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Assessment of Natural and Anthropogenic Limiting Factors to the Nesting Population of White-tailed Sea-eagle *Haliaeetus albicilla* (Linnaeus, 1758) (Accipitriformes: Accipitridae) in the Danube Delta Biosphere Reserve and its surroundings, Romania

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Abstract: The factors that negatively influence the state of the populations of the white-tailed sea-eagle in the Danube Delta Biosphere Reserve and in the surrounding areas are both natural and anthropogenic. Between 2009 and 2018, an intensive study of those limiting factors was conducted. During those ten years, we registered 166 nests in the area, out of which 73 had been destroyed or deserted. The reasons were natural factors related to inclement weather in 73.97 % of the cases and anthropogenic factors in the remaining 26.03 %. Six limiting anthropogenic factors were identified: disturbance caused by fishermen and tourists (16.44 %), forestry works (4.11 %), illegal cutting of the tree supporting the nest (1.37 %), construction of a fishing hut near the nest (1.37 %), fires (1.37 %) and agricultural works and human presence (1.37 %). We present also the results of a spatial analysis aimed at disentangling how human settlements affect the distribution of the nests and how unpredictable settings of different kinds of temporary settlements can affect the viability of the nests. Different conservation actions are discussed with the objective of reducing the negative impact of the anthropogenic factors detected.

Key words: White-tailed sea-eagle, conservation actions, anthropic impact, nesting population, bird disturbance

Introduction

The Danube Delta hosts one of the largest European raptors, the white-tailed sea-eagle (from now on WtSe for simplicity) *Haliaeetus albicilla* (Linnaeus, 1758). This is the largest diurnal bird of prey that breeds in Romania. Over time, its global population has declined significantly, even disappearing

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permanently from certain areas. At the European level, the WtSe was a very common species at the beginning of the 20th century (Dombrowski 1912, Linția 1954, Cramp 1980). In Central Europe, the estimated number reached its lowest level (120-150 pairs) in 1960 (Glutz von Blotzheim et al. 1971). The main causes that led to the decline of the species were: pesticides, poaching, habitat destruction, etc. (Dombrowski 1912, Kornis 1936, Schnell 1936, Linția 1954, Bodea et al. 1957, Rosetti-Bălănescu 1957, Tălpeanu 1967, Puşcariu 1968, Dragomir & Kiss 1972, Cătuneanu 1973, Klemm 1973, Radu 1973, Steinbacher 1977).

Anthropogenic factors led to the rapid decrease of the size of the species population in Romania during the years 1950-1960 and also in many other European countries.

Although during the 20th century legislative protection measures were taken in many countries, in Romania the decline of the population of the WtSe continued almost until the early 1990s (Dragomir & Almăşan 1973, Klemm 1973, Kiss 1982, Kiss 1985, Stănescu et al. 1985, Grimett & Jones 1989, Marinov & Kiss 1991, Munteanu 1996), when its size was estimated at 10-20 breeding pairs (Ciochia 1992, Hagemeijer & Blair 1997, Munteanu 1998, BirdLife International 2000, Ciochia 2001, Daróczi & Zeitz 2001, Munteanu 2002, BirdLife International 2004, Ulvoczki 2006, Munteanu 2009).

Fortunately, the overall trends have changed. The ban on hunting and on the use of poisons for predators, as measures to stop the bioaccumulation of chemicals, have led to higher survival rate and breeding success, which together with the establishment of pan-European protected areas have given the species a positive population trend, especially in northern and central Europe. By the year 2015, the size of the global population of the WtSe was estimated at 24,200–49,000 adult birds, out of which 9000–12,300 pairs breed in Europe, representing 50–74 % of the global population (BirdLife International 2015). The countries with the largest populations are Norway, Russia, Poland, Germany, Sweden, Finland and Greenland (BirdLife International 2004, Keller et al. 2020).

After the Danube Delta was declared a Biosphere Reserve in 1990, an increase in the number of WtSe pairs was observed (Berne Convention 1993) and more recent studies support this local population trend (Kiss et al. 2013, Kiss et al. 2014, Sándor et al. 2015, Alexe 2018, Alexe 2019). In fact, when delimitating the strictly protected areas on the Danube Delta Biosphere Reserve (hereafter DDBR for simplicity) this species' presence was taken into account and, as a result, about a quarter of the existing known nests were benefiting from the additional protection measures. However, some dangers persist and others are becoming more pronounced, such as the loss of adequate natural habitats or the still existing chemical pollution, all in the frame of a global climate change.

The WtSe is a species that is at the highest level of the trophic pyramid, being at the same time a good indicator of the ecological processes in its distribution area. In this sense, starting from the principle of umbrella species, the protection of this bird attracts the protection of other syntopic species with which it interacts. By implementing various actions to protect this species, in fact, the entire food chain is protected, the last link of which is also the WtSe.

According to the International Union for Conservation of Nature and Natural Resources (IUCN) and BirdLife International (2023), the species is listed as a Least Concern as a result of its world-wide-range evaluation. In Romania, the WtSe is considered a rare, vulnerable and endangered bird, in GEO no. 57/2007 (Act 2007) in Annex III, Red List of Plant and Animal Species from the DDBR and the Red Book of Vertebrates in Romania (Oţel et al. 2000, Munteanu 1996). In Romania, this species is required to be granted maximum protection in accordance with the wording of the international conventions of Bern in Annex II, Bonn in Annex I and Washington in Annexes I and II, taken over by current legislation on biodiversity protection, including hunting regulations and those relating to protected areas (CITES 1973, Bonn Convention 1998, Act 2006).

The aim of this paper is to study the factors that affect the species population in the study area and how the acting mechanisms, in order to propose adequate conservation actions.

Materials and Methods

Monitoring and data collection

The monitoring of the WtSe was carried out in the period 2009–2018 by a team of the National Institute for Research and Development of the Danube Delta. The team explored transects (Bibby et al. 2000) along the study area (DDBR and surrounding forests) by car or by motorboats of different capacities. Occupied, abandoned or destroyed/fallen nests were accurately located with a GPS (Global Positioning System) device Garmin 62S. When it was not possible to reach the exact location, the coordinates were corrected afterwards. When a nest was destroyed or affected, the nature of the impact factor was determined.

Regarding the meteorological factors affecting the nests, strong winds and precipitation were considered the cause of the nest destruction when the winds exceeded 30 km/h and/or were combined with precipitations, according to the Reliable Prognosis rp5 website (www.rp5.ru), and when field observations supported the hypothesis.

The human impact factors recorded were a result of field studies and the human settlements proximate to the nests were classified as permanent (localities and dwellings like holiday houses or hotels that were occupied by at least one person throughout the year) or non-permanent (fishermen's houses, fishery points, fishermen's brigades, fishermen's huts, etc., which were inhabited only during the summer or the fishing season and that were observed during the field explorations around the nests).

Spatial data analysis

The subset of occupied nests recorded in the breeding season of 2018 was studied more in detail. Using QGIS software (version 3.10.14-A Coruña), the distances from those nests to the nearest permanent and non-permanent human settlements were calculated.

In order to have a better understanding of how the human presence affects the nest distribution, we compared this set of nests with a set of randomly generated points with a Wilcoxon rank sum test with continuity correction (U de Mann-Whitney) using RStudio software (version 1.4.1103).

In order to generate the set of random points, we created a convex polygon containing all the occupied nests under study (Convex Hull functionality in QGIS) and subtracted the water surfaces given by CORINE Land Cover 2018 (CLC 2018, Version 2020_20u1). The resulting area is where the 1000 points were randomly located to calculate the distances from each of them to the nearest permanent human settlement.

Results

Between 2009 and 2018, 166 nests were recorded in the study area and 73 of them were deserted by the breeding pair or destroyed within the study period due to different impact factors.

Out of those 73 nests, 73.97 % (N=54) were affected by natural factors: abundant precipitations (solid and liquid), negative temperatures and strong winds conventionally having over 30 km/h, storms, freezing rain.

The remaining 26.03 % (N=19) of the cases were due to anthropogenic factors that we studied in more details. The disturbing factors recorded comprise activities regarding fishing, tourism, agriculture and forestry industries (Table 1).

Table 1. Association of the natural and anthropogenic factors recorded in this study with the Natura 2000 pressure/threat categories.

<table>
<tr><th>N2000 Threat Code</th><th>N2000 Pressure /Threat definition</th><th>Limiting factors identified in DDBR</th><th>No. of nests affected</th></tr>
<tr><td>L</td><td>Geological events, natural catastrophes</td><td rowspan="2">Strong winds and precipitation</td><td rowspan="2">54</td></tr>
<tr><td>L07</td><td>Storm, cyclone</td></tr>
<tr><td>D</td><td>Transportation and service corridors</td><td rowspan="6">Disturbance caused by fishermen and tourists</td><td rowspan="6">12</td></tr>
<tr><td>D05</td><td>Improved access to site</td></tr>
<tr><td>F</td><td>Biological resource use other than agriculture & forestry</td></tr>
<tr><td>F02</td><td>Fishing and harvesting aquatic resources</td></tr>
<tr><td>G</td><td>Human intrusions and disturbances</td></tr>
<tr><td>G02.09</td><td>Wildlife watching</td></tr>
<tr><td>B</td><td>Sylviculture, forestry</td><td rowspan="2">Forestry works</td><td rowspan="2">3</td></tr>
<tr><td>B02.02</td><td>Clear-cutting, removal of all trees</td></tr>
<tr><td>E</td><td>Urbanisation, residential and commercial development</td><td rowspan="2">Building of a fishing hut near the nest</td><td rowspan="2">1</td></tr>
<tr><td>E04</td><td>Structures, buildings in the landscape</td></tr>
<tr><td>H</td><td>Military action, public safety measures, and other human intrusions</td><td rowspan="2">Fire</td><td rowspan="2">1</td></tr>
<tr><td>H01.01</td><td>Burning down</td></tr>
<tr><td>A</td><td>Agriculture</td><td rowspan="2">Agricultural works and human presence</td><td rowspan="2">1</td></tr>
<tr><td>A11</td><td>Agriculture activities not referred to above</td></tr>
<tr><td>G</td><td>Human intrusions and disturbances</td><td rowspan="2">Illegal cutting of the tree supporting the nest</td><td rowspan="2">1</td></tr>
<tr><td>G05.04</td><td>Vandalism</td></tr>
</table>

During the breeding season of 2018 we recorded 67 nests of the WtSe in the DDBR and its surroundings, 49 of them being occupied for breeding. The distances calculated to the nearest permanent human settlements (Fig. 1, top) have a minimum of 639 m (which can be interpreted as the tolerance limit), median of 5146 m and maximum of 17,953 m. For its part, the distances to the nearest non-permanent human settlement (Fig. 1, down) have a minimum of 88 m, median of 3376 m and maximum of 18,801 m (we eliminated an extremely high value of 44,790 m for the representation).

Comparing the distances to permanent localities from the WtSe active nests and randomly located points showed that, although the peak of the distribution for the nests was displaced to the right, the result of the Wilcoxon rank sum test suggested that both density distributions were similar (W = 27,901, p-value = 0.1005) (Fig. 2).

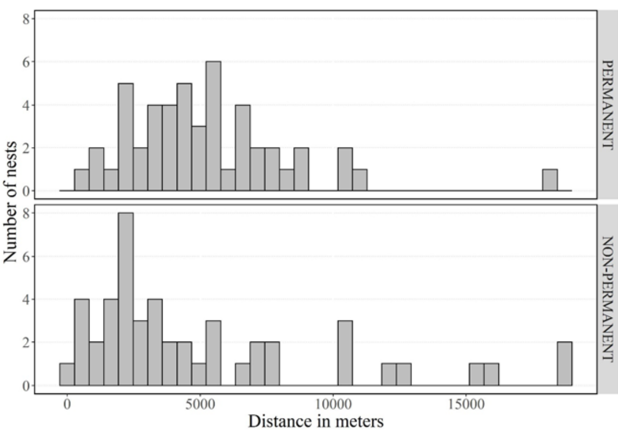

Fig. 1. Distance of the WtSe nests to permanent (N=49) and non-permanent human settlements (N = 48).

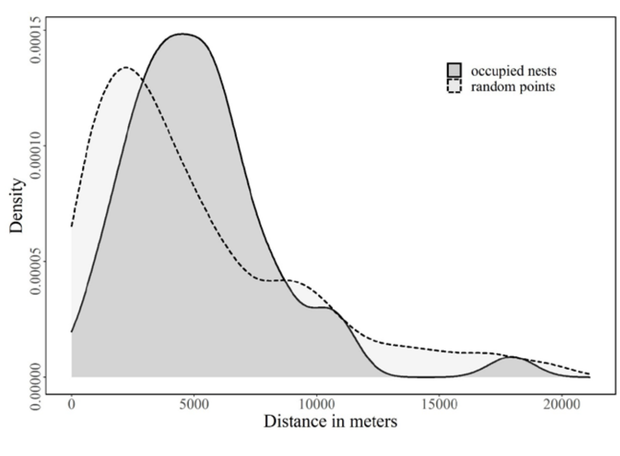

Fig. 2. Probability distributions of the distances to the nearest permanent settlement from the actual nests (N=49) and the randomly allocated points (N=1000).

Discussion

One of the most valuable qualities of the DDBR is the existence of large extensions of natural habitats. And it is not only about aesthetic criteria, but about the need of some rare birds to have a large living space, without the disturbing effects of the human populations, as in the case of the WtSe.

Based on our analysis, we found that the WtSe avoided nesting in the near vicinity of permanent human settlements. It preferred to build its nests at a distance of over 2000 m from them (Fig. 1), opting for isolated, quiet areas. These areas tended to be fewer in the researched area and the breeding pairs adjusted to the actual possibilities (Fig. 2).

Unfortunately, the limits of tolerance of the species were sometimes ignored by the unpredictable setting of non-permanent human settlements (Fig. 1). The distances from the nests to the permanent human settlements reflected the preferences of the birds but the distances to the non-permanent ones were unpredictable.

Probably, if the unpopulated wild areas were larger, these birds would do their nests even farther from human settlements. However, we encountered exceptions: since 2017 a pair of WtSe used a nest at a distance of 100 m from a sheepfold, without interrupting its nesting. Based on this example, we concluded that some pairs had a higher tolerance for certain kinds of human settlements. This was in accordance with similar findings in Finland, where Wallgren (2003) suggested that there was a decrease in fear of humans in the Finnish WtSes. In other cases, the persistence of the anthropogenic disturbing factors in the nest vicinity for a long time led to the desertion of the nest (pers. obs.).

However, the WtSe – human disturbing factor relationship is more complex in the case of feeding places, which can be negatively affected by the permanent human presence (Alexe 2022). The appearance of different structures in the wild places (fishing houses, legal or illegal mansions) inhabited throughout the year triggers the alteration of the delta habitats and endangers the biodiversity, especially during the tourism and sport fishing season. The impact of human disturbance on the WtSe is still poorly studied across its distribution (Alexe 2022), compared with similar species, e.g., the bald eagle *Haliaeetus leucocephalus* (Ruddock & Whitfield 2007), thus a future approach regarding the subject in the Danube River Delta can provide valuable information for the species conservation.

Regarding the impact factors studied that entail the destruction or desertion of the WtSe nests, 73.97 % of them were natural factors: abundant precipitations (solid and liquid), negative temperatures and strong winds, often with speed over 30 km/h, storms, freezing rain. Under such conditions, the tree can be uprooted or the branch that supports the nest can be broken. This phenomenon occurs during storms with heavy rainfall, especially when the nest is soaked with water. Another extreme meteorological phenomenon is the freezing rain, which occurs when raindrops fall on a surface (soil, trees, etc.) with a negative temperature and are instantly turned into ice. The phenomenon can cause damage, making both the tree and the nest heavier, resulting in its falling.

The results show that the most common causes of destruction or desertion of the WtSe nests are related to weather. Nevertheless, in spite of the conservation measures already in place for protecting the species inside the DDBR, 26.03 % of all the nest losses recorded in this study, 19 cases, were due to anthropogenic factors.

The recorded anthropogenic disturbances of the nests varied (Table 1) but the most frequent were related to fishing and tourism activities. Other activities from the forestry and agriculture industries perturb the species' needs more indirectly by reducing the amount of adequate nesting places. Forestry, land exploitation and disturbance during the breeding season are important factors affecting the population of the WtSe in the neighbouring Bulgaria (Todorov et al. 2015). These also threaten the positive trend of the population under study.

Some pairs of the WtSe, the nest of which had been destroyed owing to natural factors, built another nest near the fallen one. Since most of the nests fell as the support branch or the whole tree fell, the pair rarely built its nest on the same tree (pers. obs.). Usually, the new nest was located 10 to 20 m away, if an adequate support, represented by a tall enough tree, was available. Otherwise, the search for old trees in the respective habitat led to a distancing of 100-200 m from the original place. If the nest was destroyed due to a human factor, the pair did not build another nest nearby until that human factor disappeared.

Considering all, we can propose some aspects to be improved, along with concrete suggestions for conservation measures to be taken in order to protect this species in the study area.

Given that most of the anthropogenic perturbations come from fishing and tourism industries, some actions can be taken to reduce their impact, for example banning the constructions in wild areas, (including fisherman huts), monitoring the temporal campsites, controlling and banning the outboard engines larger than 15 HP and establishment of areas with lower boat circulation density around the WtSe nesting areas during the breeding season. Several reports have shown the sensitivity of the WtSe to apparently low impact activities like walking or biking (Helander & Stjernberg 2002, Probst & Gaborik 2012), thus considering these activities is needed for better conserving the species.

The impact of the forestry industry could be highly reduced by taking some actions like requesting an inventory of the WtSe nests detected before clearing actions begin and leaving a radius of at least 150 m around the tree supporting the nest when doing forest management works. By comparison, in most European countries the 'no –cut' radius around the nests of the WtsEs ranges between 50 and 300 m (Ruddock & Whitfield 2007, Probst & Gaborik 2011). It would also be beneficial to synchronise the works of dredging, deforestation or replanting with the circannual rhythm of the fauna of the DDBR. Moreover, fires are usual in the study area as it is part of the process in the reed harvesting industry. Setting fires during the correct period and within the correct areas should be aimed at. For the WtSe, the optimal period for carrying out the works mentioned above is from July to November.

One of the main hazards coming from agricultural industries is the use of animal pesticides, which are not species specific and bioaccumulate along the food chain and cause big damage to the raptor's populations (Iwata et al. 2000, Helander et al. 2002, Kannan et al. 2002, Kenntner et al. 2003). It is still a big problem that should be considered more seriously, for example through periodically testing the presence of these substances in the agricultural polders.

Other beneficial conservation actions consist of marking powerlines to reduce the deaths by collision, setting up a treatment and rehabilitation centre for wildlife inside or near the DDBR, actions focused on rising the awareness of the local population of this and other local species, banning hydrotechnical works at a large scale, maintaining a hunting plan in line with the conservation of the species, construction and installation of artificial nests in optimal habitats in case the WtSe population begins to decline and last, but very important, carry out an annual monitoring scheme of this population in order to establish the population's trends and detect possible problems.

This study evaluated how the impact factors affect the population of the WtSe in the study area. The percentage of nests affected by human factors is too large considering the status of the species and demonstrates the need of a good conservation plan. Even though the local trend is positive, the species will benefit of protected areas that can act as reservoirs for increasing the global population size and health. Improving the protection of this umbrella species will benefit also other syntopic species with which the WtSe shares its living environment.

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