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The importance of roosts for Black Storks *Ciconia nigra* wintering in West Africa

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Seasonal variations in the use of roosts by Black Storks *Ciconia nigra* in West Africa were studied by satellite tracking and field observations between 1998 and 2006. Black Storks used twelve tree species as nocturnal roost. All roosting trees were higher than the surrounding vegetation (11.4 ± 3.9 vs. 4.2 ± 0.1 m). Black storks selected dead trees in 46% of the cases and showed a preference for roosts located close to foraging areas (on average within 4 km), the distance varying significantly according to season. On average, Black Storks used roosts for four consecutive days, alternating between roosts up to 41 times per winter period. Destruction of roosting trees could impact the birds' spatial distribution.

Key words: Black Stork, *Ciconia nigra*, nocturnal roost, foraging grounds, fires, conservation, Africa

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Human impact on the environment is one of the major issues in biodiversity conservation (Meffe & Carroll 1994, Hunter 1999). The Black Stork *Ciconia nigra* is a case in point: its population is estimated at 20 000–25 000 breeding pairs in Europe, Asia and Africa. A large proportion, 7800–12 000 pairs, breeds in Europe (Tamas *et al.* 2006). Black Storks prefer to breed and winter in undisturbed areas. In many European countries, this species became extinct or suffered strong declines. Henceforth, in the last few decades habitat management on the breeding grounds has become an important conservation issue in Europe. However, Black Storks spend half of their lives in Africa, where several wetlands have been identified as important wintering sites (Dodman & Diagana 2003). Suitable winter habitat of Black Storks, however, is threatened by the expansion of cropland, cattle breeding and fishing. Another problem is the competition for water resources, which must be shared with domestic animals and the local people. Black Storks are also subjected to vandalism (Bobek *et al.* 2003) and hunting (Baillon & Chevallier 2003). These problems could be aggravated by a further increase of the human density, and widespread use of trees for firewood and fresh fodder for cattle (Chevallier & Eva 2003, Chevallier *et al.* 2003). Fires may increase the loss of foraging grounds and increase home range size (already large, i.e. on average 108 450 hectares, Chevallier *et al.* 2010).

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The status of threatened species is legitimate in Europe, and this is even more so in Africa. In this context, stopover sites and foraging areas should be located before effective conservation can be planned (Fenton 1997). Determining habitats of importance for Black Storks has received much attention in Europe (Jiguet & Villarubias 2004, Lõhmus *et al.* 2005), but hardly so in Africa (Jadoul *et al.* 2003, Portier 2003). Moreover, nocturnal roosts provide protection from predators and their location may play a role in the selection of feeding areas. In the present study we investigate the environmental and human factors which influence the spatial distribution of foraging and roosting sites of Black Storks in their wintering area.

METHODS

Study areas

This study is based on seven birds tracked by satellite in Mauritania, Senegal, Mali, Burkina Faso and Ghana during the dry season (October–March) between 1998 and 2006. A population of Black Storks (87 ± 7 birds/month, Chevallier *et al.* 2010) was more closely followed in Burkina Faso (Game Ranch of Nazinga) in the northern winters of 2003 to 2005. Birds tracked by satellite and the study population traversed two distinct geographical zones: Sahelian zone (5 tracked birds) and Sudano-Sahelian zone (2 tracked birds and one distinct Black Stork population).

Satellite tracking

We captured birds with gintraps and cage traps set along much frequented streams on the breeding grounds. Among 17 Black Storks tagged with satellite transmitters (Argos system), full winter coverage was obtained from seven individuals (Table 1). Transmitters were placed as a backpack, attached as high as possible on the storks' back with a Teflon ribbon harness to avoid feathers covering the solar panels. Five Black Storks were tagged with PTTs (45 g, Northstarst Science, USA), two others with 100 Solar-GPS PTTs (40–70 g; Microwave Telemetry, USA). The Solar-GPS PTTs were programmed to collect data every daylight hour and to download data every 72 hours. The number of positions recorded with Solar-GPS PTT was higher than with PTTs (Table 1). GPS positions which were checked in the field with a manual GPS, were accurate to within ±10 m, whereas the best Class 3 Argos positions had an accuracy of ±150 m with the traditional PTT (highest accuracy of locations, CLS/ARGOS 1996). We mapped individual positions with Arcview GIS 3.1 1998 and MapInfo 8.0 2005.

Monitoring Black Storks in Nazinga

We used the abundance kilometric index (Ferry & Frochot 1958) to assess the number of Black Storks between December and March when the number of the population was considered as stable (no migration). All birds present were counted on foot on both sides of two rivers in Burkina Faso located in Nazinga Game Ranch

Table 1. Location and period of use of wintering areas of seven Black Storks tracked by Argos PTTs. *Bird tagged with Solar Argos GPS PTT.

Birds	Status	First and last dates	Countries	Place of capture	Number of positions
Lou	adult	21/10/2005–28/02/2006	Burkina Faso	Luxembourg	173
Dany	adult	03/10/2005–31/10/2005 01/11/2005–30/11/2005 01/12/2005–10/03/2006	Mauritania Mauritania - Mali Mali	France	317
Josephine	adult	15/10/2005–31/10/2005 01/11/2005–30/11/2005 01/12/2005–13/03/2006	Mauritania Mauritania Mauritania - Senegal	France	213
Camille*	subadult	25/11/2005–28/02/2006	Mali	France	1934
Aurelia*	juvenile	09/11/2003–30/11/2003 01/12/2003–31/12/2003 01/01/2004–31/01/2004 01/02/2004–29/02/2004 01/03/2004–31/03/2004	Ghana Ghana Ghana Burkina-Ghana Burkina Faso	Burkina Faso	4043
Gerard	juvenile	01/11/1998–30/03/1999	Mali	France	383
Marie	adult	16/10/1998–26/11/1998 01/12/1998–11/02/1998	Mauritania Mauritania – Senegal	France	374

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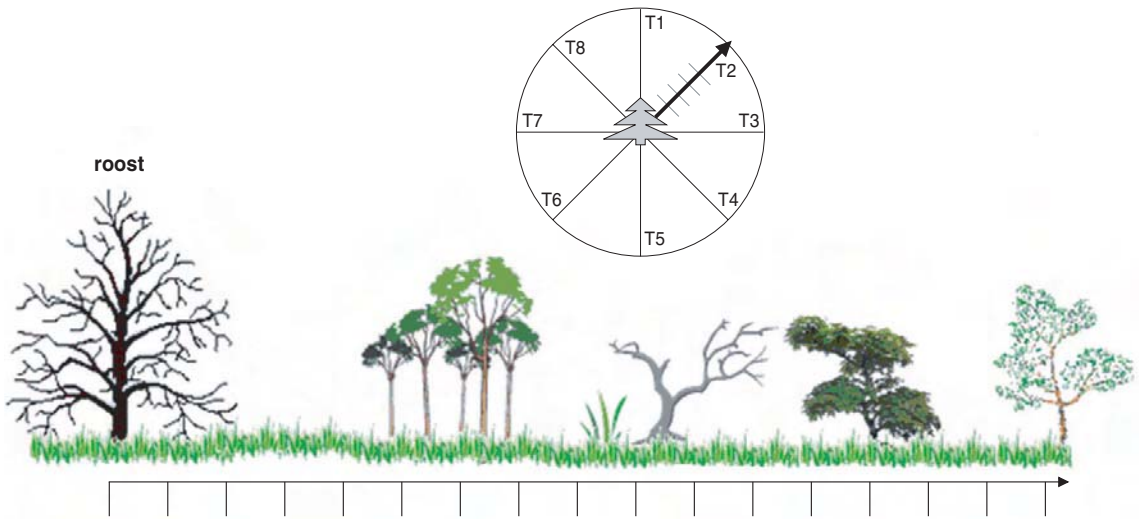


Figure 1. Method of vegetation sampling (occurrence, height and vitality) per 5-m interval along a 100-m transect (T2) from a nocturnal roost used by Black Storks in Nazinga.

(Sissili, 40 km, and Dawélé, 20 km). We crossed all types of habitats present in the studied zone. Observations were made when the activity of birds was at a peak, i.e. between 6:00 and 12:00 am, and between 4:00 and 6:00 pm (D. Chevallier, pers. obs.). The *Eaux et Forêts* service of Burkina Faso, whose collaborators recorded similar data during their annual inventory of wildlife in Nazinga, confirmed this diel activity pattern.

Nocturnal roosts

From observations in the field and data recorded by Solar-GPS PTTs, we identified and characterised roosting trees used by Black Storks in Nazinga, Burkina Faso. Each roosting tree was identified, and its height measured (with a hypsometer) and condition recorded (all branches dead, some branches dead or without dead branches). We recorded presence and height of the vegetation in a circular plot centred around the roosting tree, using 100 m transects radiating in N, NW, NE, E, W, S, SW and SE directions from the roosting tree (Fig. 1).

Foraging sites

During the dry period, rivers dry up and change into shallow ponds, the typical foraging sites of Black Storks. We mapped the locations of foraging places (ponds) used by birds with a Geographical Information System. Distances between foraging and roosting sites were calculated with SIGOGNETRACK software (Geohyd 2005; MapInfo 2005). We also calculated the distances between roosting sites and accessible rivers recorded by SIG near these resting places.

Monitoring of bush fires in Africa

Medium-resolution satellite time series (Landsat, 30 m, MODIS, 250 m), for the years 1998 to 2002, have been used to assess fire activity in the wintering areas of Black Storks in West Africa, and more particularly in Burkina Faso and the Nazinga Reserve (Burkina Faso).

Statistical analyses

We performed ANOVAs with Student–Newman Keuls as post-hoc test (P-values < 0.05) using SPSS software (version 14.0, 2006) to test factor effects.

RESULTS

Of the 47 tree species in ten different families (*Mimosacea, Bombacea, Combretacea, Anacardiacea, Rubiacea, Fabacea, Papilionacea, Fabacea, Sapotacea, Apocynacea*) inventoried in the Nazinga reserve, Black Storks used twelve species for nocturnal roosting. African Birch *Anogeissus leiocarpus*, Wild Seringa *Burkea africana* and African Baobab *Adansonia digitata* were used most frequently as roosting sites. For example, we monitored the presence of birds continuously for *Adansonia digitata* ($n = 35$), one of the most commonly used trees by roosting Black Storks. The trees were used by 610 Black Storks during October 2003 to March 2004, with a daily presence of 3–35 individuals (51–144 birds per month).

The height of twelve trees species used for roosting varied significantly ($F_{6,22} = 3.44$, $P = 0.015$), but not

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sufficiently to detect interspecific differences (post hoc tests not significant). Nocturnal roost of Black Storks were often situated in dead trees (46%) or poor-health trees (37%), and rarely in healthy trees (17%, $n = 24$). The vegetation surrounding roosting trees was predominantly dense shrub savannah. This vegetation type was significantly more dominant around African Birch and Baobab, two of the three species often used as roost ($F_{9,171} = 70.73$, $P < 0.001$, S–N–K-test, $P < 0.05$, Fig. 2). Vegetation height did not vary in relation to distance from the roost along the transect ($F_{9,171} = 0.71$, $P > 0.05$). All tree species used as roosting site were much higher than the surrounding vegetation (roosting tree 11.4 ± 3.9 m, vegetation around trees 4.2 ± 0.1 m, $F_{9,197} = 2.847$, $P < 0.05$). Roosting trees were on average located at 3.0 ± 0.9 km from foraging places (ponds) used by birds and 3.1 ± 0.4 km from accessible rivers. The distance between roosts and foraging places varied according to season; the distances were greater in November and February compared to December ($F_{3,12} = 6.29$, $P < 0.01$, Fig. 3). Satellite-tracked Black Storks used the same nocturnal roost on average for 3.8 ± 0.9 days, independent of season ($F_{3,12} = 1.740$, $P > 0.05$). These Black Storks used 41.0 ± 6.6 different nocturnal roosts during the wintering period, again without seasonal differences ($F_{3,12} = 0.103$, $P > 0.05$).

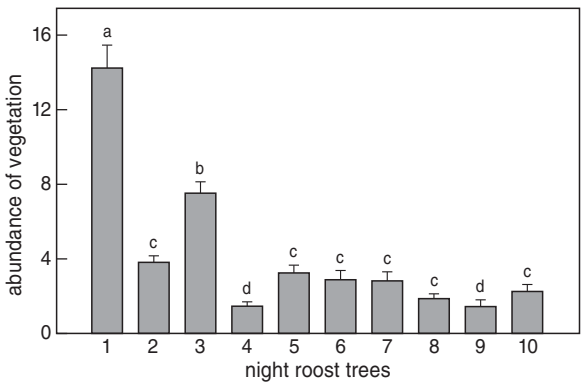


Figure 2. Average number of trees (±SE) along a 100-m transect radiating from roosts used by Black Storks in Nazinga. Means lacking common letters are significantly different ($P < 0.05$).

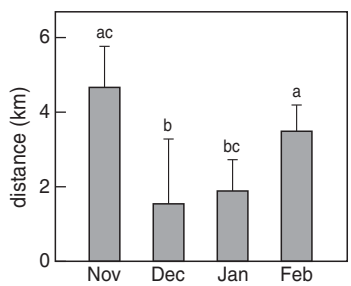


Figure 3. Monthly variation in distance between nocturnal roosts and foraging places (ponds). Means (±SE) lacking common letters are significantly different ($P < 0.05$).

Africa has a high frequency of bush fires compared to South America and Australia (on average almost 27 000 fires per year, compared to 16 000 and 14 000, respectively). Bush fires are widespread during the dry season (October to February) in West Africa, especially in Nazinga area (Burkina Faso) (Fig. 4). The occurrence of bush fires in Nazinga coincided with the presence of Black Storks (Fig. 4). By March, at the end of the burning season, fires have swept the larger part of this protected area (90% of 93 000 ha, Fig. 5).

DISCUSSION

Of the trees species present at Nazinga (Fournier 1987), 26% were used by Black Storks as roosting sites. Roosting trees were typically higher than the surround-

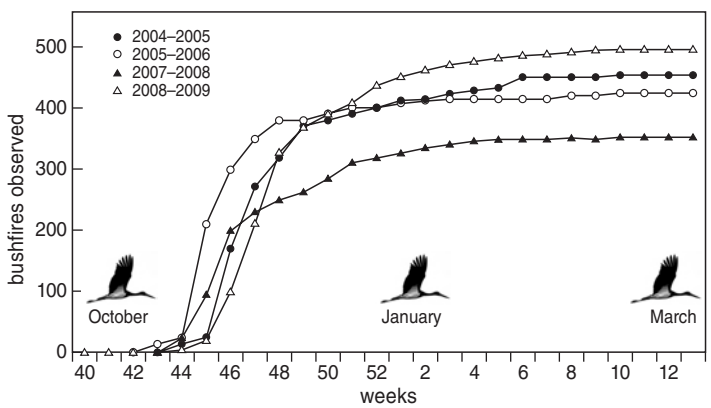


Figure 4. Cumulative number of bush fires in the Nazinga area in 2004–09.

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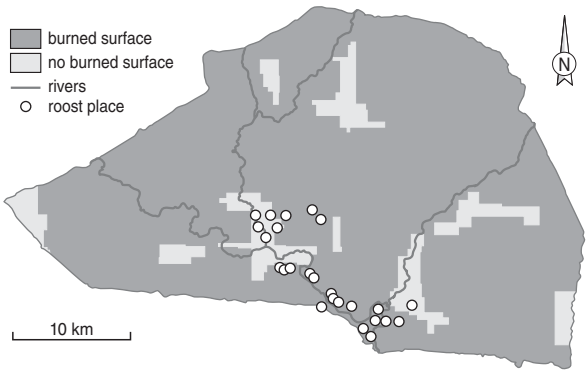


Figure 5. Cumulative area affected by burning in the Nazinga area at the end the 2008/09 dry season.

ing vegetation, the latter being denser around African Birch and Baobab, the two trees most frequently used. The dense vegetation surrounding roost (African Birch and Baobab) may prevent ground predators, including people, from sighting roosting sites (Duguay *et al.* 1997). Almost half of the trees used for roosting were dead, allowing unobstructed approach and take-off by Black Storks.

Contrary to earlier findings (Jadoul 1998), our data show that Black Storks changed roosting site frequently; individual birds used specific roost up to four days in a row, with up to 41 roosts identified for the wintering period. Black Storks in West Africa selected roost sites in close proximity of foraging areas. This is highlighted by the fact that only a few minutes passed between departure from feeding sites and arrival on nocturnal roosts. The availability of shallow water, where fish prey is abundant (Chevallier *et al.* 2008), changes seasonally, the distance between roosting trees and foraging places being the smallest at the onset (November, water level still high) and the last part (February, many ponds dried up) of the dry period. In comparison, distances between feeding and roosting sites in Africa are shorter (3 km) than those calculated for Europe's breeding grounds (15–23 km, a distance travelled several times per day; Jiguet & Villarubias 2004, Hampl *et al.* 2005).

Roosts of Black Storks in Africa are threatened by bush fires and wood cutting. Africa's contribution to the area burnt annually across the globe amounts to 60% (Chevallier & Eva 2003, Tansey *et al.* 2004). 59% of the protected areas of sub-Saharan Africa run a high risk of being burnt during the dry season (Grégoire & Simonetti 2008). In Nazinga, the incidence of wildfires coincides exactly with the presence of Black Storks. Almost all roosts of Black Storks were directly affected by fires. In addition, local people cut dead wood for their daily needs (Chevallier, pers. obs.).

Fishing by the local people adds another threat to Black Storks (Chevallier *et al.* 2008, 2010). Foraging birds are disturbed frequently, and must therefore search constantly for new foraging areas. Human disturbance results in an increase of daily flight distances (increasing energy expenditure) and a decrease in the time allocated to foraging (perhaps reducing food intake). This may have dire consequences for survival.

To adequately address these various threats, the inclusion of the Black Stork in the IUCN Red List is needed (http://www.iucn.org/search.cfm?uNewsID=1695), in order to plan effective conservation. Many of the 60–100 African waterbird species present in West Africa in 2003 (Wetlands International) occupy the same habitats as Black Storks, and may simultaneously benefit from habitat protection accorded to Black Storks.

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SAMENVATTING

De wereldpopulatie van de Zwarte Ooievaar *Ciconia nigra* telt 20.000–25.000 broedparen, waarvan iets minder dan de helft in Europa broedt. De sterke achteruitgang in de 20ste eeuw entameerde veel onderzoek, uitmondend in tal van beschermingsmaatregelen in de broedgebieden. De kennis van Zwarte Ooievaars in hun overwinteringsgebieden is echter beperkt. In dit onderzoek zijn de lotgevallen van zeven Zwarte Ooievaars met satellietzenders van 1998 tot en met 2006 gevolgd in Mauretanië, Senegal, Mali, Burkina Faso en Ghana. De meeste aandacht ging uit naar gezenderde vogels die in het Nazinga wildreservaat in het zuiden van Burkina Faso overwinterden. Deze vogels gebruikten twaalf van de 47 aanwezige boomsoorten als slaapplaats, vooral Afrikaanse Berk *Anogeissus leiocarpus* en Afrikaanse Baobab *Adansonia digitata*. Het belang van Baobabs bleek ook bij de 35 bomen die continu werden gemonitord. Deze werden in de winter van 2003/04 door 610 Zwarte Ooievaars benut, met dagelijkse aantallen van 3–35 vogels. Bijna de helft van de slaapplaatsen bevond zich in dode bomen met goede af- en aanvliegmogelijkheden. De gemiddeld 4,2 m hoge vegetatie rond deze bomen kan worden gekenmerkt als struiksavanne. Zij was het dichtst rond bovenvermelde boomsoorten (welke gemiddeld 11,4 m hoog waren). Het voordeel van een dichte vegetatie rond slaapbomen zou kunnen zijn dat het grondpredatoren (inclusief mensen) een vrij zicht op de bomen beneemt. De afstand van slaapbomen tot de foerageergebieden bedroeg gemiddeld 3,0 km voor poelen en 3,1 km voor rivieren. Deze afstand varieerde naar gelang het seizoen: de afstand was het grootst in november en februari, het kleinst in december en januari. In november is de waterstand in rivieren en poelen nog zo hoog dat veel foerageergebieden niet kunnen worden benut. In februari geldt het omgekeerde: door droogte zijn veel poelen en delen van rivieren uitgedroogd, en de waterhoudende restanten worden ook door mensen gefrequenteerd. De vogels met zenders bleken gemiddeld 3,8 dagen van een roestplaats gebruik te maken, onafhankelijk van het seizoen. In de loop van de winter benutten ze 41 verschillende slaapplekken. In de savanne en boomsavanne van West-Afrika wordt vrijwel het hele gebied door de plaatselijke bevolking in de droge tijd afgebrand. In Nazinga betrof dat bijvoorbeeld 90% van de 93.000 ha. Branden vormen een bedreiging voor de slaapbomen van Zwarte Ooievaars. Deze bedreiging komt bovenop de activiteiten van de lokale bevolking in poelen en rivieren, die Zwarte Ooievaars van hun voedselgebieden weghouden, en de houtkap voor brandhout en veevoer door de mens. Habitatbescherming in de Afrikaanse overwinteringsgebieden zou dan ook hoge prioriteit moeten krijgen, met als extra voordeel dat grote aantallen Afrikaanse vogelsoorten ervan kunnen meeprofiteren. (RGB)

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