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The recent expansion of an avian invasive species (the Cattle Egret *Ardea ibis*) in Algeria

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A B S T R A C T

This study identifies new information on the recent distribution of an invasive bird species, the Cattle Egret *Ardea ibis*, in Algeria. Breeding and wintering distributions as well as breeding numbers were obtained from large-scale surveys in 1999 and 2007, and from historical data. Between 1999 and 2007, the total number of colonies found increased from 51 to 87, and most were located in the northern part of the country. The breeding distribution area, confined to the coastal areas in the 1970s, has shifted further south, and reached the northern part of the Sahara since the 2000s. Most colonies were established during the period 1980–1995. The oldest colonies were generally larger than the recent ones. The number of colonies increased by 83% between 1999 and 2007 in the 12 administrative units (wilayas) surveyed. The number of breeding pairs increased from 7765 in 1999 to 28544 in 2007, corresponding to an annual population growth rate of 17.7%. The changes in distribution and population dynamics since the 1970s and the potential factors affecting these changes are discussed.

Keywords:

Birds
Distribution
Invasion
North-Africa
Range extension

1. Introduction

Studying the patterns and processes of biological invasions has become an integral part of the efforts undertaken to monitor and manage ecosystems worldwide, and invasive bird species have received particular attention (Van Der Bosh et al., 1992), probably because of their socio-economic interest (hunting) and/or public awareness (Pimentel et al., 2002). Moreover, birds are more easily surveyed than other animals, which may pose taxonomic and/or detection difficulties (e.g., invertebrates, amphibians, mammals). Lastly, birds in general are relevant biological models to document spatial and/or temporal patterns of invasion because of their dispersal capabilities.

The Cattle Egret, *Ardea ibis*, is a species of indo–African origin which is now cosmopolitan. It is recognized as an invasive bird species across its global range (Van Der Bosh et al., 1992) whose progression was considerably enhanced during the last 50 years through an increase of its distribution area as of its local populations (Kushlan and Hafner, 2000).

In Algeria, until the 19th century, the species was present only in the lakes of Fetzara and Halloula (north-west), and anecdotally in the Tell (Heim de Balsac and Mayaud, 1962). Ledant et al. (1981) reported

several colonies distributed on coastal areas from El Asnam (36°10'N, 01°19'E) to Hassi El Ghella (34°28'N, 01°02'E) and in the region of El Kala (36°53'N, 08°31'E). More recently, the species were observed breeding in great numbers in several areas, in particular Tizi Ouzou, Bouira, Jijel, Constantinois and on the high Plateaus such as M'sila (Isenmann and Moali, 2000). These data remain however limited spatially and temporally. To our knowledge there has been no large-scale analysis of the changes in wintering distribution and breeding populations of Cattle Egrets in either Algeria, or more generally, northern Africa.

The aim of this study was to analyze the temporal dynamics of invasive Cattle Egret populations in Algeria over ca. 40 years. We used distribution data for birds of Algeria from the 1970s and 1980s, updated in Ledant et al. (1981) and Isenmann and Moali (2000), respectively, to 1) illustrate the distributional area of these species during these periods, and 2) provide new information on the distribution of breeding colonies, breeding numbers and distribution during winter for the period 1999–2007, at the regional and the national level. The changes in distribution and populations dynamics are discussed within the context of biological invasions in arid environments and the causes of the world geographical expansion of the Cattle Egret.

2. Methods

A descriptive information sheet of the species and a questionnaire were sent to the 48 forest conservation offices (Head Forests

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Table 1

Location, year of the first observed breeding, number of colonies and of breeding pairs of Cattle Egrets in Algeria in 1999 and 2007 (nod: absence of data, +: presence of colonies). The colonies are mapped in Fig. 1, using the code of the administrative units (wilayas) indicated between brackets.

Wilaya (code)	Year of first breeding	1999		2007	
		Colonies	Breeding pairs	Colonies	Breeding pairs
El Tarf (36)	1962	3	3400	14	19900
Chlef (02)	1970	4	1320	4	727
Annaba (23)	1980	1	350	1	150
Skikda (21)	1986	+	+	+	+
Jijel (18)	1988	3	330	+	+
Bouira (10)	1990	1	120	7	500
Constantine (25)	1990	2	200	10	1220
Tizi Ouzou (15)	1993	6	2450	+	+
Bejaia (06)	1993	2	1085	5	5080
Tipaza (42)	1993	+	+	+	+
Alger (16)	1993	1	350	+	+
M'Sila (28)	1993	+	+	1	150
Sétif (19)	1993	5	332	2	550
Blida (09)	1995	1	150	Nod	nod
Batna (05)	1995	+	+	7	1030
Boumerdès (35)	1995	11	708	2	130
Mila (43)	1995	+	+	16	376
Saida (20)	1996	3	240	Nod	nod
Tlemcen (13)	1997	1	200	+	+
Khenchela (40)	1996	+	+	2	300
Oran (31)	1996	1	300	+	+
Mostaganem (27)	1996	+	+	+	+
Oum El Bouaghi (04)	1997	2	60	+	+
Mascara (29)	1997	1	100	+	+
Ain Temouchent (46)	1997	+	+	+	+
Ain Defla (44)	1997	+	+	+	+
Souk Ahras (41)	1997	1	250	7	160
Guelma (24)	1997	+	+	1	100
Tébessa (12)	1997	+	+	1	360
Sidi Bel Abbès (22)	1998	1	40	+	+
Tiaret (14)	1998	+	+	+	+
Tissemsilt (38)	1998	+	+	+	+
Relizane (48)	1998	+	+	+	+
Médéa (26)	1998	1	150	+	+
Bordj Bou Arreridj (34)	1998	+	+	4	300
Bechar (08)	2002	0	0	+	+
Djelfa (17)	2005	0	0	+	+
Laghouat (03)	2006	0	0	1	47
Biskra (07)	2006	0	0	1	60
Illizi (33)	2006	0	0	1	20
Total		51	12135	87	31160

Office, Ministry for Agriculture) of all the wilayas (administrative units) of Algeria. The questionnaire comprised a set of items bearing on the phenological status (wintering and/or breeding); the exact location of the colonies; the approximate number of breeding pairs and the date of first establishment. The number of breeding pairs was estimated as the number of nests for colonies smaller than ~100 nests. For larger colonies an estimate was made by reporting the approximate surface area of sub-plots of the colonies, with each sub-plot containing 20 individuals. Counts were ground based, and made from the edge of colonies. When the counts were made by two fieldworkers, their counts were averaged. It was requested from the fieldworkers to undertake only one count per colony, to make the counting visit as short as possible, and to avoid excessive disturbance. To limit counting errors, most colonies in each wilaya were surveyed by the same group of observers.

Two surveys were carried out in 1999 and in 2007 between May and July, a period covering the breeding chicks of the species in Algeria (Samraoui et al., 2007; Si Bachir et al., 2008). The data were collated in December and results from these surveys were used to update the distribution area of the species, the number of breeding pairs and its trend over an 8 year period. In order to compare

changes in breeding numbers between the two surveys, data were grouped by wilaya, and only the colonies of the 12 wilayas surveyed both in 1999 and in 2007 were used. The surface area covered by the surveys was 362760 km².

Geographic distribution maps were created to illustrate the changes in distribution of the species over a period of 37 years by taking into account distribution data from the 1970s (Ledant et al., 1981) and from the period 1980–1995 (Isenmann and Moali, 2000).

3. Results

Between 1999 and 2007, the number of colonies counted increased from 51 to 87 (Table 1), primarily in the northern part of the country. The northernmost colony was located in Sidi Ammar close to the town of Annaba (36°54'N), and the southernmost colony was observed in Bechar (31°61'N). From east to west, the colonies were distributed from El Tarf (8°E) close to the Tunisian border, to Tlemcen (1°W) near the Moroccan border (Table 1, Fig. 1).

In the period 1980–1995, 59.8% colonies were established; 22.0% during 1996–2000; 14.2% in the 1970s and 3.9% for the period 2001–2007. The older colonies were generally larger than the recent ones, which often hosted only a few tens (<100) of breeding pairs. In 2007, the mean (\pm SD) of the number of nests per colony was 1616 \pm 1231 ($N = 6$) for the oldest colonies (period of 1970s). This mean was 565 \pm 1122 ($N = 35$) for the period 1980–1995; 64 \pm 83 ($N = 24$) for the period 1996–2000 and 58 \pm 52 ($N = 22$) for the period 2001–2007 (Table 1, Fig. 1).

The total number of breeding pairs estimated for the entire Algerian territory was 12135 in 1999, with more important breeding numbers in the extreme east of the country, in particular in the national park of El Kala (El Tarf), the area of Chlef, the region of Boumerdes and Kabylie (Béjaia, Tizi Ouzou). In 2007, the total number of breeding pairs was estimated at 31160 (Table 1, Fig. 1). In the 12 wilayas surveyed both in 1999 and 2007, the number of colonies counted increased from 30 in 1999 to 55 in 2007. The number of breeding pairs more than tripled, increasing from 7765 in 1999 to 28544 in 2007, corresponding to an average annual increase of 17.7% per year.

In addition to the colonies already listed in 1999, new colonies were found in wilayas recently colonized, mainly during the period 2002–2006 (Table 1). These wilayas (Bechar, Djelfa, Laghouat and Biskra) are dominated by arid or desert habitats. One colony was found in the town of Illizi situated in the extreme south of the country in the Sahara (Table 1, Fig. 1). The breeding distribution area, confined to the coastal areas in the 1970s, now covers all the northern part of the country, and has reached the northern part of the Sahara since the 2000s at latitude 31°61'N (Fig. 1).

The wintering distribution of the Cattle Egret covers almost the same surface as the breeding area and is localized mainly in the northern part of the country, with however an extent in the southern part. In addition to this vast wintering area, local observations made in the Chott Melghigh (between Biskra and El Oued), the valley of Saoura (Béchar), in some oases of Biskra, El Oued, Ghardaia and Djanet (Illizi), the Sebkhass of Makerghane and Azel Mati close to Ain Salah (Tamanrasset) like in Timimoun (Adrar) and Illizi (Fig. 2), indicate that wetlands situated in the south of the country are used during the wintering period.

4. Discussion

Although the surveys carried out in the present study were not exhaustive, they clearly reveal that the Cattle Egret in Algeria expanded its distribution area as noted elsewhere in the world and in North Africa in particular (Kushlan and Hafner, 2000). In 2007, the species bred in 40 of the 48 wilayas in the country, compared to

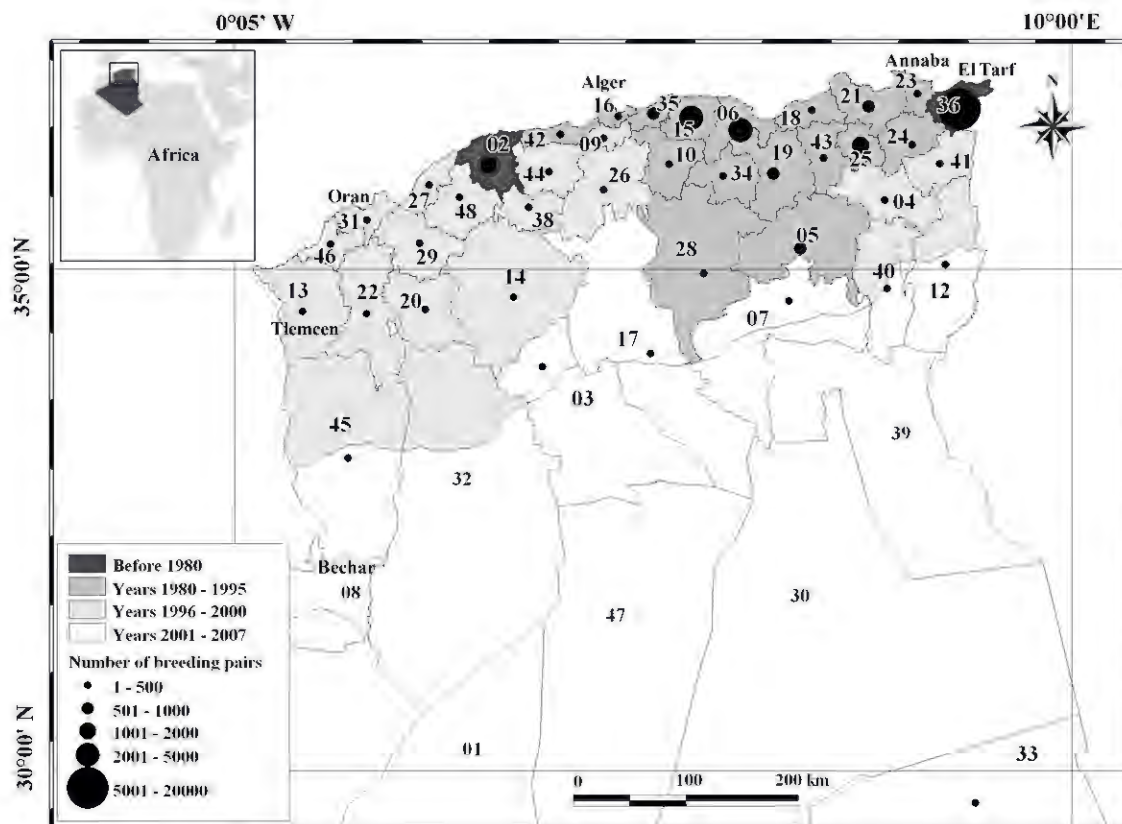


Fig. 1. Changes in the breeding distribution of the Cattle Egret in Algeria between the 1970s and 2007 (coding of wilayas as in Table 1).

35 in 1999. Several new areas of Algeria were colonized by Cattle Egrets during the wintering period, and new breeding colonies were established during the last decades. Before 1970s, breeding and wintering cattle egrets were confined to wet coastal areas (Ledant et al., 1981). From the 1990s, the semi-arid high plateaus of the east and the center of the country were colonized (Isenmann and Moali, 2000). In the vicinity of colonies, the presence of rivers, temporary ponds and irrigated perimeters were often noted. Proximity of to feeding habitats of this type is a strong determinant of the establishment of colonies (Farinha and Leitao, 1996). Thus the increase in the area of irrigated lands during the last decade in semi-arid areas (from 20000 ha in 1994 to 40000 ha in 1999) (Benmouffok, 2004) may partly explain the geographical expansion and numerical increase in breeding numbers in Algeria. The Cattle Egret also shows dietary plasticity, and forages in artificial habitats such as refuses or feeds behind agricultural machinery (Si Bachir et al., 2001). During the last decade, all the northern part of the country became occupied, as well as some areas within the Sahara. In less than 40 years, the species thus expanded its range more than 5° (~560 km) of latitude to the south.

It can be hypothesized that the colonization of Algeria by the Cattle Egret was initiated from old colonies (wetlands complex of El Kala and region of Chlef) and then spread out to the extreme west of the country with a simultaneous colonization of the southernmost areas. Also, the colonization of the western part of the country was possibly due to immigration from Southern Spain, Morocco, and the Camargue (France) (no banded birds were observed). Colonization generally started with the establishment of some individuals in the new wintering areas where the wintering roosts became breeding colonies. In North Africa, the Cattle Egret also colonized new areas. In the south of Morocco, for example, the species breeds in the area of Ouarzazat (Thevenot et al., 1982)

and in Tiznit since 1994 (Kushlan and Hafner, 2000). In Tunisia, the species breeds in almost all the northern part of country (Isenmann et al., 2005).

The Algerian population increased from a few hundred pairs at the beginning of the 1970s to 87 colonies hosting more than 30000 pairs in 2007. In Europe, Andalusia (Spain) hosted the single European breeding population of ~4000 pairs in 1944 (Riddel, 1944), whereas in the 1990s, the breeding population was estimated at 80000 to 100000 pairs in seven countries (Kushlan and Hafner, 2000). In France, the breeding population increased from 1171 pairs in 1992 to 14098 pairs in 2007 (Marion, 2007).

Several authors suggest that the world geographical expansion of the Cattle Egret has been favored by intrinsic factors (large clutch size, high breeding frequency and success, early age at first breeding and diet plasticity). The nesting period is relatively short in Algeria (generally 4 months; Si Bachir et al., 2008; Samraoui-Chenafi, 2009) compared to other areas (up to 5 months in Spain and France) (Hafner, 1977; Prosper and Hafner, 1996). This would allow the breeding individuals to suffer less from the extreme climatic conditions in the arid areas, in particular the hot and very dry summer. The clutch size, which generally varies between 1 and 5 eggs (Hafner, 1977; Siegfried, 1972), is larger in Algeria with nests containing up to 6 and 7 eggs (Si Bachir et al., 2008; Samraoui-Chenafi, 2009). Si Bachir et al. (2008) also reported the realization of two broods during the same year. Finally, young Cattle Egrets are able to move in new areas and are potentially at the origin of new breeding colonies (Si Bachir et al., 2008; Siegfried, 1972).

Extrinsic factors may also play an important role, especially those related to habitat changes due to human activities such as deforestations, expansion of agriculture, in particular irrigated crops and livestock farming (Hafner, 1977). However, although these factors facilitate the geographical expansion and numerical

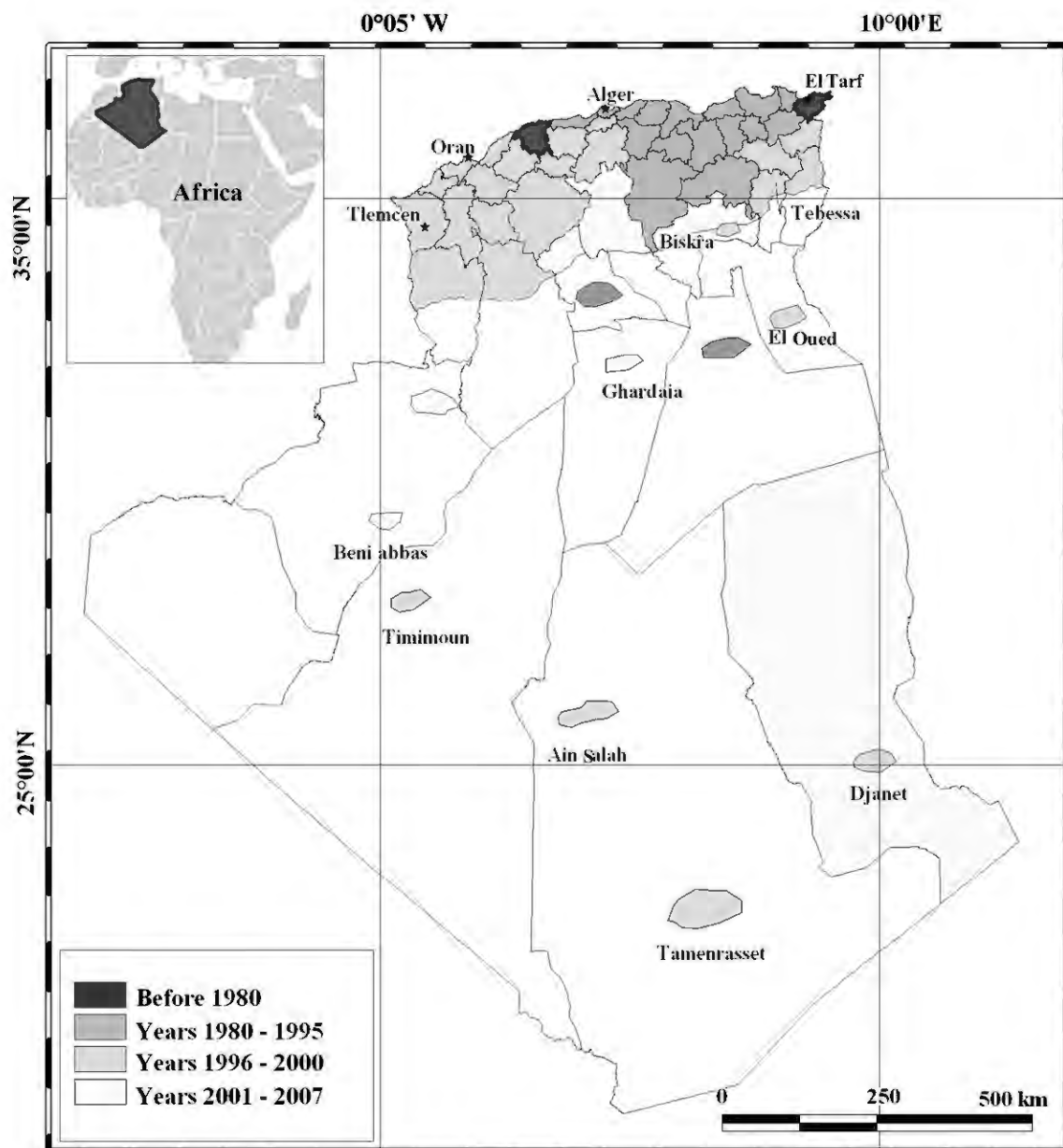


Fig. 2. Changes in the wintering distribution of the Cattle Egret in Algeria between the 1970s and 2007.

increase of the populations, the initial driving factors remain poorly known (Telfair and Bister, 2004). In Algeria recently established colonies were both within and outside urban areas and generally terrestrial. In absence of the most appropriate breeding habitats (sites surrounded by water) (Farinha and Leitao, 1996; Hafner, 1977), Cattle Egrets established colonies in sites made safe by the height of the trees carrying nests.

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