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Factors affecting the nest site selection of the black stork, *Ciconia nigra* in the Dadia-Lefkimi-Soufli National Park, north-eastern Greece

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Abstract. Nest site preference of black stork nesting in the Dadia-Lefkimi-Soufli National Park, northeastern Greece was studied through the 2003 - 2004 field seasons. Seventeen nest-trees and their surroundings (0.1 ha circular plot centered at nest-tree) were described and compared to the characteristics of the same number of paired, randomly selected plots. Black storks usually nested in old pines, on branches at a mean distance 1.5 m from the trunk or against the trunk. Nest sites were located at slopes significantly steeper and significantly closer to small streams compared to random plots. The total tree density at nest sites was significantly lower and the mean canopy closure immediately adjacent to black stork nest trees was also significantly lower compared to that adjacent to the randomly selected trees. Nest sites had lower tree basal area than randomly selected sites, suggesting that the less wood volume sites were preferred for nesting by black storks in the study area.

Key words: nesting habitat, nest tree, forest structure, logging activities, NE Greece

Introduction

The black stork, *Ciconia nigra* is a rather shy, solitary species, vulnerable to human disturbances and avoids its habitation (Kahl 1987). In contrary to the white stork, *Ciconia ciconia* which is found mainly in human habitations, the black stork is a forest dwelling species and it inhabits old undisturbed forest areas, interspersed with shallow lakes, marshes and ponds as well as streams (Mériaux et al. 1991).

The black stork has an extensive breeding range – from Europe to northeastern China and also breeds in southern Africa. The European population has suffered considerable decrease throughout its range, particularly in west Europe along the 20th century (Cramp & Simmons 1977, Del Hoyo et al. 1992) but the whole population remained stable recently and the species is currently evaluated as Least Concern in the IUCN Red List of Threatened Species (Birdlife International 2000, IUCN 2004). Destruction of forests and particularly the limitation of large nesting trees have been reported as the main threats for black stork population decline (Lõhmus & Sellis 2003, Rosenvald & Lõhmus 2003). In addition, foraging habitat degradation and especially the drainage of permanent water courses (Lõhmus & Sellis 2001), the loss of wetlands and the use of pesticides in wintering grounds in Africa have contributed to the population decline (Hancock et al. 1992).

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The black stork population has also declined in Greece, and it is listed as an endangered species in the Red Data Book of threatened vertebrates (Karandinos 1992). The reasons for the species decline have not been yet firmly established and it is possible that several causes are involved. Land use changes due to new agricultural practices, intensive exploitation of the forests, alteration of wetland habitats and the drainage of small ponds and marshes have been recognized the factors reducing the population of black stork in Greece. The province of Evros is the most important breeding area for the species in Greece. It has been estimated that more than 30 pairs breed in the area (pers. observations) while in the whole country the total breeding population is approximately 30-50 pairs (BirdLife International 2004).

The present study was carried out in the Dadia-Lefkimi-Soufli National Park (thereafter D-L-S NP) during the 2003-2004 field seasons to determine the species nesting habitat requirements, in order to provide useful management implications to forest managers for the increasing the breeding habitat availability in the region.

Study Area

The 8000-ha study area is situated in the northeastern part of Greece, in the middle of the province of Evros and it is includes a number of natural areas with high ecological value for wildlife. It is a part of the D-L-S NP which covers approximately 43,000 ha. The main vegetation associations are consisted by mixed sclerophylous oak-woods in the south (mainly evergreen shrubs such as *Erica arborea*, *Phillyrea media*, *Arbutus andrachne* and *Quercus pubescens*) and mixed thermophylous woods in the north (mainly deciduous forest, mixed pine-oak forest and pure pine forest).

In the study area, the main tree species are Calabrian pine, *Pinus brutia* and black pine, *Pinus nigra*, which form pure and mixed stands with oaks, *Quercus* spp. and other broad-leaved species in the understory. Willows, *Salix* spp., poplars, *Populus* spp. and black alder, *Alnus glutinosa* are present in river valleys.

The forested part of the study area is managed under a multi-used management system by the Forestry Service. In higher successive stages a detailed selective felling is carefully planned, while various intermediate cuttings such as thinning and pruning are conducted to the young stands in order to regulate the growth of the stands or species composition. Logging activities occur from the beginning of April to the end of September and most of the timber is removed from the stands to the forest roads by mules to ensure both the least possible damage to the tree seedlings and the minimum disturbance to the birds of prey which they breed in the region.

Materials and Methods

Seventeen black stork nests were located in the study area during the 2003-2004 field seasons using historical descriptions of traditional nesting sites and extensive exploratory surveys on foot (Fuller & Mosher 1987). Data on nest-tree and nest-site characteristics were collected after fledging in August and September. A nest site was defined as a circular plot of 0.1 ha (18 m radius) centered on the nest tree. The plot size used in studies of other species nesting in forested areas varies from the most common 0.04 ha (Titus & Mosher 1981, Buchanan et al. 1995, Squires & Ruggiero 1996) to 0.145

ha (Speiser & Bosakowski 1987) or larger in few raptor studies (Penteriani 1997, Bakaloudis et al. 2001, McGrath et al. 2003). This size plot was determined in order to make comparisons with those used by the Forestry Service in management plans in the region.

Habitat description

For nest-trees the following information was recorded: tree species, height (m), age (years), diameter at breast height (dbh; cm) and height of the living canopy (m). The nests were characterized by their height above ground (m), diameter (cm), distance to the trunk (cm) and diameter of the supporting branch (cm). Dbh was measured using a dbh tape and the age was determined using an increment core by counting growth rings. All heights were measured with a Blumme-Leiss altimeter (accuracy ± 0.25 m). Canopy height of nest trees was estimated by subtracting the height of the bottom of the canopy (lowest living branch) to the ground from the height of the tree.

Within nest-site plots all trees species present were identified and grouped according to dbh into four diameter classes (thin pole: 10 - 21 cm, thick pole: 21 - 30 cm, large trees: 31 - 45 cm, and mature trees: > 45 cm). All saplings with a diameter less than 10 cm were not recorded. Four canopy closure estimations (%) were visually obtained (facing to north, east, south and west) in a 10-m radius around each of the nest tree.

For the physiographic site description percent slope adjacent to nest tree was measured using a clinometer. Elevation of the site above sea level and distance of nests to small streams were estimated from 1:5000 scale topographic maps.

In order to detect habitat preferences of the stork, 17 randomly selected 0.1 ha plots were established and similarly described (excl. variables concerning nest characteristics) in the neighbouring area. Each random plot was situated between 40 m and 400 m from the nest-tree; a minimum distance of 40 m was taken to avoid overlap between the nest-site and random plots. In order to establish each random plot the following steps described by Bakaloudis et al. (2001) were followed: firstly, the forest-stand centered on the nest-tree was divided into four quadrants (1=northeast, 2=southeast, 3=southwest and 4=northwest) and one of these was randomly selected. Secondly, two randomly selected numbers between 0 and 400 were taken to calculate the distance in meters of the random plot along the north-south axis and the east-west axis. The intersection of lines extending from these points perpendicular to the axes identified the location of the center of the random plot. Finally, the closest dominant tree to this centered point similar in dbh size to the nest-tree was selected. This tree was defined as the random nest-tree and the center of the random plot was shifted so as to correspond with the location of this tree (Titus & Mosher 1981).

When random points identified a plot in non-forested areas such as grasslands, shrublands, cultivated areas, or in an area with only young trees, they were rejected and a new plot was selected.

Statistical analysis

All variables were tested for heterogeneity of variances using Bartlett's test (Zar 1996), and for normality using the Anderson-Darling test. Variables that did not meet the assumptions of homoscedasticity and normality were log-transformed (log (x+1)) prior to parametric analysis. Normally distributed variables were analyzed using paired-sample *t*-test, but those not meeting normality assumptions after transformation were analyzed using the Mann-Whitney test. Variables expressed as percentages were arcsine transformed to standardize variance.

Means ± 1 standard errors (S.E.) are presented in the text. All statistical analyses were performed using the Minitab statistical software (version 13.3) and differences were considered significant at $\alpha < 0.05$.

Results

Black storks nested mostly in Calabrian pine (59%) and black pine (29%), but also in oak trees *Quercus cerris* (12%). All nest trees were alive and they had the largest dbh in the plot area. The structure of nest trees was similar to random trees in terms of their dbh, height, canopy height and age (Table 1). Sixty-five percent of the nests were located on branches with a mean diameter of 11.6 cm and at a mean distance from the trunk of 1.04 m. The rest were located on branches against the trunk. Nests' diameter was on average 110.82 ± 3.8 cm and they were located on average 8.24 m above ground.

Table 1. Characteristics (mean ± S.E.) of 17 black stork nest trees and 17 randomly selected mature trees in the Dadia-Lefkimi-Soufli National Park, northeastern Greece. *P* - value indicates statistical significance of difference between the pairs of means.

Variable	Nest-tree	Random tree	*P* – value
DBH (cm)	51.6 ± 2.6	48.6 ± 1.0	0.59*
Height (m)	14.5 ± 0.7	14.9 ± 0.4	0.51*
Canopy height (m)	6.5 ± 0.4	6.6 ± 0.3	0.74
Age (yrs)	93 ± 3.3	86 ± 3.5	0.15

* Value was based on Mann-Whitney non-parametric test.

Nest sites had significantly different physiographic features from random sites. Nest sites (37.6 ± 0.2%, range = 10 – 60%) were in steeper slopes than random sites (21.5 ± 0.06%, range = 2 – 34%) (Mann-Whitney test: W = 382, $P = 0.0037$). The mean elevation of nest-sites above sea level was 110.6 ± 14.8 m (range = 28 – 230 m), which was significantly different from random sites (162 ± 11.9 m, range = 74 – 248 m) (*t*-test: t = 2.71, $P = 0.011$). Nest trees were located significantly closer to small streams (12.4 ± 2.1 m, range = 2 – 32 m) than were randomly selected trees (49.8 ± 8.7 m, range = 12 – 135 m) (*t*-test: t = 5.56, $P < 0.001$).

Black stork nesting sites were associated with pine forests (53%), while 29% were in mixed pine-oak forest associations and 18% were in deciduous forests. The distribution of nest-site plots across habitat types was similar to the random plots ($\chi^2 = 4.0$, df = 2, $P = 0.139$).

Total tree density and density of conifers were significantly lower at nest-sites compared to random sites (t = 3.39, $P = 0.002$ and W = 209, $P = 0.002$, respectively) (Table 2). However, there was no difference between deciduous tree densities in nest and random sites. Mean density of thin pole-size trees was similar in nest and random sites. Nest-sites contained significantly fewer thick pole-size trees and large size trees than random sites. In contrast, nest sites had more mature size trees than random sites, but this difference was no significant (Table 2).

Total trunk basal area (t = 2.15, $P = 0.039$) and total conifer basal area were significantly lower on sites selected by black storks for nesting compared to randomly selected sites (Table 3). The difference between sites in overall trunk basal area was wholly determined by the between site differences in large diameter size class trees (Table 3).

Table 2. Mean (±SE) tree density/0.1ha at 17 circular black stork nest sites and 17 random plots in the Dadia-Lefkimi-Soufli National Park, northeastern Greece. *P* - value indicates statistical significance of difference between the pairs of means.

Variable	Nest-site	Random site	*P* – value
Total trees density	32.35 ± 2.97	46.29 ± 3.32	<0.01
Total conifer density	14.18 ± 1.79	30.47 ± 4.10	<0.01*
Total deciduous density	17.18 ± 3.58	15.82 ± 2.90	0.95*
Thin pole (10-20 cm) density	15.70 ± 3.00	21.40 ± 2.40	0.16
Thick pole (21-30 cm) density	3.94 ± 0.51	8.47 ± 1.40	0.01*
Large trees (31-45 cm) density	8.53 ± 1.00	13.76 ± 1.80	0.02*
Mature trees (≥46) density	3.18 ± 0.72	2.65 ± 0.54	0.67*

* Value was based on Mann-Whitney non-parametric test.

Table 3. Mean (±SE) trunk basal area (BA) (m^2/0.1ha) of trees at 17 circular black stork nest sites and 17 random plots, in Dadia-Lefkimi-Soufli National Park, northeastern Greece. *P* - value indicates statistical significance of difference between the pairs of means.

Variable	Nest-site	Random site	*P* – value
Total tree BA	2.18 ± 0.20	2.89 ± 0.27	0.03
Total conifer BA	1.70 ± 0.26	2.57 ± 0.31	0.03
Total deciduous BA	0.47 ± 0.13	0.32 ± 0.08	0.53*
Thin pole (10-20 cm) BA	0.26 ± 0.06	0.35 ± 0.05	0.25
Thick pole (21-30 cm) BA	0.20 ± 0.03	0.043 ± 0.07	0.02*
Large trees (31-45 cm) BA	1.00 ± 0.12	1.53 ± 0.19	0.02
Mature trees (≥46) BA	0.71 ± 0.16	0.57 ± 0.12	0.52*

* Value was based on Mann-Whitney non-parametric test.

Mean canopy closure immediately adjacent to black stork nest-trees (39.1 ± 0.2%, range = 15 - 75%) was significantly lower than adjacent to randomly selected trees (60.9 ± 0.2%, range = 21 - 83%) (t = 3.52, *P* = 0.013).

Discussion

Black storks nesting in D-L-S NP preferred the largest trees available as nest trees. Large trees and especially Calabrian pines, which were mostly used as nest-trees in the area, have few and thick side branches or strong forks that can offer adequate support to the voluminous black stork nests. In addition all the nests were located within the foliage of nest trees. Such conifer trees also probably provide greater shelter from predators and inclement weather than broadleaved trees during the early of the breeding season when black storks arrive in the study area (B a k a l o u d i s et al. 2000).

Our results show that black storks prefer places at steep slopes for nesting, denoting a preference for low human disturbances, as these steeply sites are less accessible by humans. In addition such places close to small streams in low elevations could be associated with high quality site index which in turn support less trees density but with larger diameter sizes than poor sites (S m i t h et al. 1997). This is true for our study area, as well as in Lithuania and Estonia where black stork prefers nest stands on fertile soils (D r o b e l i s 1993, R o s e n v a l d & L õ h m u s 2003).

Breeding sites on the lower position of the slope and close to open habitats (streams and small rivers) are probably the most suitable for black storks' nests, because they provide both easy access to the birds and advantage of nearby foraging sites. Drobelis (1993) also found that black storks in Lithuania establish their nests on trees near bogs, streams, sparse growths of trees and other open areas. In our study area most of the streams are dried during the summer and only in lowland areas there is sufficient water in the streams and marshy ponds, which they consist the principal black storks' foraging sites (Overal & Jacob 1989, Lõhmus & Sellis 2001). The proximity of black stork nests near to small streams may also be associated with the different vegetation and the resulting micro-environmental conditions especially as the breeding season progresses. Similarly other avian species (e.g. short-toed eagle, lesser spotted eagle *Aquila pomarina*) preferably nest close to rain water gullies in the study area due to favorable conditions created by the vegetation occurred in this sites during the hot period of summer (Vlachos 1989, Bakaloudis et al. 2000).

In silviculture, the value of an area is often measured in terms of the volume or basal area of wood available. No data were available in the literature on tree densities or basal area of black stork nest-sites so far. In Dadia, the sites where black storks nested generally had lower total tree density than the random sites. However, only thick pole tree densities and large tree densities were significantly lower in nest-sites than in random sites, both of which are important in determining the suitability of an area by facilitating accessibility to the nest and visibility of the surrounding area. The average basal area of all trees at black stork nest sites was also smaller than that at random sites. The similar trend was observed for other birds in the study area (Bakaloudis et al. 2000, 2001) supporting that the logging operations should be concentrated at medium diameter size class trees (dbh: 21-30 cm), providing a favorable access to the nest by the black stork.

The primary goal of forest management for the D-L-S NP is to maintain old trees in order to provide as many nesting sites as possible. Such mature trees seem to be vital not only for the black stork but for many raptors in the D-L-S NP (Bakaloudis et al. 2001). Furthermore, the protection of old pine trees, surrounded by sparse canopy in the middlestory and/or understory and close to rainwater gullies will enhance the breeding population of the species. A combination of wood extraction and wildlife conservation has become of increasing interest the last decades by public services. Thus, forest operations such as tree felling have been practiced on the medium sized diameter trees the last decade, anticipating the lost of wood volume from the larger diameter sizes by promoting and extra funding forest cultivation (brashing in late thicket stage and crown thinning in pole stage) of medium size diameter tree classes by the Forestry Service (Bakaloudis 2000). Drastic thinning along the medium sized diameter trees it is entirely possible to produce suitable nesting trees with larger diameter than that they would have attained in the same time without thinning (Smith et al. 1997). As a general rule, these logging operations could be applied during the late of the breeding season and/or after the young fledged form their nests, in order to minimize disturbances not only for the black stork but for other sensitive birds of prey that breed in the region. However, further research is needed on nest site preference by black storks outside the protected cores of the D-L-S NP where silviculture is applied.

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