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HABITAT PARAMETERS AND BREEDING DENSITY OF KRÜPER'S NUTHATCH *SITTA KRUEPERI* PELZELN IN SOUTHERN TURKEY

ABSTRACT: Krüper's Nuthatch (*Sitta krueperi,* Passeriformes) is small-area confined species and it mainly occurs in Anatolia in Turkey, but small numbers are found on the adjacent Lesvos Island and the Caucasus region. It is considered as a "near" threatened species by IUCN. Breeding success of Krüper's Nuthatchs, which use nest cavities excavated by woodpeckers or make their own entrance holes in slightly decayed old tree trunks, is about 72% fledged birds and main food is composed of Coleoptera and Lepidoptera. Although this species is mainly confined to red pine (*Pinus brutia*) forest, it occurs also in the other coniferous habitats. Krüper's Nuthatch was surveyed in four regions of Mediterranean Turkey: the Antalya, Central Taurus, Aladağlar region and Amanos Mountains on an area of 27.9 km^2. Total of 395 point counts were taken in coniferous forests during the breeding season 2005 to explore the factors which affect the population distribution and density. For each point counts following habitat parameters were measured: (1) height of canopy top, (2) height of canopy bottom, (3) tree diameter at breast height, (4) percentage cover (5) average distance between two trees, (6) total number of strata of vegetation and topographic data (altitude, degree of slope, direction of slope, soil texture). The average density of Krüper's Nuthatch recorded in the all sites was 7.38 ± 0.57 birds km^{-2}. However, it differs between regions (ANOVA*; P* <0.0001) with highest density in the Antalya region (12.10 ± 2.10 birds km^{-2}), and a decrease to the east with lowest density in the Amanos Mountains (2.42 ± 0.98 birds km^{-2}). Krüper's Nuthatch breeding density was higher in high altitude and in black pine (*Pinus nigra*) forest. The highest mean density was found in black pine forests (12.69 ±2.4 birds km^{-2}; n = 29), followed by Cilician fir (*Abies cilicica)* forest (11.61 ± 2 birds km^{-2}; n = 39), Lebanon cedar forest (*Cedrus libani*) (8.49 ± 1.8 birds km^{-2}; n = 25) and red pine (*Pinus burutia*) forest (7.75 ± 0.9 birds km^{-2}; n = 188) respectively. We also found a negative correlation between the densities of Krüper's Nuthatch and the total number of strata of the vegetation. High number of the birds occurs in more open coniferous forests. Mature coniferous forests especially black pine forests at high altitudes should be preserved for its conservation in Antalya region.

KEY WORDS: Krüper's Nuthatch, *Sitta krueperi*, distribution, density, Mediterranean region

1. INTRODUCTION

Krüper's Nuthatch (*Sitta krueperi)* is the species confined to rather small area as it is mainly distributed along coastal regions of Anatolia in Turkey; small numbers are found also on the adjacent Lesvos Island and the Caucasus region (Frankis 1991, Hagemeijer and Blair 1997, Handrinos and Akriotis 1997). Krüper's Nuthatch is

mostly sedentary with some post-breeding dispersal and seasonal altitudinal movements (Cramp and Perrins 1993, Harrap and Quinn 1996, Handrinos and Akriotis 1997). However, the species is strictly confined to coniferous habitats (Löhrl 1988, Harrap and Quinn 1996, Hagemeijer and Blair 1997). Krüper's Nuthatch is categorized as Species of European Conservation Concern 4 (Tucker and Heath 1994), 'Near Threatened' species (IUCN 2006) and is listed in the Greek Red Data Book (Karandinos and Paraschi 1992). In previous study, the diameter at breast height of nesting trees averaged 50.6 cm. The species makes use of the nest cavities excavated by woodpeckers, or makes its own entrance holes in slightly decayed, old tree trunks. The breeding success of Krüper's Nuthach in Red pine and Lebanon cedar forests was found to be 71.6 ± 7.8% fledged birds and main food for nesting birds were Coleoptera (33%) and Lepidoptera (14%) (Albayrak and Erdogan 2005).

Low-elevation ecosystems support more non-migratory bird species at higher densities (Herbers *et al.* 2004) and marginal distribution of bird species has low bird density (Tomiałojć 2005). We don't know the breeding density and habitat preferences of Krüper's Nuthach in Anatolia. We measured the density of the species and its habitat components in order to explore the habitat components which affect the distribution and the density of Krüper's Nuthatch in different kind of coniferous stands.

2. STUDY AREA

The study areas were located in the southern part of the Mediterranean region of Turkey, in the west and central Taurus Mountains. Four areas were selected: the Antalya region, Central Taurus, the Aladağlar region, and the Amanos Mountains (Fig. 1). All areas were located within a steep topography ranging from sea level to 3750 m a.s.l. Twenty six per cent of the whole study area of 172 km^2 is wooded, and of these 29% were coniferous stands, dominated by red pine (*Pinus brutia* Ten.) – 73%, black pine (*Pinus nigra* Arnold.) – 22%, Cilician fir (*Abies cilicica* Carr.) – 5%, and Lebanon cedar (*Cedrus libani* A.Rich.) – 1%. Collected forest types in sample points in each study area were given as percentage of conifers composition in Fig. 2. The climate of the area is typically Mediterranean with hot and dry summers and temperate and rainy winters.



Fig. 1. Location of study areas and density of Krüper's Nuthatch. A – Antalya region, B – Central Taurus, C – Aladağlar region and D – Amanos Mountains.

Prediction of Krüper's Nuthatch density was calculated using stepwise regression model with eight variables, Alt, BC, TC, DeS, DbH, CP, ADbT, TNSV. DenKN values were calculated using the following equation:

$$DenKN = n / \pi r^2 = birds\ km^{-2},$$

where n is the number of the individuals detected along the point, r is the fixed radius (0.15 km).

All statistical tests were performed using SPSS 11.5 (Norusis 2002). Results are presented as means ± SE, and P <0.05 is set for significance.

4. RESULTS

4.1. Overall population density and distribution

Krüper's Nuthatches were found in all four study sites (Fig. 1), and they were present at 147 of the 395 sampled census points. Average DenKN across all sites was 7.38 ± 0.57 birds km^{-2}. Densities were significantly different among sites (ANOVA; P <0.0001) with highest DenKN in the Antalya region, and a decrease to the east with lowest DenKN in the Amanos Mountains (Table 1). We found a

Table 1. Habitat parameters and Krüper's Nuthatch *Sitta krueperi* breeding density (DenKN) in study areas (Fig. 1), (south eastern Turkey): Alt – altitude, TC – height of canopy top, BC – height of canopy bottom, DbH – diameter at breast height, CP – percentage of canopy coverage, ADbT – mean distance between two trees, TNSV – total number of strata of vegetation, DeS – degree of slope, ST – soil texture; results are given as a mean ±SE, n – samples size.

Parameter	Study Areas				ANOVA test
	Antalya region	Middle Taurus	Aladaglar region	Amanos Mountain	
DenKN (birds km^{-2})	12.10 ± 2.10 n = 55	9.31 ± 1.47 n = 73	6.51 ± 0.65 n = 226	2.42 ± 0.98 n = 41	$F_{3,391}$=7.395 P = 0.000
Alt (m)	1182 ± 69 n = 55	800 ± 55 n = 73	868 ± 21 n = 226	560 ± 47 n = 41	$F_{3,391}$=22.202 P = 0.000
TC (cm)	2044 ± 84 n = 48	2012 ± 67 n = 59	1761 ± 33 n = 157	1700 ± 49 n = 18	$F_{3,278}$=7.769 P = 0.000
BC (cm)	199 ± 2 n = 48	252 ± 23 n = 59	358 ± 20 n = 157	165 ± 4 n = 18	$F_{3,278}$= 10.912 P = 0.000
DbH (cm)	46 ± 2 n = 48	48 ± 2 n = 59	48 ± 2. n = 157	38 ± 1 n = 18	n.s
CP (%)	67.7 ± 3 n = 48	55.1 ± 2 n = 59	62.3 ± 1 n = 157	55 ± 1 n = 18	$F_{3,278}$=5.775 P = 0.001
ADbT (cm)	250 ± 0 n = 6	n = 0	589 ± 21 n = 139	350 ± 12 n = 18	$F_{3,160}$=14.393 P = 0.000
TNSV	2.81 ± 0.17 n = 48	2.71 ± 0.08 n = 59	3.01 ± 0.05 n = 157	3 ± 0 n = 18	$F_{3,278}$=2.953 P = 0.033
DeS	23 ± 1 n = 48	24 ± 2 n = 59	23 ± 1 n = 157	35 ± 1 n = 18	$F_{3,278}$=10.036 P = 0.000
ST	2.6 ± 0.2 n = 48	3.5 ± 0.1 n = 59	3.7 ± 0.1 n = 157	3.5 ± 0.1 n = 18	$F_{3,278}$=24.805 P = 0.000

Table 2. Correlation coefficients between the habitat parameters and Krüper's Nuthatch *Sitta krueperi* breeding density (DenKN) along coastal regions of Anatolia, Turkey (for abbreviations – see Table 1).

Parameter	DenKN (birds km^{-2})	Topographic data			Tree species				
		Alt	DeS	ST	TC	BC	DbH	CP (%)	ADbT
Longitude[1]	0.23**								
Alt	0.283**								
DeS	–0.132*	–0.225**							
ST	–0.252**	–0.408**	0.016						
TC	–0.077	0.034	0.021	–0.108**					
BC	0.059	–0.199**	–0.090	0.266**	0.298**				
DbH	0.029	0.168**	0.128*	–0.098	0.370**	0.051			
CP(%)	0.040	0.386**	–0.023	–0.318**	–0.146*	–0.197**	0.047		
ADbT	0.100	0.203**	0.165*	–0.043	0.311**	0.202**	0.330**	–0.525**	
TNSV	–0.194**	–0.007	0.120*	0.003	0.197**	–0.200**	0.241**	0.368**	–0.075

[1]: from west to east; *P <0.05; **P <0.01

significant positive correlation between DenKN and the areas, from west, Antalya region, to east, Amanos Mountains region (r = 0.23 P <0.01). Bird density correlated positively with longitude and Alt and negatively with DeS, ST, and TNSV (Table 2).

4.2. Habitat characteristics

Habitat parameters were significantly different among four study sites, except for mean values of DbH (Table 1). The slopes in the Amanos Mountains were steeper (35 ± 1.2°, 50% S, 50%W direction of slope) than in the other areas ($F_{3,278}$= 10.036, P <0.001). ST of the Antalya region was significantly different from the other areas ($F_{3,278}$= 24.805, P <0.001), with mainly stony soil (36.5% of 20–200-mm sized gravel (Table 1). Habitat parameters were significantly different among the forest types (Table 3).

4.3. Habitat related density

Krüper's Nuthatches were recorded in all four coniferous stands – red pine, black pine, Cilician fir, and Lebanon cedar. DenKN in the various pine stands did not differ significantly ($F_{3,277}$= 2.166, P = 0.92). Highest mean DenKN was found in black pine stand (12.7 ± 2.4 birds km^{-2}; n = 29), followed by Cilician fir (11.6 ± 2 birds km^{-2}; n = 39), Lebanon cedar (8.5 ± 1.8 birds km^{-2} n = 25), and red pine (7.8 ± 0.9 birds km^{-2}; n = 188) stands, respectively.

DenKN and Alt in each forest type was given as boxplot graph (Fig. 3). Correlations between DenKN and habitat characteristics are shown in Table 2. We found a significant negative correlation between DenKN and DeS, ST, and TNSV and a positive correlation with Longitude and Alt (Table 2, Fig. 3). Also, Alt and BC positively and TC negatively proved to be the strongest predictors of Krüper's Nuthatch density in

Table 3. Habitat parameters and Krüper's Nuthatch *Sitta krueperi* breeding density (DenKN) in forest types. All study areas together (for abbreviations – see Table 1).

Parameter	Red pine *Pinus brutia*	Black pine *Pinus nigra*	Lebanon cedar *Cedrus libani*	Cilicica fir *Abies cilicica*	Total	ANOVA
DenKN (birds km^{-2})	7.75 ± 0.9 n = 188	12.69 ± 2.4 n = 29	8.49 ± 1.8 n = 25	11.61 ± 2 n = 39	8.87 ± 0.7 n = 281	$F_{3,277}$= 2.166 P = 0.092
Alt (m)	622 ± 24 n = 188	1408 ± 55 n = 29	1404 ± 23 n = 25	1317 ± 10 n = 39	869 ± 27 n = 281	$F_{3,277}$= 144.217 P= 0.000
DeS	24.3 ± 0.6 n = 188	25.3 ± 1.6 n = 29	16.8 ± 2.1 n = 25	26.9 ± 1.5 n = 39	24.1 ± 0.5 n = 281	$F_{3,277}$= 7.235 P = 0.000
TC (cm)	1882 ± 27 n=188	1572 ± 58 n=29	1924 ± 161 n = 25	1931 ± 105 n = 39	1860 ± 28 n = 281	$F_{3,277}$= 4.215 P = 0.006
BC (cm)	377 ± 17 n = 188	183 ± 5 n = 29	110 ± 9 n = 25	117 ± 16 n = 39	297 ± 13 n = 281	$F_{3,277}$= 33.495 P = 0.000
DbH (cm)	44 ± 1 n = 188	40 ± 1 n = 29	39 ± 4 n = 25	70 ± 8 n = 39	47 ± 1 (n = 281	$F_{3,277}$= 20.326 P = 0.000
CP (%)	54.8 ± 1.1 n = 188	54.1 ± 2.1 n = 29	86.4 ± 1.1 n = 25	81.0 ± 1.2 n = 39	61.2 ± 1.1 n = 281	$F_{3,277}$= 79.855 P = 0.000
ADbT (cm)	550 ± 21 n = 115	950 ± 0 n = 10	309 ± 36 n = 17	557 ± 52 n = 21	550 ±19 n = 163	$F_{3,159}$= 19.402 P = 0.000
TNSV	2.9± 0 n = 188	1.9 ± 0.2 n = 29	3.9 ± 0.2 n = 25	3.3 ± 0.1 n = 39	2.9 ± 0 n = 281	$F_{3,277}$= 59.567 P = 0.000

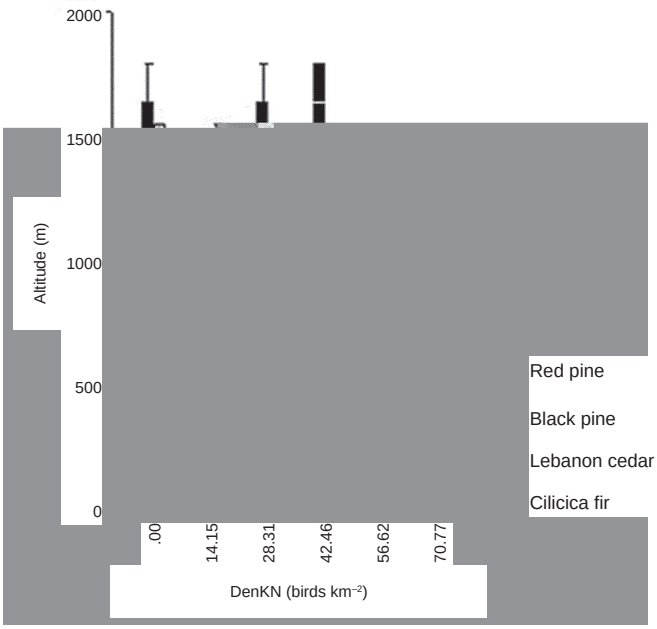


Fig. 3. Boxplot graph of altitude and Krüper's Nuthatch *Sitta krueperi* breeding density (DenKN) on coniferous forest types in study areas, south eastern Turkey.

a stepwise regression model (Table 4). DeS, DbH, CP, ADbT, TNSV were excluded in the stepwise regression model.

5. DISCUSSION

The results show that Krüper's Nuthatch occured mostly at higher altitude and in slightly more open forests and stands with lower number of strata (Table 2) in the southern coniferous forest region of southern Turkey. Mature forests usually are located at high altitudes. Krüper's Nuthatch does occur at higher density at higher elevations in breeding season but it moves to lower elevations during the strong winter period. The general result proves the idea that low-elevation ecosystems support more non-migratory bird species at higher densities (Herbers *et al.* 2004). Although Frankis (1991) mentioned that the distribution of Krüper's Nuthatch and of red pine forests were very closely related, we found the highest density in black pine forest followed by Cilician fir and Lebanon cedar forests, and the lowest one in red pine forests respectively.

Density of Krüper's Nuthatch decreased with longitude from west to east. The low density of Krüper's Nuthatch in the Amanos Mountains might be related to the fact that coniferous forests, namely red pine forests, reach here their eastern-most distribution range. Highest density of Krüper's Nuthatch was found in the Antalya region, where black pine dominated (42%). The Antalya region also differs significantly form the other study sites by altitude, soil texture, and partly by height of canopytop, height of canopy bottom, percentage of canopy coverage, and degree of slope. Although highest within our study, the average density of Krüper's Nuthatch in the Antalya region (*ca.* 12 birds km^{-2}) was lower than reported for closely related Corsican Nuthatch (*Sitta whiteheadi* Sharpe, 1884) in black pine forests of Corsica (15.8 pairs km^{-2} – Thibault *et al.* 2002).

In our study, Krüper's Nuthatch was recorded solely in coniferous stands with maximum density in black pine forests. The preference of coniferous stands is similar to that for Corsican Nuthatch which was mainly found in Corsican pine forest (*Pinus nigra laricio*) (Thibault *et al.* 2002, Villard *et al.* 2003). Also Pygmy Nuthatch (*Sitta pygmaea* Vigors 1839), and Brown-headed Nuthatch (*Sitta pusilla* Lathan 1790), are indigenous to coniferous forests (Cramp and Perrins 1993, Harrap and Quinn 1996, Matthysen 1998, Pasquet 1998, Wilson and Watts 1999). In contrast, Eurasian Nuthatch (*Sitta europaea* L. 1758), breeds mostly in deciduous stands, while coniferous patches were seldom used by this species in Bialowieza National Park (Wesolowski and Rowinski 2004). Birds density reflected the changes in quality and location of food resources (Ciach and Bylicka 2009). Krüper's Nuthatch distribution and density may be influenced by the seed crops of preferred coniferous trees.

Due to its specialized habitat requirements, Krüper's Nuthatch could be assessed as very vulnerable to changes in the distribution and composition of coniferous habitats. Therefore, understanding the relationship between the species' requirements and forest composition and structure is crucial for understanding the consequences of habitat alterations on the population development of

Table 4. The strongest predictors of Krüper's Nuthatch *Sitta krueperi* breeding density (DenKN) in stepwise regression model (Alt – altitude, TC – height of canopy top, BC – height of canopy bottom).

	Standardized coefficients Beta	Std. Error	t	*P*
(Constant)		4.065	1.677	0.096
BC	0.417	0.003	5.618	0.000
Alt	0.305	0.002	4.401	0.000
TC	–0.221	0.002	–2.971	0.003

Dependent variable: DenKN (birds km^{-2})

Krüper's Nuthatch in its main range in Mediterrean region. Mature coniferous forests especially black pine forests at high altitudes should be preserved for its conservation especially in Antalya region.

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