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# Breeding habitat selection of the Black Woodpecker *Dryocopus martius* L. in Mediterranean forests

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**Abstract** – The Black Woodpecker has a wide northern Palearctic range, but in much of western Europe it has a highly fragmented distribution. As these isolated populations are vulnerable to land cover change, a better understanding of the factors driving their presence is needed in the perspective of conservation. To shed light on the habitat preferences of the Black Woodpecker in the southern part of its range, we carried out a research in a large protected area, the Cilento and Vallo di Diano National Park (the first investigation on this species anywhere in southern Italy). We used a playback technique to detect occurrence of Black Woodpeckers, as well as sympatric woodpecker species, and recorded environmental characteristics that might explain the bird's occurrence, such as tree species and stand age. The "extent of occurrence" of the Black Woodpecker was calculated, and its habitat preferences investigated. Occurrence of the species was clearly dependent on beech dominance, in contrast with the other woodpecker species, with an estimated total population for National Park 18.56 (± 6.19) pairs in beech-dominated woods. Habitat preferences were narrower compared to northern European populations, highlighting the dependence of this species on beech forests in southern Europe. Since beech forests in the Mediterranean region are predicted to recede due to climate change, our findings highlight the vulnerability of southern Black Woodpecker populations.

**Key-words**: beech, climate relict, extent of occurrence, Picidae.

## INTRODUCTION

Due to their ecological importance and high sensitivity to disturbance that affects other components of avifauna, woodpeckers have been identified as a particularly important conservation target (Drever & Martin 2010, Mikusiński *et al*. 2001). Woodpeckers are good indicators of forest biodiversity as their presence is representative of the condition of the forest and its overall environmental health (Angelstam 1990, Mikusiński 1997). The considerable reduction of deadwood not only at the stand but at the landscape level is considered to be one of the principal causes of biodiversity loss in managed forest ecosystems worldwide. The presence of woodpecker assemblages and their association with standing deadwood for both nesting and foraging is used to emphasize the importance of the entire range of snag degradation stages for maintenance of key ecological processes in habitat remnants of managed landscapes (Drapeau *et al*. 2009).

One of the most widely distributed woodpecker species is the Black Woodpecker *Dryocopus martius* L., whose global range extends from Europe through the taiga forest belt into Asia, with a core area between 62° and 69° N (Winkler *et al*. 1995). Black Woodpecker usually utilizes tall and large trunks of many coniferous and broadleaved trees forming extensive unbroken forests (Glutz & Bauer 1980, Cramp 1985). Habitat use is possibly related to its peculiar food requirements, especially carpenter ants (Formicidae) (Cuisin 1988, Ceugniet 1989, Pechacek & Krisvtin 1993, Rolstad & Rolstad 2000).

In Europe it ranges from the Arctic Circle region to southern Italy, using a wide variety of tree species for feeding and nesting (Angelstam 1990). In contrast with this overall wide distribution, however, populations in the southern part of the range, including the Iberian, Italian and Balkan peninsulas, are often small and fragmented (Brichetti & Fracasso 2007, Aierbe *et al*. 2014). Animal populations at range margins are especially vulnerable to environmental modification, e.g. due to climate change, and may differ from core populations in ecological preferences and therefore conservation requirements (Hampe & Petit 2005). This is exemplified by the contrast between the large Black Woodpecker population in northern Italy, with an estimate of 1,300-3,700 breeding pairs mainly located in forested Alpine and sub-Alpine regions, and the small fragmented populations in the southern Apennines (Nardelli *et al.* 2015).

Northern Italian population appears in expansion and in the last twenty years there has been a progressive colonization of hilly areas and, in some cases, planitial, by this species, once relegated to the mountain forests (Nardelli *et al.* 2015), whereas poor information is known about southern population.

Reasons for this might go beyond climatic factors, as for instance only occasional records have been reported from the Abruzzo, Latio and Molise National Park, despite the abundance of suitable old beech *Fagus sylvatica* forest habitat. A long history of hunting may explain why the Black Woodpecker is largely absent today from much of peninsular Italy (P. Harris in Gorman 2011). Small size of suitable forest fragments is also an important limiting factor for this species, as shown in the Iberian Peninsula (Garmendia *et al*. 2006).

In order to improve our understanding of Black Woodpecker habitat requirements in southern Europe, we investigated its presence and habitat in a large protected area in southern Italy using the playback technique. The specific objectives of our study were: a) to test the relationship between the species occurrence and forest structure characteristics, b) to determine its extent of occurrence (EOO).

## MATERIALS AND METHODS

### Study area

The study area, "Parco Nazionale del Cilento, Vallo di Diano e Alburni", henceforth referred to as the Cilento National Park, is one of the largest protected areas in southern Europe, it extends from sea level to 1899 m a.s.l. of Cervati mountains and is of outstanding ecological interest due to its diverse range of habitats and the high biodiversity it supports (La Valva & Carrabba 1999, Persiani *et al*. 2010, Ravera & Brunialti 2012, Romano *et al*. 2010). Established in 1991, it covers an area of about 180,000 hectares encompassing a wide range of vegetation types. About 1,800 plant species were surveyed in the park, among which Yew *Taxus baccata*, Holly *Ilex aquifolium* and an Italian endemism, the Neapolitan Alder *Alnus cordata*. The inland area is covered by deciduous hardwood forests, with a mix of Turkey Oak *Quercus cerris*, Downy Oak *Quercus pubescens*, Maples *Acer* spp., Hornbeam *Ostrya* spp., Manna Ash *Fraxinus ornus* and Chestnut *Castanea sativa* up to about 1000 m above sea level. Beyond this elevation, beech *F. sylvatica* dominates, usually preceded by a band of Neapolitan Alder.

### Woodpecker survey

For this study, the park was divided into 2.5 × 2.5 km grid plots using ArcGIS. Although a Black Woodpecker's home range may vary in size, depending on the region, plot size was based on an average of the minimum home range sizes known for Europe (western Italian Alps: 3 $km^2$, Bocca & Rolando 2003; Sweden: 5 $km^2$, Tjernberg *et al*. 1993; Norway: 1 $km^2$, Rolstad *et al*. 2000; Denmark: 1.30 $km^2$, Johansen 1989; Hungary: 2 $km^2$, Gorman 2011). A first selection of 104 grid plots was made, on the criterion that each plot had to be at least 50% covered by woodland. All woodland types in the park were included, as the Black Woodpecker is known to occur in many forest types (Angelstam & Mikunsinski 1994). Subsequently, 34 plots were randomly selected and investigated (Fig. 1).

The plots were surveyed one time between February and March 2012, as courtship in the Black Woodpecker can start anytime from February (Cramp 1985). The playback technique (Falls 1992, Douglas and Mennill 2010) was used to record the number of individuals of the Black Woodpecker. Sounds used for play-back were taken from Roché (2008). An initial play-back was followed by five minutes of silence in order to detect any response; the operation was then repeated once. The procedure was used for other Woodpecker species in this order: *Leiopicus medius*, *Dryobates minor*, *Dendrocopos major*, *Picus viridis.* Although the sampling period may not have been optimal for these species, European woodpeckers are essentially non-migratory and sedentary birds (Gorman 2011), and so we opportunistically also detected their presence.

Since our main target species is highly territorial, the location of breeding territories was used as a census proxy, i.e. a targeted census (Svenssons 1979, Bibby *et al*. 1992). We investigated the effect of the different forest variables on Black Woodpecker during the breeding season. Therefore, the conclusions that may be drawn from our data are relevant to the territories used for breeding and not necessarily to the habitats exploited during other seasons; however all woodpeckers are predominantly sedentary, especially the fragmented population (Gorman 2011).

### Habitat evaluation

In each plot a set of environmental variables was measured, including forest characteristics and elevation. Forest type was identified based on the tree species assemblage as one the following: Beech, Chestnut, Holm Oak-Alder, deciduous oaks, deciduous oaks and beech, mixed-oak, and mixed-Mediterranean forest. Stand maturity was

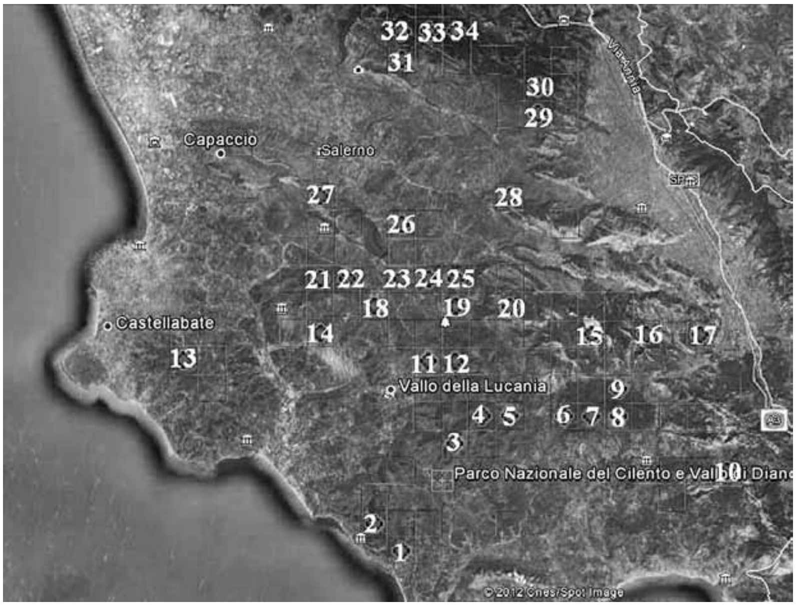


**Figure 1**. Study area in Cilento National Park, Southern Italy. Red squares are the parcels established at the beginning of the study, with numbers marking those selected for the field survey.

classified on a discrete scale from 1 to 3, from recent (< 15 years) coppice to mature stands. Likewise, beech density and presence of dead trees were classified from 1 (no living beech trees and no dead trees detected, respectively) to 3 (beech-dominated, i.e. virtually only beech as arboreal species, and over 10 dead trees per km$^2$ respectively).

**Analysis**

Occurrence, habitat use and population size of the Black Woodpecker and other co-occurring *Picidae* were investigated in a subset of 34 plots randomly selected from the initial set of 104 grids. To highlight potential differences in plot use among the five woodpecker species surveyed, we performed Principal Component Analysis (PCA) on species presence/absence data (five species) using plots as sites. A generalised linear model (GLM) with a binomial distribution of errors and a clog-log link function was used to model the probability of recording a Black Woodpecker in relationship to beech tree density, presence of dead trees and woodland age. Each of the explanatory variables was dropped in turn and subjected to an analysis of deviance using Chi-square tests to assess its significance. Values were considered significant at a 5% probability level, and variance explained by the model was calculated as the ratio of the difference between null and residual deviance to null deviance (Zuur *et al*. 2009). GLM estimates are presented as means ± standard errors.

Based on our field data, we used kernel estimation to evaluate the EOO of the Black Woodpecker in Cilento. This technique was chosen because it is one of the best known in statistics (Börger *et al.* 2006) and is the main choice for modern studies of animal-habitat relationships (Marzluff *et al.* 2004). We adopted the fixed kernel method for bivariate data as recommended by Seaman & Powell (1996). Regarding the choice of the bandwidth, a parameter showing a very strong effect on kernel estimation (Seaman & Powell 1996, Burgman & Fox 2003, Börger *et al.* 2006), as it regulates its smoothing, we followed the 'rule of thumb' proposed by Scott (1992):

- $h_{opt} = 1.06An^{-1/5}$ where $h_{opt}$ = optimal bandwidth;
- n = sample size;
- A = min (standard deviation, interquartile range/1.34).

Following the recommendation of Börger *et al.* (2006) to adopt a utilization distribution isopleth between 90% and 50% (the range in which kernel estimators perform better), we chose a 50% isopleth to calculate the external range boundaries. Statistical analyses and kernel estimations were performed in R 2.15.3 (R Development Core Team, 2012; maptools and Genkern packages).

In addition we estimated density of Black Woodpecker in beech-dominated woodland dividing the number of birds by the explored area and assuming the every birds contacted represented a pair (see Douglas & Mennill 2010). Based on the total number of plots identified as beech-dominated, pairs were estimated to occur across all beech forests in the Cilento National Park.

## RESULTS

Black Woodpeckers were recorded in 10 out of 34 plots. In nine of these only one individual was found, and only in one two distinct males were recorded. Most individuals were found in beech-dominated plots, with only three found in mixed-oak forest. PCA suggests that the Black Woodpecker shows markedly different habitat preferences from the other four species in the study area (Fig. 2). The first two axes together account for 63% of the variation in the woodpecker assemblage. The first axis was positively correlated with beech density (Spearman's r = 0.34, p = 0.05), while neither the first nor the second axis were significantly correlated with stand age or the presence of dead trees (r < 0.1, p > 0.1) According to the GLM, the probability of recording a Black Woodpecker was significantly related to increasing beech dominance (p < 0.01), increasing from 8.9 ± 6.5% in areas without living *F. sylvatica*, to 56.2 ± 13.51% in areas with complete *F. sylvatica* cover (Fig. 3), whereas it was influenced by neither stand age (from 27.3 ± 21.9% in young coppice to 29.5 ± 7.9% in mature stands, p = 0.7), nor presence of dead trees (from 33.3 ± 10.2% in absence of dead trees to 23.1 ± 11.7% with over 10 dead trees per km$^2$, p = 0.7). The final model with beech dominance explained 20.4 % of the total variance in Black Woodpecker occurrence, and its residual variance was 32.16 on 31 degrees of freedom (ratio = 1.04), therefore indicating no over dispersion.

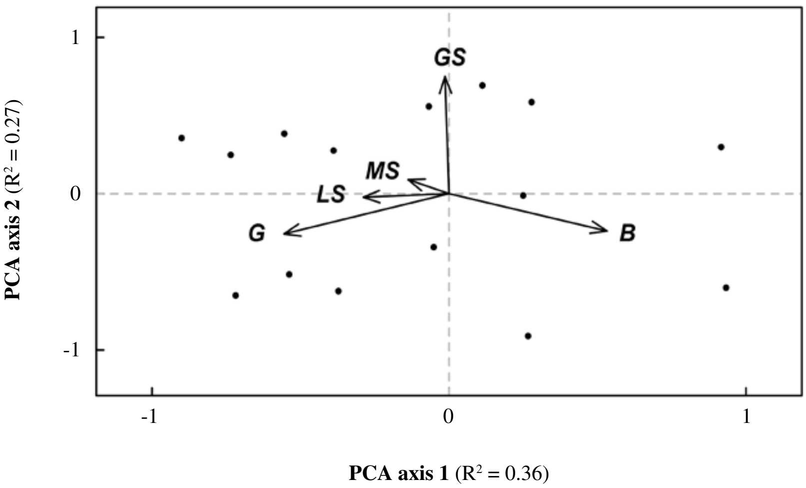


**Figure 2**. Principal component analysis based on presence of five woodpecker species in the study area. Black dots represent the sampled parcels (n = 34). Parcels where the same bird numbers were recorded overlap. Arrows refer to the species, with the following abbreviations: B = Black Woodpecker *Dryocopus martius*; GS = Great Spotted Woodpecker *Dendrocopos major*; MS = Middle Spotted Woodpecker *Leiopicus medius*; LS = Lesser Spotted Woodpecker *Dryobates minor*; G = European Green Woodpecker *Picus viridis*. The eigenvalues for the first, second, and third axes are, respectively, 0.355, 0.266 and 0.170.

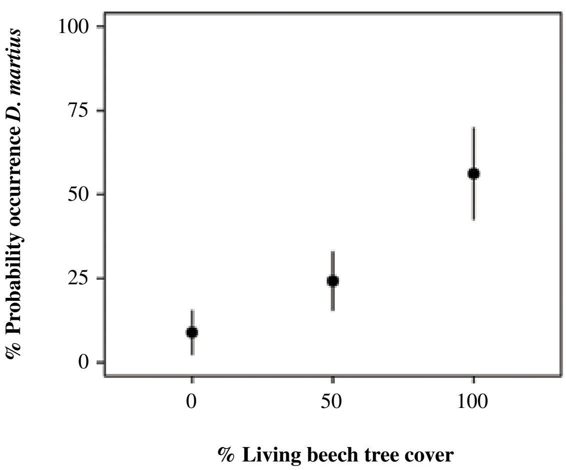


**Figure 3**. Probability of observation of the Black Woodpecker *Dryocopus martius* in Cilento National Park as related to beech *Fagus sylvatica* density. The shading represents the 95% confidence region around the mean estimate (solid line).

Black Woodpecker density in beech-dominated woodland was estimated at 0.09 (± 0.03) pairs per km$^2$. Based on the total number of plots identified as beech-dominated, 18.56 ± 6.19 pairs were estimated to occur across all beech forests in the Cilento National Park. According to the EOO, the species is mainly distributed in the northern part of the Cilento Park, especially in proximity to the Alburni and Cervati mountains (Fig. 4).

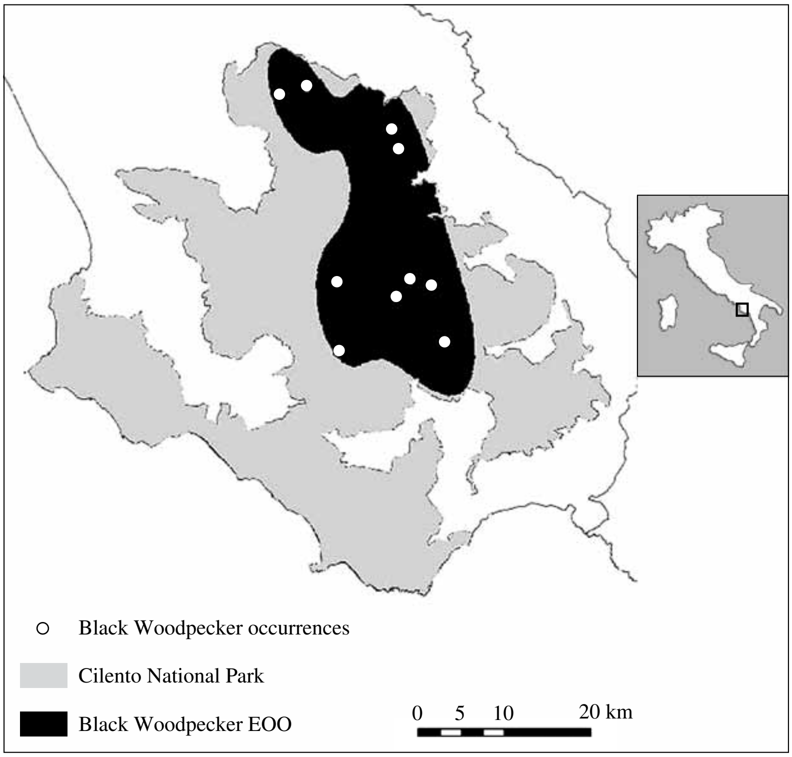


**Figure 4**. Extent of occurrence of the Black Woodpecker in Cilento National Park study area.

## DISCUSSION

In our study sites, the Black Woodpecker used plots dominated by *F. sylvatica*, as the probability of recording an individual was significantly higher with increasing beech tree density. Conversely, woodland age did not influence its occurrence. This may well be partly due to the presence of very old trees in old non-productive snow deposits used in the past. Indeed, these could be perfect breeding sites also in young forests, where it is easier for woodpeckers to find ants (Mikusinski 1997). Species presence clearly corresponded to the Alburni and Cervati mountains (Fig 4), likely to be the only two locations in the national park where suitable large trees in which to excavate nest holes can be found. One caveat is that non-detection may not necessarily indicate true absence as assumed in our analysis.

Our results indicate that the Black Woodpecker has different habitat preferences at our study site when compared to more northerly sites across Europe, where broader tree species choices have been recorded (Angelstam & Mikunsinski 1994). This is in line with studies in the Italian Alps which recorded a different habitat choice as compared with the Pyrenees and other parts of Europe (Bocca *et al*. 2007). Therefore, the Black Woodpecker's habitat choice appears to be context-dependent. This implies that local data should be preferred for woodland management aiming to address this species' conservation, as opposed to data from other populations.

The Black Woodpecker appears to be a specialist regarding habitat choice, with a strong selectivity for beech-dominated stands. Such habitat use differed from that of the other co-occurring species of Picidae (Fig. 1). This difference is probably due to the breeding ecology of Black Woodpecker with respect to other woodpecker species: only in beech forest it may find large enough trees in which to excavate cavities, as the other forest types are over-exploited and offer few suitable trees for nesting.

Although overall Italian population of Black Woodpecker appears to be increasing in numbers and expanding geographically, as indicated by recent observations in the Foreste Casentinesi National Park (Ceccarelli *et al*. 2003) and in the Aspromonte National Park (G. Martino, *pers. comm.*), occurrence in the Apennines remains scarce (Boitani *et al*. 2002). Our data led to an estimation of fewer than 20 pairs inhabiting beech woodland in the Cilento National Park. This indicates that even in the second largest protected area in Italy this glacial relict species has a very small population size, suggesting that its survival in southern Italy may be precarious (Calvario *et al*. 2011, Peronace *et al*. 2012). The fact that it almost only occurred in beech woodland may be especially critical, since this habitat is predicted to decrease dramatically in the coming decades due to ongoing climate change (Innangi *et al*. 2015).

Such a small local population might be a consequence of the current management of beech woodland in the Cilento National Park, which may need to be modified if conservation of rare beech woodland species, such as the Black Woodpecker, is of the overriding consideration. More studies in the other areas of southern Europe where the Black Woodpecker occurs are required to understand the links between its demographic status and forest management. An important contribution may come from studies on juvenile dispersals and adult movements using telemetric techniques (Rostald *et al.* 1998, Bocca *et al.* 2007). These data could be linked to the spatial expansion of Woodpecker species in the last decades of the 20th century in Mediterranean Europe, which seems to be closely related to forest maturation, following large-scale decline in traditional uses (Gil-Tena *et al*. 2013). Notably, however, our findings show that Black Woodpecker occurrence in Cilento National Park is linked to the presence of beech but not to stand age.

To our knowledge, no other studies on the density of this species have been carried out in other areas of southern Italy. Indeed, ours is a first attempt to quantify the hitherto unknown population size of the Black Woodpecker in this important region near the margin of its range. We suggest that Black Woodpeckers may be more widespread in southern Italy than is currently believed, although the absence of environmental corridors connecting to larger, more stable populations in continental Europe make southern populations particularly vulnerable to climate change and land use change.

In conclusion, although the Black Woodpecker is expanding in continental Europe (Vos *et al*. 2008), isolated populations in the southern part of the range, such as southern Italy, are to be considered endangered, with a lack of data on context-specific ecological requirements hindering their conservation. In addition, considering the Black Woodpecker as an indicator species, like those species whose ecological requirements guarantee the existence of particular environmental conditions (Campbell & Lack 1985) would also help to protect a wide range of animal species that share its habitat, including important wild pollinators, rare Coleoptera and bats.

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