/absence

A great number of responses were recorded in January, while no response in April. This means that Wood Warbler wintering population is completely installed in January, and return to Europe by end of March and early April. Also we found no seasonal change in habitat preferences of Wood Warbler during its wintering period. Then we could hypothesize that, this Afro Palearctic birds arrive very quickly in Cameroon, setup a non-breeding territory, stay for five months then quickly depart. This fast departure could be justified by the fact that they should synchronize their reproductive period with the time of prey availability on the breeding grounds (Wesolowski and Maziarz 2009).

Effect of Habitat characteristics on Wood Warbler presence/absence

Probability of Wood Warbler detection or presence increased significantly (estimate = 0.45; p = 0.014) with number of trees between 3 - 7 m in height (which were dominant in forest-savannah transitional zone). This result is consistent with those of Mallord et al. (2016) in Burkina Faso and Ghana. This could be due to the fact that Wood Warbler preferred wooded habitat with relative widely-spaced branches to allow movement and foraging (Gerber 2011). Also, spacing between branches requires a certain vegetation height (Glutz von Blotzheim and Bauer 1991). In addition, these trees could provide adequate cover and camouflage, particularly when roosting. Preference for these trees could suggest that Wood Warblers like landscape with open canopy structure which probably increased the physical availability of prey (Mallord et al. 2016). Probability of Wood Warbler detection or presence decreased significantly (estimate = -0.66; p = 0.019) with number of shrubs between 0.5 – 3m in height (which were dominant in savannah habitat). Based on absolute effect sizes, the *n* shrubs 0.5 – 3 m has a greater effect than *n* trees 3- 7 m. This result could be justified by the fact that, a high shrub density obstructs Wood Warbler moving or foraging. In addition, Quelle and Lemke (1988); Delahaye and Vandevyvre (2008); Marti (2007); Hillig (2009); Reinhardt and Bauer (2009) found in Wood Warbler breeding ground that high shrubs density limit the establishment of a dense herb layer, which is necessary to conceal Wood Warbler nests from predators. Furthermore, herb cover and herb height were found to have significant influences on Wood Warbler territory choice (Gerber 2011), yet we found that they weren't have significant influence on Wood Warbler presence/absence in this study. This could be due to contrasting habitat requirements on the breeding grounds and during the overwintering period.

Marginal R^2 for the minimum adequate model was 13%. This means that only 13% of variation in Wood Warbler presence/absence was explained by the most parsimonious model. Suggesting Wood Warbler presence could dependent on other factors that we did not look at. These might include, for example, the availability of food resources or specific tree species. Since Mallord et al. (2016) found a significant correlation between Wood Warbler presence and tree species like *Albizia sp* and *Anogeissus leiocarpus*, this could play an important part in determining Wood Warbler presence that was overlooked during this study.

Anthropogenic activities such as agriculture are amongst the main causes of deforestation in Africa and greater threats on avifauna (Bobo 2007). Agriculture was found in all sites and was dominated by cocoa land, mostly in Forest habitat in Batchenga following by savannah in Ntui. But we found that activities like agriculture and bush fire were not having significant effect on Wood Warbler presence/absence. These results are similar with those found by Mallord et al. (2016). This suggests that species tolerate farm land holding high density of trees. Nonetheless, Wood Warblers, like other Afro-Palearctic migrants could be vulnerable to woodland loss due to the land-use change in tropical Africa (Mallord et al. 2016).

Wood Warblers were mostly found in forest-savannah transitional zone habitat, and prefer forested habitats with a relatively low canopy and an open understory which probably favors the species' foraging strategy. Wood Warbler shows fine-scale selection in terms of tree height, and land-use change and forest clearance in sub-Saharan Africa could therefore be contributing to declines by deforestation of wooded land. We suggest future conservation research to focus on investigating changes in Wood Warbler habitat. This study encourages farmers to retain trees on farmland to increase suitable tree cover on farmland required by Wood Warbler. Also regenerate degraded woodland with a diversity of trees which could help the species and others birds. Furthermore, managing these regenerated forests by incorporating crop rotation, edge type forest, crop activity, given that Wood Warbler avoid close forest and may be consider as species that require adoption of wildlife-friendly farming practices that integrate the needs of birds and people.

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TABLES

Table 1: Variable names and descriptions recorded in each of the three habitats (forest, forest-savannah transitional zone and savannah).

Variable	Description
Dominant land cover	Dominant vegetation: dense forest, open forest, agricultural/natural mosaic, others (arable, bare ground, grassland, plantation, shrub land)
Tree cover	Tree cover: 1 = 0%, 2 = 1 – 4%, 3 = 4 – 15%, 4 = 15 – 40%, 5 = 40 – 65%, 6 = >65%
Tree 3 – 7 m	Number of trees
Tree 7 – 14 m	Number of trees
Tree > 14 m	Number of trees
Shrub cover	Shrub cover: 1 = 0%, 2 = 1 – 4%, 3 = 4 – 15%, 4 = 15 – 40%, 5 = 40 – 65%, 6 = >65%
Shrub 0.5 – 3 m	Number of shrubs
Shrub 3 – 5 m	Number of shrubs
Grass cover	1 = 0%, 2 = 1 – 4%, 3 = 4 – 15%, 4 = 15 – 40%, 5 = 40 – 65%, 6 = >65%
Grass 0.03 – 0.3 m	Grass with height of 0.03 – 0.3 m
Grass 0.3 – 1 m	Grass with height of 0.3 – 1 m
Grass 1 – 3 m	Grass with height of 1 – 3 m
Wood	Evidence of wood removal (whole trees, branches or for charcoal): yes/no

Burn	Evidence of burning, either in this year, the previous year or not at all: yes/no
Agriculture	Evidence of agriculture cycle: 1 = annual, 2 = perennial, 3 = 2 crops / year.
Vegetation density	Mean of four measurements taken at the cardinal points.

Table 2: Habitat characteristics explaining Wood Warbler presence/absence from the best GLMM. β coefficients are given on the link scale (odds-ratios)

Variable	**β**	**-95% CI**	**+95% CI**	**P**
Intercept	-2.57	-3.45	-1.97	< 0.001
***n* trees 3-7m**	0.45	0.04	0.84	0.014
***n* shrubs 0.5-3 m**	-0.66	-1.31	-0.13	0.019

FIGURE LEGENDS

Figure 1: Map of study area and study site in Centre Region of Cameroon.

Figure 2: Average number of responses per habitat

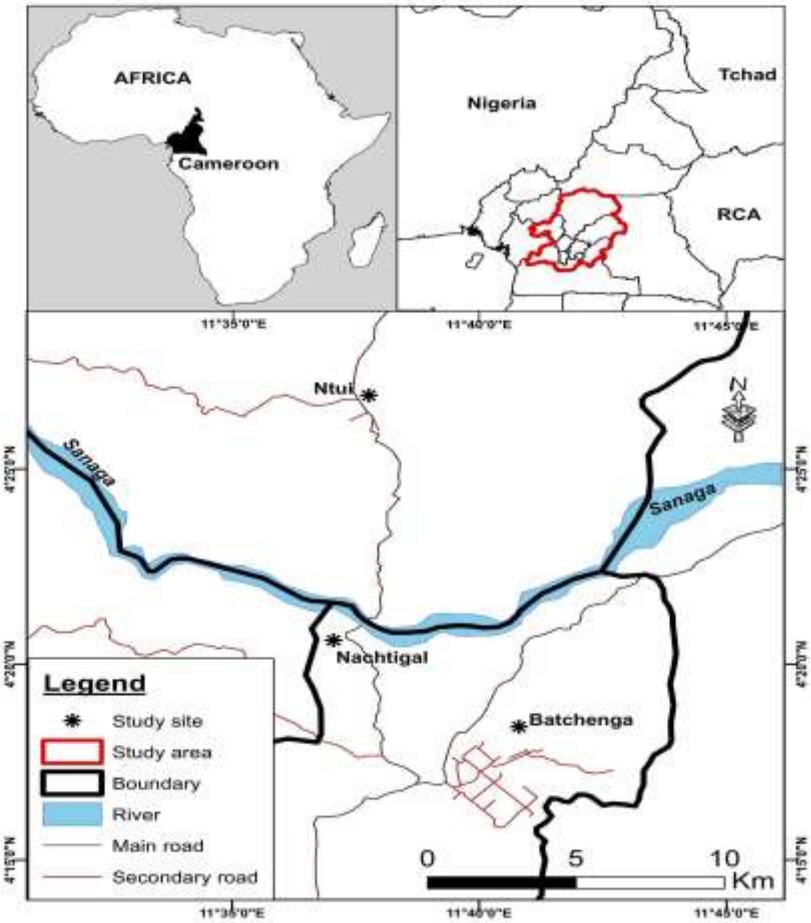
Figure 3: Number of responses recorded per month surveyed

Figure 4: Fitted values (red line +/- 95% CI) from the top GLMM explaining Wood Warbler presence showing the effect of *n* trees 3-7 m on Wood Warbler presence at a survey point. The histograms show the frequency of presence/absence for a given value on the x-axis.

Figure 5: Fitted values (red line +/- 95% CI) from the top GLMM explaining Wood Warbler presence showing the effect of n shrubs 0.5 - 3 m on Wood Warbler presence at a survey point. The histograms show the frequency of presence/absence for a given value on the x-axis.

Figure 6: Conditional modes of the intercept (+/- 95% CI) for the random effect of transect nested in study site extracted from the minimum adequate GLMM explaining Wood Warbler presence. Study site abbreviations are NAT: Nacthigal, BAT: Batschenga and NTUI: Ntui.

FIGURES



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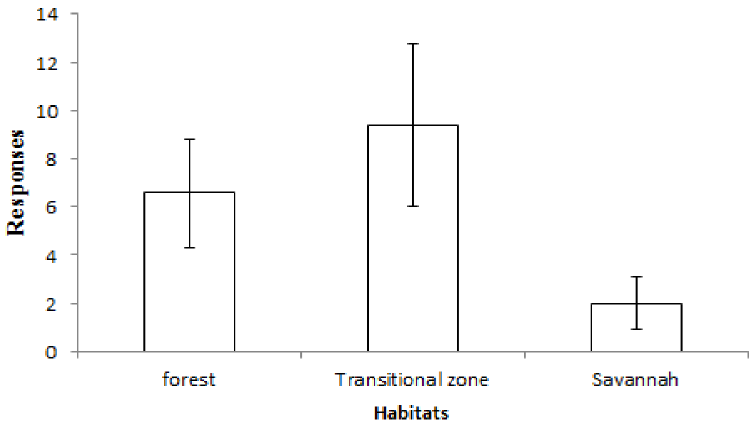
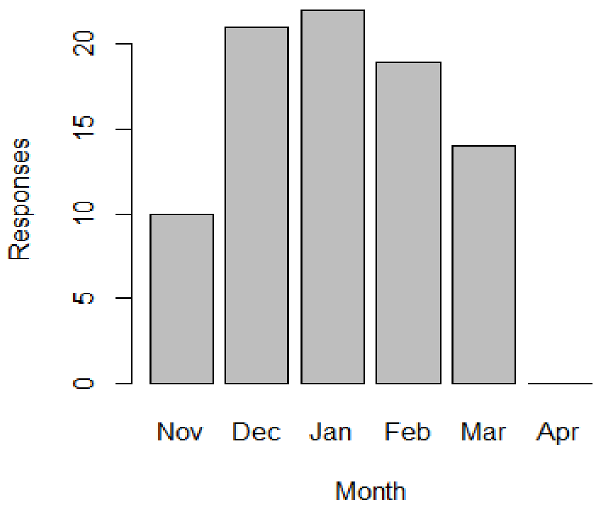


Figure 2: Average number of responses per habitat



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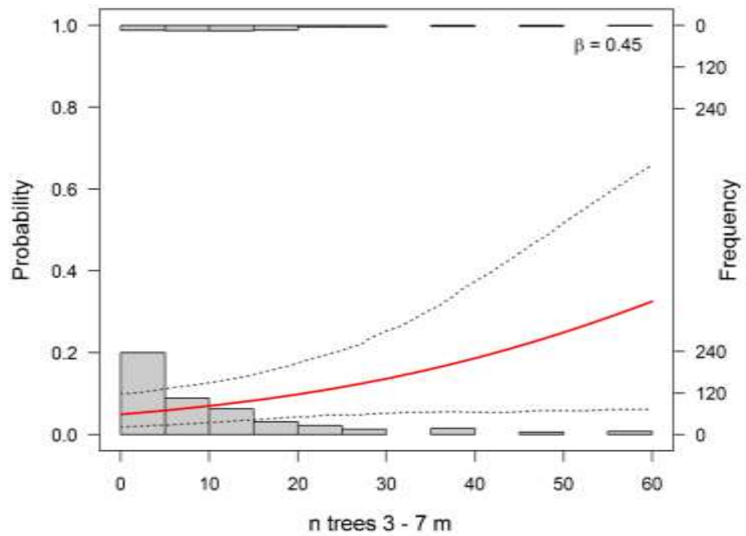

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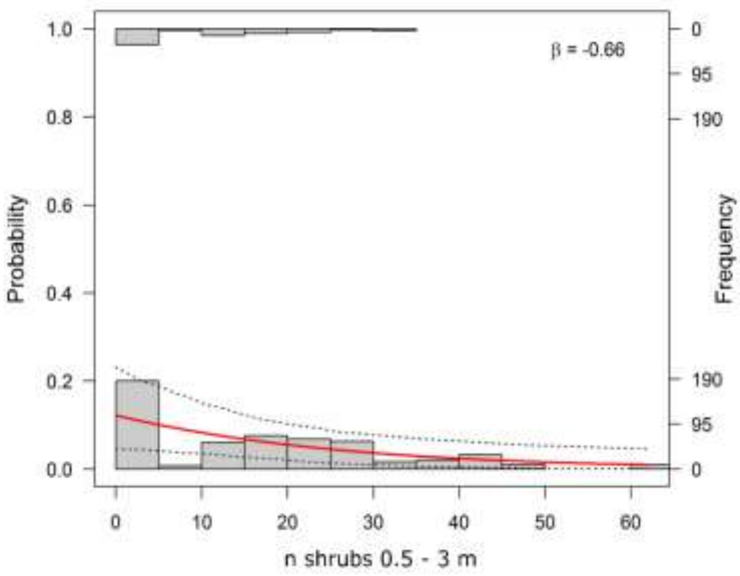

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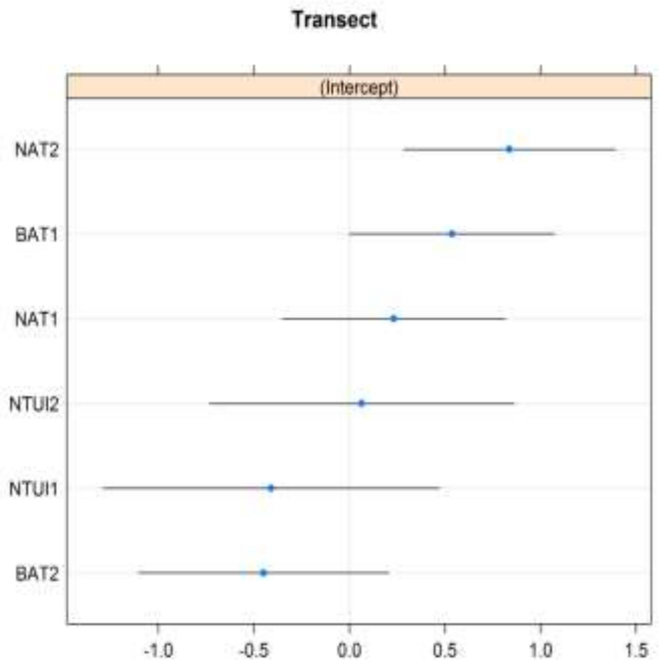

Figure 6: Conditional modes of the intercept (+/- 95% CI) for the random effect of transect nested in study site extracted from the minimum adequate GLMM explaining Wood Warbler presence. Study site abbreviations are NAT: Nacthigal, BAT: Batschenga and NTUI: Ntui.