

EFFECT OF ALTITUDE AND URBANIZATION ON THE ECOLOGY OF THE BREEDING WHITE STORK (*Ciconia ciconia*) IN THE TIZI-OUZOU REGION (KABYLIA, NORTHERN ALGERIA)

OUENZNA KECHOUT ¹, FATIHA METNA-ALI AHMED¹, NORA TALMAT-CHAOUCHI^{2,3}

¹Natural Resources Laboratory, Mouloud MAMMERI University, Tizi-Ouzou, Algeria; e-mail: kechoutouezna@gmail.com

²Laboratory of Ecology, Biotechnology and Health, Mouloud MAMMERI University, Tizi-Ouzou, Algeria

³Laboratory of Applied Zoology and Animal EcoPhysiology, Abderrahmane Mira, University of Bejaia, Algeria

 Corresponding author

Received: 2 November 2024 / **Accepted:** 3 May 2025

Abstract

Kechout O., Metna-Ali Ahmed F., Talmat-Chaouchi N.: Effect of altitude and urbanization on the ecology of the breeding white stork (*Ciconia ciconia*) in the Tizi-Ouzou region (Kabylia, Northern Algeria). *Ekológia (Bratislava)*, Vol. 44, No. 2, p. 160–168, 2025.

The ecological breeding conditions of the Tizi-Ouzou white stork (*Ciconia ciconia*, Linnaeus, 1758) are examined in this study. The population was estimated, as well as its evolution, and the impact of altitude on breeding pairs was examined throughout two breeding seasons (2019 and 2021). The first census showed 650 breeding pairs in 2019. By 2021, there are 830 pairs. In 2019, piedmont areas had 601 stork pairs (92%) by altitude. In the mid-mountains, 49 pairs (8%) were seen. There are no pairs above 1200 m in the high mountains. Similar percentages were seen in 2021. The breeding pair density rose from 65.76 in 2019 to 83.97 in 2021. At altitudes below 400 m, the density exceeded 230 pairs per 100 m² for both study years. The mid-mountain zone has fewer pairs/100 km² than the foothills over the same period. The following proportions indicate that this Ciconiidae prefers heights between 10 and 14 m: 67.69% (2019) and 69.04 (2021). Over the two-year study, 94.62% of nests were installed on artificial supports and 5.38% on natural supports. Urban pairs make up 63% of the spatial distribution. Both years saw 36% fewer pairs outside built-up areas. The altitude distribution of stork nests shows that this bird prefers to live from 15 to 550 m. The average nesting pair is 329.5 between 0 and 100 m. This distribution is mainly determined by habitat quality and food availability. Other agronomic parameters, such as the presence of irrigated agricultural areas and landfills, which may feed the studied species, also affect it.

Key words: white stork, *Ciconia ciconia*, breeding ecology, altitude, urbanization, Tizi-Ouzou.

Introduction

The white stork *Ciconia ciconia* (Linnaeus, 1758) is a wild bird with a predatory nature. It is distinguished by its tendency to inhabit areas close to human populations and is renowned for its white plumage embellished with black feathers. The species is classified as a nationally protected species in Algeria and benefits from protection under Executive Decree 12-235, published on May 24, 2012. Furthermore, Algeria has officially approved multiple agreements, including the Bonn Convention, the Bern Convention, and the AEWA Agreement, in which the species is categorized under Appendix II. The species in France is safeguarded under articles 1 and 5 of the decree dated April 17, 1981. Additionally, it is included in Appendix I of the Birds Directive, as stated by Gourari et al. (2021). Globally, the International Union for Conservation of Nature (IUCN) has classified the species as of minor concern on the Red List (Appendix I) according to Gourari et al. (2021).

Several studies conducted since the 1930s have improved our understanding of this species' global ecology. These stud-

ies concentrated on the decline in population numbers across all breeding areas, with a particular emphasis on North Africa (Schüz, 1979; Schaub et al., 2004). Algeria's breeding population has also declined, as reported by Bouet (1936), Thomas et al. (1975), Moali-Grine (1994), and Moali-Grine et al. (1995). However, since the 1990s, the population of this wader species has increased due to breeding (Schaub et al., 2004; Masseurin-Challet et al., 2006). In Algeria, the number of breeding pairs increased significantly from 1,195 in 1993 to nearly 6,000 in 2001, nearly tripling the initial figure (Moali-Grine, 2007; Moali-Grine et al., 2004).

In Algeria, several studies on the breeding ecology of the white stork have been carried out, with contributions from authors such as Bouriach (2016), Sbiki (2016), Benharzallah (2017), and Chenchouni (2017). The white stork population in Kabylia has been monitored since 1991 (Moali et al., 1992), with additional comprehensive surveys carried out in collaboration with the Forestry Department (Moali et al., 1999). In the early 2000s, several authors, including Boukhamza (2000), Moali-Grine (2005), and Fellag (2006), carried out research into the

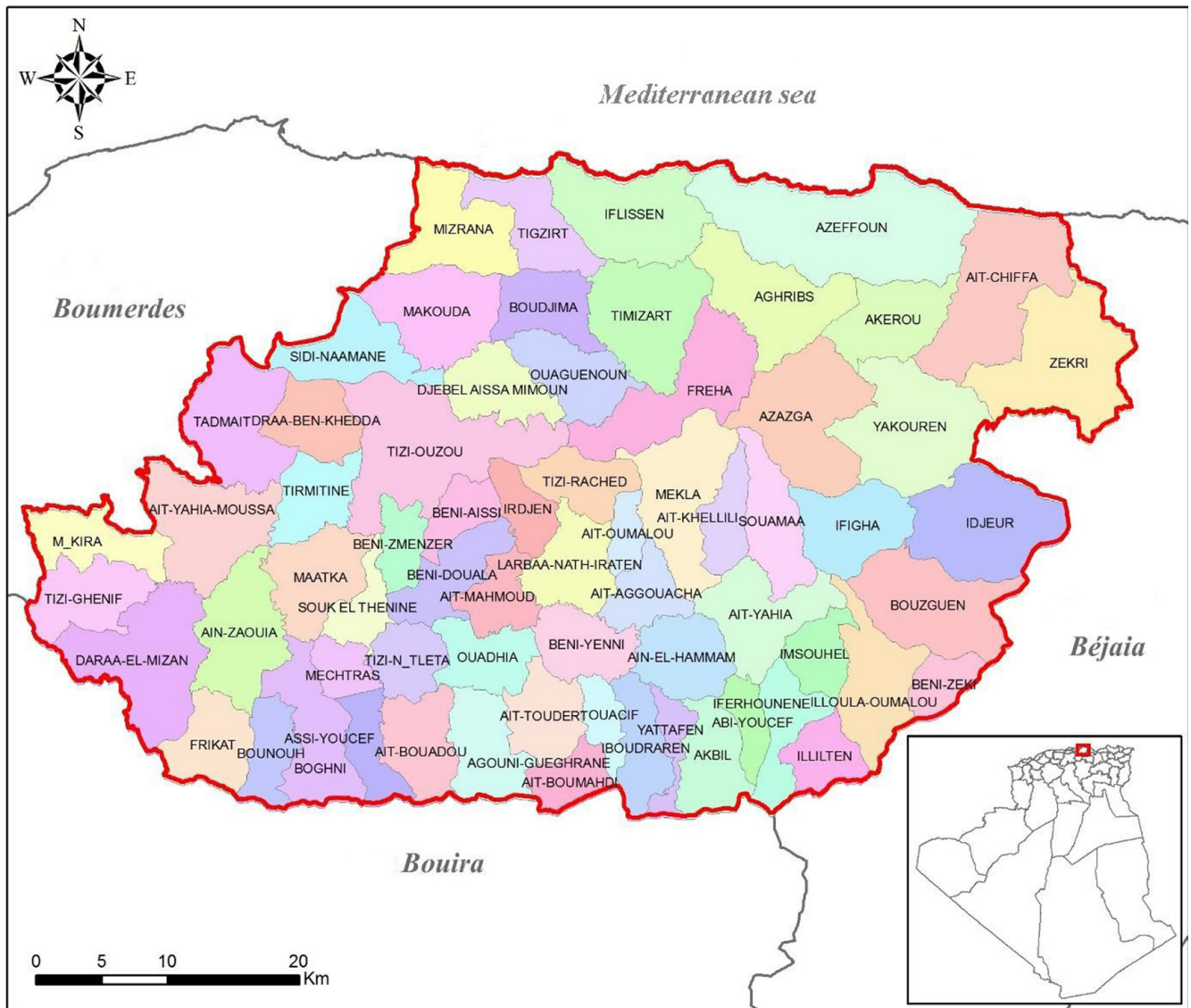


Fig. 1. Geographical location of the wilaya of Tizi-Ouzou.

breeding ecology of this population. This study aims to monitor and analyze the changes and reproductive behavior of the breeding population of white storks in the Tizi-Ouzou region (Grande Kabylie) between the breeding seasons of 2019 and 2021, with a particular focus on how altitude affects reproduction. The results of the study yielded comprehensive and specific data on the ecological requirements of the species studied. These findings can be used to develop effective and appropriate management strategies to conserve this vulnerable avian species in its nesting habitat.

Material and methods

Study area

The Tizi-Ouzou region is a coastal area located in the north-central part of Algeria. The area is distinguished by a sequence

of mountain ranges, typically aligned in an east-west direction, encircling narrow alluvial plains. The location is situated within the angular coordinates of 36°28' north latitude to 36°55' north-east latitude and 3°45' east longitude to 4°31' east longitude. The Mediterranean Sea forms its northern boundary, while the wilaya of Béjaïa lies to the east, characterized by the Akfadou massif. To the west, it is bordered by the wilaya of Boumerdes, which is known for its hills and valleys. Finally, to the south, it is bounded by the wilaya of Bouira, home to the Djurdjura mountain range, known for its crystalline composition (Fig. 1). Tizi-Ouzou, located in northern Algeria, is situated in the transitional area where polar and tropical air masses meet from October to November until March to April. Arctic air masses typically dominate, resulting in a cold and wet season. In the remaining months of the year, there is an upward movement of tropical air masses, resulting in the occurrence of heat and drought (Anonymous, 2022).

Methodology

Two censuses of the white stork breeding population in the Tizi-Ouzou region were carried out over two consecutive breeding seasons: 2019 and 2021. Throughout this period, we carried out frequent and systematic observation of breeding pairs, enabling us to estimate population size and study the impact of altitude on breeding pair abundance. Throughout each observation, various parameters were documented, including the characteristics and altitude of supports, as well as the positioning of nests in relation to urbanization. Both censuses were carried out in April, once the entire population had established residence and all pairs had formed, until June.

We mainly carried out censuses on foot to verify the position of each nest using GPS technology, which enabled us to acquire precise coordinates for each nest and accurately document its elevation.

Statistical analysis

To perform a statistical analysis of the data, a two-factor analysis of variance (ANOVA) was used to examine the impact of elevation and time on the distribution of nesting pairs of white storks in the Tizi-Ouzou region. The Newman-Keuls test was used to classify results into homogeneous groups with a significance level of 5%. A principal component analysis (PCA) was performed to highlight associations between white stork populations and various agricultural factors.

Results

Census and density of white stork populations in the Tizi-Ouzou region

The first census conducted in the study area revealed that there will be 650 breeding pairs in 2019. This figure has increased significantly, reaching 830 pairs by 2021. The nests identified are spread across 22 of the 67 communes in the Wilaya of Tizi-Ouzou. In terms of stork population distribution by altitude, data from 2019 show that 601 pairs (or nearly 92%) are found in piedmont areas and 49 pairs (or 8%) in mid-mountain areas. It is worth noting that the stork is completely absent from high

mountains with elevations greater than 1,200 m. The same outcomes were observed in 2021 (Table 1).

The population density of white stork breeding in the Tizi-Ouzou region is calculated in relation to the region's exploited agricultural area, which is estimated to be 988.42 km² over the two study years. It rose from 65.76 pairs/km² in 2019 to 83.97 pairs/km² in 2021. It should be noted that the number of breeding pairs increased by 21.69% during this period (Table 1). The recorded density at altitudes below 400 m exceeded 230 pairs/100 km² during the study period. Densities in the mid-mountain zone (400–1200 m) were lower than in the foothills, with less than 50 pairs/100 km² for the same period (Table 1).

Distribution of breeding pairs in the Tizi-Ouzou region

Field observations show that the distribution of white stork nests varies by region (Fig. 2). Pairs of this ciconiidae are commonly seen in the central, central-western, and south-western regions. They are completely absent from the coast (north), the east, and the east-south sides. The number of pairs obtained has increased in several communes, including Tizi-Ouzou, Tadmaïth, Tizi-Rached, Freha, and Ouagnoune, for the year 2021 (Fig. 2).

The PCA was used to highlight the correlations between white stork numbers and a set of agricultural parameters in the Tizi-Ouzou region: land at rest (LR), herbaceous crop (HC), utilized agricultural area (UAA), total agricultural area (TAA), irrigated land (IL), forest (F), and meadow (M). A multivariate statistical analysis was performed on data on white stork populations in the 22 communes of the Tizi-Ouzou wilaya, as well as a set of agricultural data expressed in the ACP's F1×F2 factorial plan. This yielded 64% of the information, with the F1 axis accounting for 45% and the F2 axis for 19%.

Figure 3 shows that Axis 1 includes the following agronomic parameters: herbaceous crops, useful and total agricultural area, irrigated land, resting land, and a set of communes with the highest numbers on the positive side. On the negative side, we find communes with low populations. On the positive side, Axis 2 includes herbaceous crops, forests, lawns, and five communes with varying bird populations, while on the negative side, there is irrigated land and several sites; large populations characterize the latter.

Nest distribution by type of support

Table 1. Density and rate of increase in white stork numbers in the Tizi-Ouzou region (2019 and 2021).

Year	2019				2021			
	HPa	UAA (km ²)	Density (/100 km ²)	RI (%) (2001)	HPa	UAA (km ²)	Density (/100 km ²)	RI (%)
Piedmont [0-400m]	601	231.51	259.60	-	757	327.84	230.91	18.80
Medium mountain [400-1200m]	49	97.19	50.42	-	731	49.86	48.71	2.90
Region of Tizi-Ouzou	650	688.42	65.76	47.69	830	988.42	83.97	21.69

Notes: HPa, number of breeding pairs; UAA, useful agricultural area; RI, rate of increase in numbers; RI (2001), data from Moali-G (2001).

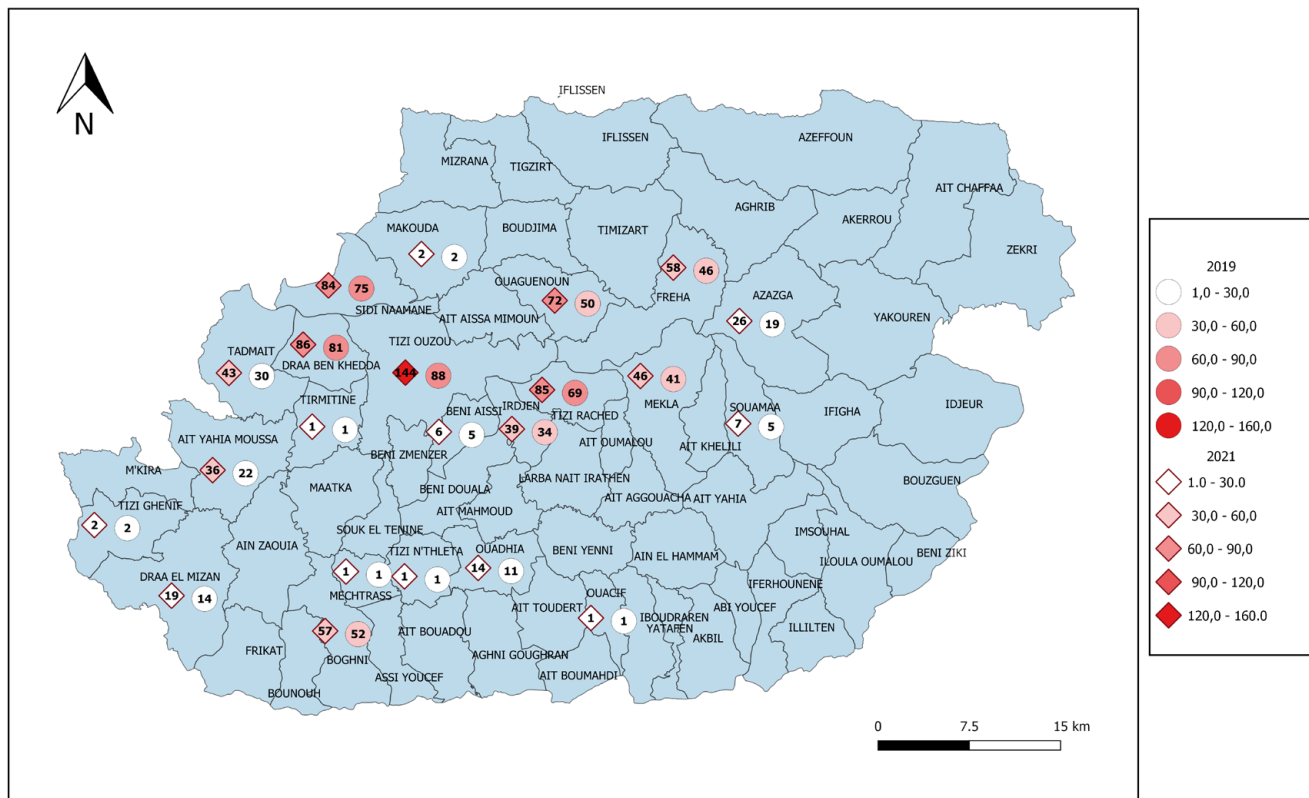


Fig. 2. Distribution of the number of breeding pairs of white stork (*Ciconia ciconia*) in the Tizi-Ouzou region in 2019 and 2021.

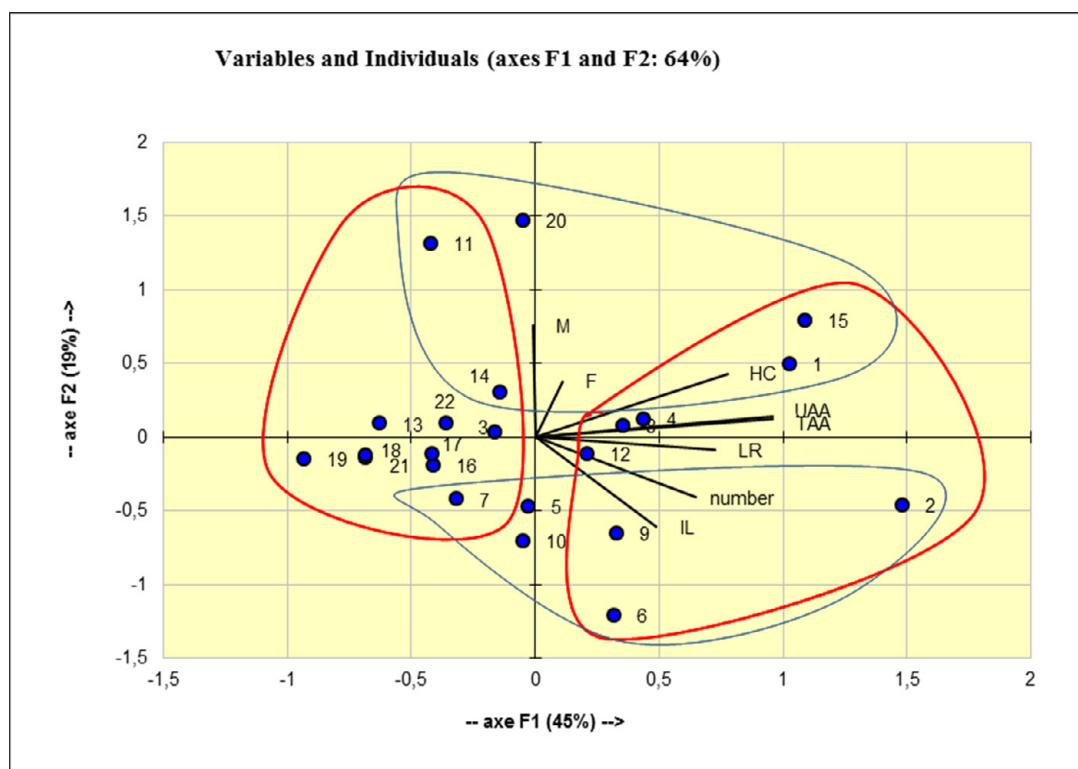


Fig. 3. F1 × F2 factorial plan of the PCA of correlations between white stork numbers and agricultural parameters in the Tizi-Ouzou region.



Fig. 4. Stork nesting aids.

Field data indicate that the selection of support types for white stork nest construction varies across different regions. This discovery indicated that the organism has a preference for manufactured structures as its support system. During the year 2019, a significant majority of 94.62% of the nests that were examined were found to be situated on manufactured structures, specifically electricity poles and pylons. In contrast, a mere 5.38% were documented as being supported by natural means. In 2021, similar findings were recorded, with rates of 93.86 and 6.14%. For both years of the study, a consistent finding is reported in the piedmont and mid-mountain zones, where artificial supports accounted for over 93% and natural supports accounted for less than 7%. SONEGAS agents have installed stork devices to mitigate power outages. These devices, designed as a specialized area, make it easier to build nests and promote the preference for manufactured structures by our species (Fig. 4). Additional devices have been implemented with the same objective. However, they now hinder the large bird from finding a place to settle (Fig. 5).

Nest support height

The white stork nest supports in the Tizi-Ouzou region have a height range of 2 m (found on an old gendarmerie cabin in Drâa Ben Khedda) to over 50 m (found on very high-voltage electricity pylons). Based on the data in Table 2, the minority of pairs in 2021 constructed their nests on supports that were less than 10 m away. A total of 29 pairs were documented, representing 3.49% of the total. Out of the total number of pairs, 228 pairs, which accounts for 27.47%, selected heights that were greater than 14m. The Ciconiidae species shows a preference for heights ranging from 10 to 14m, with a total of 573 pairs observed in this range. It is important to highlight that they make up the largest percentage, specifically 69.04%. In 2019, a similar observation was noted and documented in Table 2. The results obtained for



Fig. 5. Devices to prevent stork nests.

the piedmont zone are comparable to those for the mid-mountain zone in both years of the study. The results are similar to those already achieved for the entire study region.

Spatial distribution of pairs by urban area

In 2019, there were a total of 414 pairs situated within urban areas throughout the Tizi-Ouzou region. A marginal rise was observed in 2021. A total of 524 pairs were obtained, which accounted for approximately 63% of the study's two-year period. In 2019, there were 236 pairs located outside built-up areas, which decreased to 306 pairs in 2021. The percentage of pairs located outside built-up areas remained consistent at around 36% for both study years (Table 2). The foothills yielded comparable findings, with over 61% of results observed within the conurbation and 38% outside. Similarly, in the mid-mountains, over 80% of results were found within the conurbation, while less than 6% were observed outside. These results were consistent across both study years, as shown in Table 2.

Distribution of white stork numbers by altitude

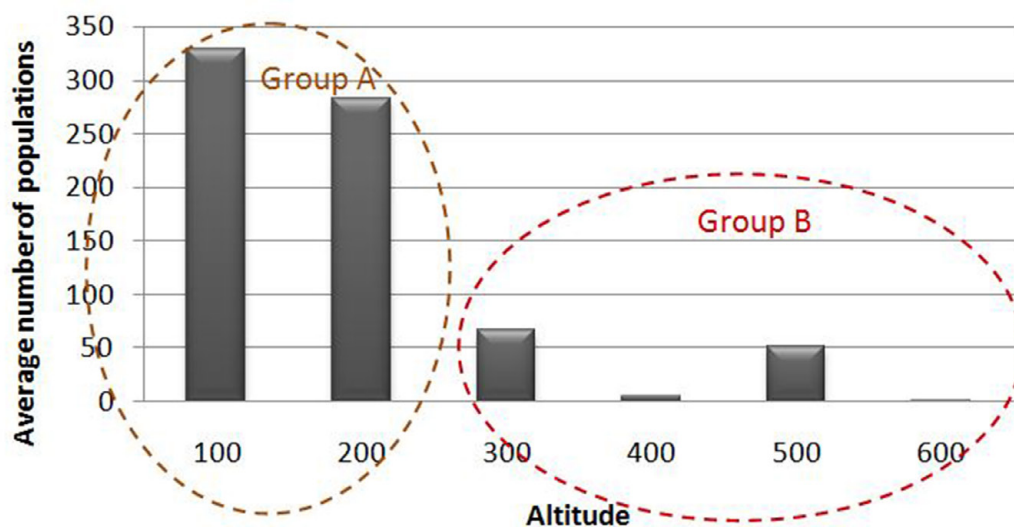
Table 3 presents the results of the two-factor ANOVA. The time factor results show that there is no significant difference between the 2019 and 2021 averages ($P > 0.05$). As a result, the findings from the two years of study are similar. The ANOVA results for the altitude factor indicate a significant difference ($P \leq 0.001$). It should be noted that altitude had a significant impact on the distribution of white stork populations in the Tizi-Ouzou region. The 5% Newman-Keuls test divides the results into two homogeneous groups. Group A has the highest averages at altitudes of 100 m (329.5 pairs) and 200 m (283 pairs). Group B has the lowest averages at elevations of 300 m (68), 400 m (5), 500 m (52.5), and 600 m (2) (Fig. 6). The distribution of the number of stork nests by altitude recorded during the two-year study period demonstrates that this bird prefers to live at a variety of altitudes.

Table 2. Inventory and characteristics of white stork nests in the region of Tizi-Ouzou (2019 and 2021).

Altitude			Piedmont [0-400 m]	Medium mountain [400-1200 m]	Total for the Region of Tizi-Ouzou
year					
2019 (Old nests)			601 (92.46%)	49 (7.54%)	650 (78.31%)
2021 (New nests)			156 (91.2%)	24 (8.80%)	180 (21.69%)
2021 (Hpa)			757 (91.2%)	73 (8.80%)	830 (100%)
Nest distribution by type of sup- port	2019	Artificial supports	566 (94.18%)	49 (100%)	779 (93.36%)
		Natural supports	35 (5.82%)	00 (0%)	51 (6.14%)
	2021	Artificial supports	711 (93.92%)	68 (93.15%)	779 (93.86%)
		Natural supports	46 (6.08%)	5 (6.85%)	51 (6.14%)
Nest location by urban environ- ment	2019	Interior	368 (61.23%)	46 (93.88%)	414 (63.69%)
		Exterior	233 (38.77%)	3 (6.12%)	236 (36.31%)
	2021	Interior	465 (61.43%)	59 (80.82%)	524 (63.13%)
		Exterior	292 (38.57%)	14 (19.18%)	306 (36.87%)
Support height (m)	2019	-10m	24 (3.99%)	01 (2.04%)	25 (3.85%)
		10-14m	404 (67.22%)	36 (73.47%)	440 (67.69%)
		+14m	173 (28.79%)	12 (24.49%)	185 (28.46%)
	2021	-10m	26 (3.43%)	3 (4.11%)	29 (3.49%)
		10-14m	521 (68.82%)	52 (71.23%)	573 (69.04%)
		+14m	210 (27.74%)	18 (24.66%)	228 (27.47%)

Table 3. Results of the analysis of variance and the Newman-Keuls test of white stork numbers according to time and altitude.

	SCE	DDL	CM.	TEST F	PROBA	ET.	CV.
TOTAL VAR.	215748.7	11	19613.52				
FACTOR 1VAR. (Time)	2700	1	2700	3.919	0.10322		
FACTOR 2VAR. (Altitude)	209603.7	5	41920.73	60.843	0.00053		
RESIDUAL 1VAR.	3445	5	689			26.249	21.28%

**Fig. 6.** Results of the Newman-Keuls test.

The most nesting pairs are found between 0 and 100 m, with an average of 329.5 pairs.

Discussion

Census of white stork populations in the Tizi-Ouzou region

The population of white storks in Algeria has been consistently increasing since 1970. Tizi-Ouzou, along with other regions, has been impacted by this rise. Moali-Grine (2005) reported an increase in the number of breeding pairs in this region, from 233 pairs in 1995 to 289 pairs in 1998 and further to 340 pairs in 2001. The quantity of this number doubled in 2019, reaching a total of 650 pairs, which represents a growth of 47.69%. In 2021, there were 830 pairs, representing a growth rate of 21.69% compared to previous years. Mammeria et al. (2019) also observed a similar increase in El Taref. The population in this region has significantly increased, growing from 174 breeding pairs in 1996 to 949 in 2014. In the Sétif high plain region, the number of pairs doubled from 875 to 1192 between 2001 and 2007 (Djerdali, 2010). According to Sbiki (2016), the number of pairs in Tébessa increased from 235 in 2009 to 321 in 2012.

According to Benharzallah (2017), the census conducted in the Constantine region recorded a total of 1149 pairs of storks. This represents a growth rate of 12% compared to the 1990s. The consistent rise in population can be attributed to enhanced nesting conditions (Moali-Grine, 2005) and improved conditions during the winter season (L'hote et al., 2002; Nabu, 2006). In addition to its unique adaptive behavior, this species has successfully adapted to the loss of its preferred habitats by finding new sources of food in household waste dumps and irrigated agricultural areas (Tortosa et al., 2002; Peris, 2003; Mammeria et al., 2012, Moali-Grine et al., 2013). Additionally, the existence of poultry waste dumps has a substantial impact on the ability to reproduce successfully (Djerdali, 2010).

Distribution of breeding pairs in the Tizi-Ouzou region

The white stork breeding pairs are distributed unevenly across different areas in the Tizi-Ouzou region. The determining factors are the quality of the habitat and the abundance of food resources (Lack, 1954; Watson, Moss, 1970). Altitude, relief, climate, vegetation cover, and hydrological potential are the factors that influence these conditions. The biotope of the white stork is distinguished by the presence of open, moist areas with distinct vegetation that is either very short or trimmed to enhance its mobility and provide excellent visibility (Moali, 1999). Tucakov (2006) states that the white stork shows a preference for flooded meadows and pastures located in close proximity to rivers for its feeding activities. The northern part of Tizi-Ouzou is characterized by a coastal range that runs from east to west. The region is characterized by a mountainous arc that runs parallel to the coast. The terrain is broken and rugged, with an average elevation of no more than 300 m. Additionally, there is a small forest massif located on the western side of the region (Anonymous, 2019). The absence of the white stork in this area can be attributed to the fact that these environments are not conducive to its presence.

The study area is defined by the Djurdjura mountain range, which is a vast and rugged massif composed of limestone ridges.

These ridges have a jagged appearance and an average altitude of 1000 m. This section primarily consists of cedar and holm oak (Anonymous, 2019). No individuals were detected within this specific section of the study area. Similar findings were observed in the mountainous areas located to the north of the wilaya of Sétif, where the stork population is sparse (Djerdali, 2010).

A similar observation was made in the eastern region of the Tizi-Ouzou province, which is known for its forests, which are predominantly composed of resilient tree cultivation. The central part, which is primarily characterized by the Oued Sebaou valley, contains a significant abundance of pairs. The area is defined by elevations below 300 m (known as the piedmont zone), precipitation exceeding 600 mm, and a significant hydrological capacity (Anonymous, 2019). All the necessary conditions for the proliferation of stork populations are present, especially the availability of food sources. Nevertheless, the uniformity of the topography is disrupted by Djebel Aissa Mimoun, which stands at an elevation of 801m and lacks the presence of storks.

The region situated between the Oued Sebaou valley and the Djurdjura mountain range consists of a large expanse of land characterized by narrow, deeply carved valleys. The average elevation in this area exceeds 400 m (Anonymous, 2019). Several pairs have been documented in this region of moderate elevation. The numbers exhibited a decrease in comparison to those observed in the foothills. The variation in these areas is a result of the elevated elevations, with slopes surpassing 20%, along with lower temperatures and increased rainfall. These factors have a detrimental impact on the white stork's feeding environment and living conditions, as well as the survival rate of their offspring (breeding success). The sole exception is the commune of Draa El Mizan, which possesses a substantial quantity of pairs. The justification for this value is based on the topographical characteristic of the region, which is a depression with an average elevation of 300 m. One notable characteristic of this area is the existence of a landfill, which is frequently visited by storks, particularly during their breeding period.

The distribution of breeding pairs in the Tizi-Ouzou region is affected by various agronomic factors, including the presence of agricultural areas that are suitable for breeding, particularly those that are irrigated and used for herbaceous crops. These habitats are highly appealing to white storks and support the largest populations due to their open and humid characteristics. As a result, these areas are regarded as feeding grounds for this species of bird called Ciconiidae. In contrast to Moali-Grine's (2005) findings, our results indicate a negative correlation between breeding pair densities in Algeria and both agricultural land and irrigated land over three years (1995, 1998, and 2001). The change in stork behavior can be attributed to their adaptation to this specific habitat, which offers them a plentiful food source.

Nest distribution by type of support

Moali-Grine's (2005) research in the Tizi-Ouzou region has enabled the monitoring of nesting pairs and their choice of support for locating their nests in the white stork population. Since 1995, there has been a dominant trend of nesting pairs predominantly selecting artificial structures, particularly poles and pylons. This

trend has continued to increase, with over 95% of nesting pairs choosing artificial structures in 2021. In contrast, the proportion of nesting pairs using natural supports is significantly lower at 6%. The surge can be attributed to the expansion of the electricity and telephone infrastructure, which experienced a threefold growth from 2000 to 2020.

Another factor that we noticed during our field trips was the extensive process of urbanization that has expanded throughout the entire area we were studying, causing harm to the natural land and landscapes. This has modified the natural environment and impacted the selection of habitat for the white stork. As a result, this situation has caused a decrease in natural assistance and the proliferation of artificial assistance. Typically, these manufactured structures are located in urban areas and along roadsides near open farmland or unused land, which offers our species a plentiful food supply.

The findings of our study closely align with the research conducted by Mammeria in 2013 in El-Taref, Guelma, Annaba, and Skikda. We observed a significant proportion (90%) of nests being built on manufactured structures, such as poles, pylons, and roofs. Similar findings were documented in Batna by Djeddou and Chenchouni (2008), in the Béjaïa region by Zennouche (2002), and in the Tébessa region by Khelili (2019). Benharzallah and Si Bachir (2011) made a similar observation in the Constantine region, with a significant proportion of nests placed on trees (44%). Multiple authors have documented a pattern of rising numbers of nests constructed on poles in various European regions (Lovász, 1999; Rubacha, Jerzak, 2006; Tryanowski et al., 2009).

Nest height above ground

The height of white stork nest supports in the Tizi-Ouzou region ranges from 3 to 50 m. Our findings are consistent with those found by Djaddou and Bada (2006) in the Batna region, Boukhemza et al. (2007) in the Oued Sebaou valley, Zennouche (2002) in the Béjaïa region, and Benharzallah (2017) in the Constantine region. Khelili (2019) reported different results in the Algerian highlands. She noticed a height ranging from 10 to 16 m. According to Sbiki (2016), nest supports in the Tébessa region range in height from 2 to 48 m. According to our findings, this wader's preferred height ranges between 10 and 14 m. This is the same conclusion Sbiki reached in 2016 (Tébessa). This height provides security and shields the eggs and chicks from environmental and human stressors (Boukhemza, 2000).

Spatial distribution of pairs by urban area

The white stork is an anthropophilic species par excellence. It nests close to people and breeds more inside built-up areas than outside, with 63% of nests built indoors and only 37% outside, and a large proportion nesting near built-up areas (suburban). The results of Moali-Grine (2005) are roughly similar to those obtained in 2019 and 2021, with a percentage of 65% in 1995, 58.5% in 1998, and 53% in 2001. The same findings were obtained in the Tébessa region, with 86% of breeding pairs found in urban areas and only 14% in suburban and natural areas (Sbiki, 2016). Between 2010 and 2013, the Constantine region showed the same distribution (Benharzallah, 2017).

Nest distribution by altitude

In our study area, white storks can be found at elevations ranging from 35 m (Ait Yahia Moussa commune) to 550 m (Azazga commune). The results of the two-factor statistical analysis of variance showed that altitude had a highly significant effect on the distribution of white stork numbers in both study years. The Newman-Keuls test divided the results into two homogeneous groups. Group A has the highest averages at altitudes of 100 m (329.5 pairs) and 200 m (283 pairs). Group B contains the lower averages for altitudes ranging from 300 m to 600 m. These findings reflect the species' unfavorable environmental conditions in high mountains. The results obtained by Moali-Grine (2005) during his three years of study (1995, 1998, and 2001) show that the white stork is found at all altitudes in Algeria, but its numbers are more concentrated between 0 and 100 m. This author's observed trend does not appear to change in 2019 or 2021.

Our findings are consistent with those found in Bulgaria in 1994, where the highest numbers of nesting pairs were found between 100 and 200 m (Petrov et al., 1999). However, Benharzallah (2017) stated that in the Constantine region (2010–2013), the stork can be found at lower altitudes (306m) and has even reached 911m. According to the same author, the majority of nests are located at elevations ranging from 550 to 600 m. The highest nest location in Poland was 890 m (Tryjanowski et al., 2005), while in Morocco, it was 2500 m. As a result, the white stork is attempting to broaden its range and colonize new high-altitude environments in order to find favorable habitats and avoid those that are already saturated.

Conclusion

The distribution of white stork breeding pairs in the Tizi-Ouzou region is influenced by various factors, including topography, vegetation, urban development, hydrological conditions, and, most importantly, elevation. The latter has a profound impact on this distribution. At high altitudes comprising a mountain range or in regions with dense forest, no individuals are observed. It can be inferred that a significant quantity of pairs are present in the Oued Sebaou valley. One additional factor that affects the occurrence of storks in specific mid-mountain areas is the presence of technical landfill sites, which are highly attractive to storks, particularly during the breeding season. The presence of fertile agricultural land in these regions, particularly land that is equipped with irrigation systems, is also regarded as a favorable environment for the proliferation of this species. The fieldwork definitively established that altitude has no impact on the type, height, and location of nests in relation to the settlement chosen by the white stork.

References

- Anonymous (2019). *Annuaire statistique de la Wilaya de Tizi-Ouzou 2018*. La Direction de la Programmation et du Suivi Budgétaire de la Wilaya de Tizi-Ouzou.
- Anonymous (2022). *Annuaire statistique de la Wilaya de Tizi-Ouzou 2018*. La Direction de la Programmation et du Suivi Budgétaire de la Wilaya de Tizi-Ouzou.
- Benharzallah, N. (2017). *Contribution à l'étude de la bio-écologie de la Cigogne blanche (Ciconia ciconia, Aves, Ciconiidae) dans le Constantinois*. Thèse de Doctorat, Université de Betna.

- Benharzallah, N. & Si Bachir A. (2011). *Effectifs et caractérisation des colonies et des sites du nid de la population de Cigognes blanches (Ciconia ciconia) lors de la saison de nidification 2010 dans la wilaya de Constantine*. Actes du Séminaire International sur la Protection des végétaux Ecole Nationale Supérieure Agronomique El Harrach, Dép. Zool. Agri. Forest. (pp. 336–343). Du 18 à 21 avril 2011.
- Bouet, G. (1936). Nouvelles recherches sur les cigognes blanches d'Algérie. Densités du peuplement des cigognes nichant en Algérie. Une campagne de baguage en 1935. *Loiseau et la R.F.O.*, 5, 287–301.
- Boukhemza, M. (2000). *Etude Bio-écologique de la Cigogne blanche (Ciconia ciconia L. 1775) et du Héron garde-boeufs (Bubulcus ibis L. 1775) en Kabylie : Analyse démographique, éthologique et essai d'interprétation des stratégies trophiques*. Thèse doctorat, Inst. Nat. Agro., El Harrach, Alger.
- Boukhemza, M., Boukhemza-Zemmouri, N. & Voisin J.F. (2007). Biologie et écologie de la reproduction de la Cigogne blanche (*Ciconia ciconia*) dans la vallée du Sébaou (Kabylie, Algérie). *Aves*, 44(4), 213–222.
- Bouriach, M. (2016). *Ecologie de reproduction de la cigogne blanche (Ciconia ciconia) dans un milieu anthropisé, Dréan, nord-est d'Algérie*. Thèse de Doctorat, Université de Guelma.
- Chenchouni, H. (2017). *Contribution à l'étude de la bio-écologie de la Cigogne blanche (Ciconia ciconia) dans la région de Batna (Nord-est Algérien)*. Thèse de Doctorat, Université de Batna.
- Djeddou, N. & Bada N. (2006). *Contribution à l'étude bioécologique de la Cigogne blanche Ciconia ciconia dans la région de Batna: Recensement des colonies, biologie de la reproduction et écologie trophique*. Mémoire d'Ingénieur Écologie Végétale et Environnement, Département de Biologie, Université de Batna.
- Djeddou, N. & Chenchouni H. (2008). *Rapport du recensement de la Cigogne blanche dans la wilaya de Batna en 2008*.
- Djerdali, S. (2010). *Etude éthoécologique de la cigogne blanche Ciconia ciconia (Linné, 1758) dans la région des hautes plaines sétifiennes (Nord de l'Algérie)*. Thèse de Doctorat, Université de Sétif.
- Djerdali, S., Tortosa, F.S. & Doumandji S. (2008). Do white stork *Ciconia ciconia* parents exert control over food distribution when feeding is indirect? *Ethology Ecology Evolution*, 20(4), 361–374. DOI: 10.1080/08927014.2008.9522517.
- Fellag, M. (2006). *Ecologie trophique des poussins de la Cigogne blanche (Ciconia ciconia Linne 1758) dans la vallée de Sébaou en Kabylie (Algérie)*. Thèse Magister, Science d'Agronomie, Institut Nationale d'Agronomie, El Harrache.
- Gourari, B., Bouacha, M.I. & Bounaceur F. (2021). Statuts de protection et de conservation de l'avifaune recensée dans le chott ECH Chergui oriental (Algérie occidentale). *Agrobiologia*, 11(2), 2777–2790.
- Khelili, N. (2019). *Etude écologique de la Cigogne blanche (Ciconia ciconia) dans les Hauts Plateaux algériens*. Thèse de Doctorat, Université de Oum El Bouaghi.
- Lack, D. (1954). *The natural regulation of animal numbers*. Oxford: Clarendon Press.
- L'hote, Y., Mahé, G., Somé, B. & Triboulet J.P. (2002). Analysis of a Sahelian annual rainfall index from 1896 to 2000; the drought continues. *Hydrological Science Journal*, 47(4), 563–572. DOI: 10.1080/02626660209492960.
- Lovász, P. (1999). Conservation status of the White Stork in Hungary. In H. Schulz (Ed.), *Weißstorch im Aufwind? – White Storks on the up?* (pp. 203–211). Proceedings International Symposium on the White Stork, 26–29 September 1996, Hamburg. Bonn: NABU.
- Mammeria, A.B. (2013). *Abondance de la Cigogne blanche Ciconia ciconia et parasitisme dans le Nord-Est de l'Algérie*. Thèse de Doctorat, Univ. El-Tarf.
- Mammeria, A.B., Bitam, I. & Houhamdi M. (2012). FRANCE (1876) (Revue). INISTCNRs, Cote INIST: 5023 35400050415364.0080. ISSN 0037-962X. CODEN BZOFAX. The White Stork *Ciconia ciconia* in Wetland of Northeastern Algerian, El-Tarf Area between 1996 and 2011, vol. 137. Zoological Society of France, Paris, pp. 103–111. No 1-4, 286.
- Mammeria, A.B., Triplet, P. & Bitam I. (2019). The white stork *Ciconia ciconia* in the northeast of Algeria, and its relation with climatic change between 1996 and 2014. *Estuarine Coastal and Shelf Science*, 216, 165–170. DOI: 10.1016/j.ecss.2018.01.001.
- Massemin-Challet, S., Gendner, J.-P., Samtmann, S., Pichegru, L., Wulgué, A. & Le Maho Y. (2006). The effect of migration strategy and food availability on White Stork *Ciconia ciconia* breeding success. *Ibis*, 148(3), 503–508. DOI: 10.1111/j.1474-919X.2006.00550.x.
- Moali, A. (1999). *Déterminisme écologique de la distribution et biologie des populations des oiseaux nicheurs en Kabylie*. Thèse de doctorat d'état. Univ. Mouloud Mammeri (Tizi-Ouzou).
- Moali, A., Akil, A. & Isenmann P. (1992). Decline of the White Stork in an area of Central Algeria. *Vogelwarte*, 36, 326–328.
- Moali, A., Moali-Grine, N. & Isenmann P. (1999). The White stork *Ciconia ciconia* 1994–1995 breeding census in Algeria. In H. Schulz (Ed.), *Weißstorch im Aufwind? – White Stork on the up*. In *Proceedings Intern. Symp. White Stork. Hamburg 1996* (pp. 89–96). Bonn: NABU.
- Moali-Grine, N. (1994). *Ecologie et biologie des populations de la Cigogne blanche Ciconia ciconia en Algérie: effectifs, distribution et reproduction*. Thèse de magister, Université de Tizi-Ouzou.
- Moali-Grine, N. (2005). *Dynamique des populations et Biologie de la conservation de la Cigogne blanche Ciconia ciconia en Algérie*. Thèse de doctorat d'état, Univ. Mouloud Mammeri (Tizi-Ouzou).
- Moali-Grine, N. (2007). Dynamique de la population de la Cigogne blanche *Ciconia ciconia* en Algérie depuis 1995. *Ostrich*, 78(2), 291–293. DOI : 10.2989/OSTRICH.2007.78.2.27.107.
- Moali-Grine, N., Moali, A. & Isenmann P. (1995). The White Stork *Ciconia ciconia* census 1993 in Algeria. *Vogelwarte*, 38, 35–40.
- Moali-Grine, N., Moali, A. & Isenmann P. (2004). L'essor démographique de la Cigogne Blanche *Ciconia ciconia* en Algérie entre 1995 et 2001. *Alauda*, 72(1), 47–52.
- Moali-Grine, N., Moali, L. & Moali A. (2013). Distribution et écologie de la reproduction de la Cigogne blanche (*Ciconia ciconia*) en Algérie. *Rev. Ecol.*, 68(1), 59–69.
- Nabu (2006). *Preliminary results of the 6th International White stork census*. Hamburg: International Ornithological Congress.
- Peris, S.J. (2003). Feeding in urban refuse dumps: ingestion of plastic objects by the white stork (*Ciconia ciconia*). *Ardeola*, 50(1), 81–84.
- Petrov, T., Iankov, P. & Georgiev D. (1999). Population status of the White Stork (*Ciconia ciconia*) in Bulgaria in the years 1994/95. In H. Schulz (Ed.), *Weißstorch im Aufwind? – White Stork on the up?* (pp. 241–246). Proceedings, Internat. Symp. on the White Stork, Hamburg 1996. Bonn: NABU.
- Rubacha, S. & Jerzak L. (2006). Changes in the white stork *Ciconia ciconia* population number, density and breeding places in Zielona Góra region 1926–2004. In *The white stork in Poland: studies in biology, ecology and conservation* (pp. 47–54). Poznan: Bogucki Wyd Nauk.
- Sbiki, M. (2016). *Contribution à l'étude du régime alimentaire et de la biologie de reproduction de la Cigogne blanche (Ciconia ciconia, Aves, Ciconiidae) et du Héron garde boeufs (Ardea ibis, Aves, Ardeidae) dans la région de Tébessa*. Thèse de Doctorat, Université de Batna.
- Schaub, M., Pradel, R. & Lebreton J.D. (2004). Is the reintroduced white stork (*Ciconia ciconia*) population in Switzerland self-sustainable? *Biol. Conserv.*, 119(1), 105–114. DOI : 10.1016/j.biocon.2003.11.002.
- Schüz, E. (1979). Results of the III international Census (1974) of the White stork. *Int. Council Bird Preserv. Bull.*, 13, 173–179.
- Thomas, J.P., Heringa, A.C., Ledant, J. P. & Mazerm W. (1975). *Recensement National des Cigognes blanches en Algérie*. Document polycopie. I.N.A. El Harrach, Alger.
- Tortosa, F.S., Caballero, J.M. & Reyes-López J. (2002). Effect of rubbish dumps on breeding success in the White Stork in southern Spain. *Waterbirds*, 25(1), 39–43. DOI: 10.1675/1524-4695(2002)025[0039:EORDOB] 2.0.CO;2.
- Tryjanowski, P., Jerzak, L. & Radkiewicz J. (2005). Effect of water level and live-stock on the productivity and numbers of breeding White Storks. *Waterbirds*, 28(3), 378–382. DOI: 10.1675/1524-4695(2005)028[0378:EOWLAL]2.0.CO;2.
- Tryjanowski, P., Kosicki, J.Z., Kuźniak, Z.E. & Sparks T.H. (2009). Long-term changes and breeding success in relation to nesting structures used by the white stork *Ciconia ciconia*. *Ann. Zool. Fenn.*, 46(1), 34–38. DOI: 10.5735/086.046.0104.
- Tucakov, M. (2006). Population development, nest site selection and conservation measures for White Stork *Ciconia ciconia* along the lower Tamiš River (Vojvodina, N Serbia). *Acrocephalus*, 27(128–129), 13–20.
- Watson, A. & Moss R. (1970). Dominance, spacing behaviour and aggression in relation to population limitation in vertebrates. In A. Watson (Ed.), *Animal Populations in Relation to Their Feed Resources* (pp. 167–218).