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Four nesting attempts of a Great Bustard *Otis tarda* female in one reproductive season

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Abstract A mature Great Bustard *(Otis tarda)* female tagged with a satellite transmitter in Dévaványa made four breeding attempts in 2019. A total of seven eggs were laid on the four occasions. None of the breeding attempts were successful, and the bird was killed by a predator, presumably a Red Fox *(Vulpes vulpes)*, during the fourth breeding attempt. The four egg-laying attempts are a new experience in the reproductive biology of the species. The failure of the nestings and the death of the bird itself confirm that the conservation measures of the species, as emphasised in international and national conservation plans – controlling predators and egg predator populations, ensuring undisturbed breeding conditions – are important conservation biology actions serving for the protection of the species.

Keywords: satellite tracking, reproductive biology, Great Bustard, *Otis tarda*, conservation biology

Összefoglalás Egy Dévaványán műholdas jeladóval jelölt, ivarérett túzoktojó 2019-ben négy alkalommal próbálkozott költéssel, ezalatt összesen hét tojást rakott. Egyik költés sem volt sikeres, sőt a madarat a negyedik költés alatt ragadozó, feltehetően vörö róka zsákmányolta. A négy tojásrakási próbálkozás új fejlemény a faj költésbiológiáját illetően. A költések tönkremenetele és a madár pusztulása megerősíti, hogy a faj védelmének nemzetközi és hazai tervekben rögzített természetvédelmi céljai – ragadozók és tojáspredátorok állományszabályozása, költési feltételek zavartalanságának biztosítása – fontos konzervációbiológiai teendők a faj megőrzése érdekében.

Kulcsszavak: műholdas jeladó, költésbiológia, túzok, *Otis tarda*, konzervációbiológia

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Introduction

The Great Bustard *(Otis tarda)* is a strictly protected (MME 2022), globally threatened (BirdLife International 2017), vulnerable species in Hungary. Globally, its population is stable with a slight increase observed only in the Iberian Peninsula and the Carpathian Basin (Alonso 2014). Its population in Hungary has stabilised and started to increase slightly after a decline until the 1980s, owing to conservation programmes (Alonso 2014, Czifrák 2014). In the Hungarian context, its reporoductive biology (Faragó 1992, Demeter *et al.* 1994, Janó & Végvári 2016, Haraszthy 2019) was described as females having nests with 1–3 eggs (2 eggs being the most typical), and the literature also mentions that it may have a

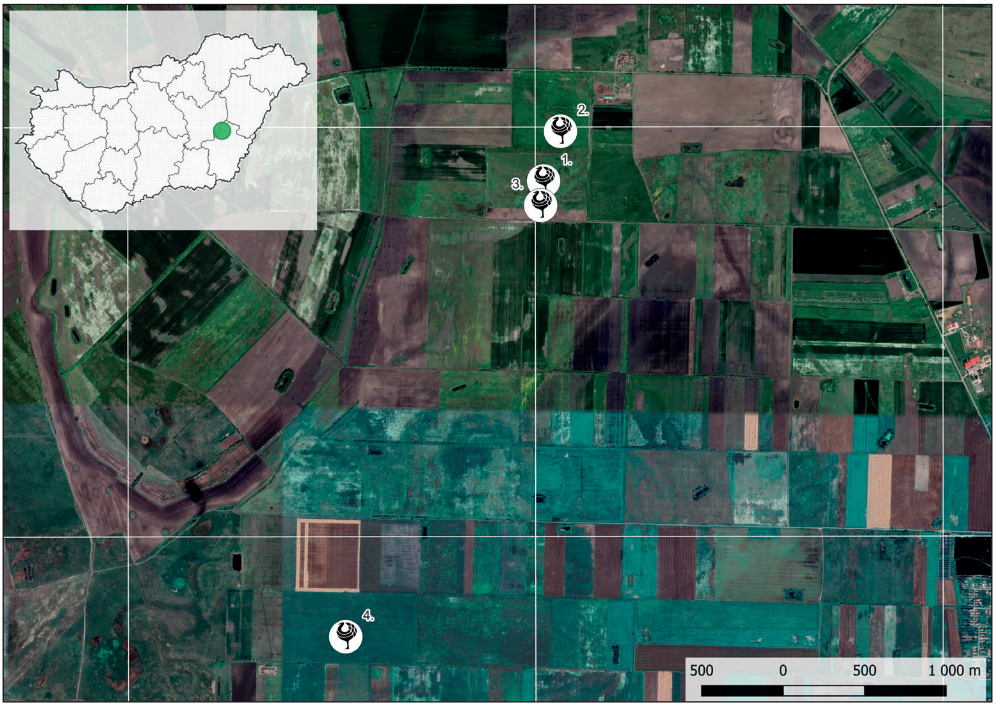

Figure 1. Overview map of the nesting attempts, see *Table 1*
1. ábra A fészkelési próbálkozások áttekintő térképe, lásd *1. táblázat*

Table 1. Basic data of the nesting attempts
1. táblázat A fészkelési próbálkozások alapadatai

Nesting attempts	Period	Laid eggs	Incubation time	Cause of failed nesting	Remark
1.	20.04.–25.04.	3	1–5 days	probably too many Roe Deers on the plot	faeces contamination
2.	02.05.–06.05.	2	3–6 days	probably too many Roe Deers on the plot	faeces contamination
3.	15.05.–28.05.	1	13 days	disturbance of an egg predator	egg predation
4.	04.06.–21.06.	1	14–17 days	most probably Red Fox predation	egg predation

second hatch or replacement nest, i.e. it may start a second nesting when its first nest failed, had been destroyed or abandoned. Previous studies based on rescued eggs (Németh *et al.* 2009), indicate that replacement nesting can be significantly prolonged, with up to four local nesting peaks in a year, but this could not be linked to individual bird behaviour, and it was questioned whether this pattern had a population, behavioural, autecological or weather-related background. Note that the study of rescued eggs also indicates that the nesting site is typically a site under some kind of agricultural management or other human activity that hinders the nesting female bird to incubate the nest, and thus, the egg must be rescued

(Demeter *et al.* 1994, Janó & Végvári 2016). The study of satellite tracked Great Bustards eliminates this factor, ideally also providing information from individuals that choose plant cultures, free from human disturbance, as nesting sites.

According to the Hungarian Great Bustard Species Conservation Plan (Faragó 2004) and Hungarian conservation studies (Vadász & Lóránt 2014), it is of key importance to preserve older, experienced female Great Bustards, and thus, increase the success rate of nesting, which is key to the conservation of the species in the context of the relatively low reproduction rate.

BirdLife Hungary/MME has been carrying out satellite tracking of Great Bustards in the framework of the LIFE Nature project „Cross-border conservation of Great Bustards in Central Europe", LIFE15 NAT/AT/000834, under the conservation authority permit PE-KTF/5218-16/2017, also in cooperation with National Park Directorates. The aim of the action was, among others, to identify the ecological factors that can be influenced by conservation measures affecting the Great Bustard population, in particular the land use of old females, their nesting behaviour and identifying the reasons for the loss of these experienced birds, which are important for the population (Alonso *et al.* 2004).

Previously, a single GPS transmitter was installed on Hungarian Great Bustard (Lóránt 2018). Within the framework of the above mentioned project, one mature female was equipped with a GPS transmitter (Ecotone) in March 2018, and a total of 16 wild birds (2 mature females, 14 chicks, respectively) until spring 2021. Besides, 6 repatriated chicks (from rescued eggs) received satellite transmitters by then.

Several instances of breeding or breeding attempts by the tagged old females and matured, tagged female chicks were detected.

Prior to our work, data collection and analysis of Great Bustard populations by satellite (radiotransmitter) tracking has been carried out on a large scale in Spain (Martin *et al*. 2007, Alonso 2008). Based on their experience, in addition to monitoring individual behaviour, population parameters and habitat use can be investigated. We started our studies with similar ambitions for tagging birds in our country. The Spanish research mainly analysed the survival of chicks, based on the number of chicks that already accompanied the female. There were no publications on nesting.

The present paper is a by-product of the study, while the project plans to adopt the data from tracked birds into a similar habitat suitability model described by Spanish Great Bustard conservation and research community (Suárez-Seoane *et al.* 2002), apart from the above mentioned aims. This model is expected to improve the overall nature conservation efforts on different Great Bustard habitats, and future habitats suitable for the hopefully expanding population in Hungary.

Materials and Methods

On 14 July 2018, an Ornitela GPS transmitter was placed on an mature Great Bustard female at the Great Bustard Rescue Centre in Dévaványa, in cooperation with the staff of the Körös-Maros National Park Directorate (KMNPD). The Ornitela transmitter type is OrniTrack50, a

50 g device with GSM based communication and solar charging. The data of the transmitter can be followed online via the basic geoinformatics interface with graphs of the transmitter sensor data available on the manufacturer's website, or the partial or complete data set can be downloaded and analysed in GIS software. When the transmitter was mounted, a flexible harness was attached to the ears on the transmitter housing, and two strands of this harness were threaded across the bird's chest, with a tension such that the harness could track the bird's changes in condition (including growth in the case of chicks) without hindering its movement or behaviour (Alonso 2008). A soft neoprene sheet was attached under the transmitter housing, cushioned against the bird's body.

The transmitter was set to optimise battery charge. During the breeding period, the transmitter attempted to connect to the GSM network and transmit data every 3 h, recording GPS points at a minimum of every 4 h depending on battery charge, but typically of every 5 min at maximum battery charge and every half hour below 50% battery charge.

We have monitored the behaviour and movements of the marked birds on a daily basis, and when needed, we communicated with the staff of the National Park Directorate responsible for the area where the bird was to be found. The data collected from the satellite tracking during the project will be used and evaluated for modelling the species' land use, which will underpin conservation management.

In this paper, we summarise our experience from the raw data of this tagged bird and related field studies for a given breeding period.

Results

According to the data from the tagged bird, the begining of the year 2019 until the breeding season was characterised by movements from wintering sites towards male displaying sites (leks), while it also occasionally used potential nesting areas, as if probing their quality.

On 19th April 2019 it stayed several times in the immediate vicinity of the point that was later identified as its first nest for short periods of time and on 20th April 2019, she started to spend increasingly longer periods of time there. This area was an uncultivated fallow field. We documented clear breeding behaviour for the first time on 24th April, when it seemed certain that the bird had started nesting: successive points marked a specific location, and the accelerometer showed a smaller variation than normal daily activity patterns. The bird, although it made quite a lot of comfort movements almost through the whole day, sometimes even leaving the nest for slightly longer periods overnight, presumably most often was under cover of vegetation as its battery charge began to decrease. On 25th April, in the early hours of the morning, the bird left the nest and did not return for several hours. KMNPD staff went to the area and found the nest with three eggs. The eggs and the nest were heavily contaminated with bustard faeces and it was certain that the female would not return to it. The eggs were collected and transported to the Great Bustard Rescue Centre to hatch by the conservation officers. Meanwhile, according to the transmitter, the bird was moving around nearby on adjacent fields, but was not observed. The fallow land, where the nest was abandoned, was used by several Roe Deer *(Capreolus capreolus)*.

The bird stayed nearby until the next nesting attempt, she used more open areas evidenced by the charging of the transmitters's battery. She did not return to the exact location of her former nest, but visited nearby a few times.

On 1st May 2019, the bird first started to give GPS locations at its second nesting site in a few point recordings. This site was an agricultural area adjacent to the previous nest location. The nesting was detected on 2nd May, based on movement changes described above. The nest was about 330 m far from the previous one. The bird spent much more time on the nest than the first time, less comfort movements were observed, and it travelled shorter distances. On 6th May, in the early morning hours, the bird left the nest and did not return until midday, when the conservation officers visited the nest and found two eggs heavily contaminated with faeces, meaning that it was certain that the bird would not return to the nest. Meanwhile, the female that had left the nest was again not observed, but recorded points showed that it had used the same nearby agricultural land as after the first failed nesting, and returned to its first nest site briefly at noon the following day.

On the same day, 6th May in the afternoon, there was a major movement in the direction where the bird later started its fourth nesting (see below). The female then returned the next day, on 7th May, to the same area where its first two nesting attempts had taken place. On 11th May, at dawn, she repeated this behaviour moving to more southerly areas, did not return further north, but moved to the east of the Dévaványa-Ecsegfalva road, south of the 400 ha fenced Great Bustard Protection Area, which also functions as a prolonged displaying site during this period (probably looked for males). From there the bird returned to the western side of the road on 13th May. From 14th May onwards, she used the same fallow land continuously where its first breeding failed. She visited the location of its first nest once for a short period.

On the afternoon of 15th May, the female first visited the site that was later identified as its third nesting site, staying overnight, but the next day, 16th May, it moved around the area only. On 18th May, she was observed to start its third nesting, staying at this point for short periods, but returning regularly. During the nesting period she moved less, compared to the previous attempts, its comfort movements were short in space and time. Meanwhile, contrary to expectations, the battery of the transmitter did not decrease, as the solar panel was able to recharge compared to the first breeding attempt on the same patch, presumably because the bird chose lower, less overcast vegetation as a nesting site. On the previous day, the points obtained were not always from the nest itself, within a few metres of it, but this was not to be considered of major importance due to the shading of the vegetation that had grown up fast in the wet weather. On 28th May, the bird was observed to have left the nest in late morning, not returning back, and its accelerometer showed a different, restless pattern, although the female did not show any major movements. Conservation officers who arrived on the scene in the afternoon found the nest in the edge of a damp patch of the fallow land, with no eggs, only the imprint of one egg in the soft soil. No eggshells were found, presumably because of nest predation, but no other evidence of a predator was observed. No sightings of the bird were made, the transmitter data indicating that she remained on the agriculture plot at this time.

The bird stayed on and near this fallow land for the next two days, 29–30 May, once visiting the area around the first nest. At noon on 30th May, after the bird flew a distance of about 2 km, it arrived to the previously visited southern area, where it used a rather small plot until 2nd June. The bird repeated this with another nearby plot, and then on 3rd June, it visited the fallow land where it had its first and third nests, from where it again flew to the southern area. On these days, its accelerometer showed more pronounced activity.

The female first touched the point that turned out to be its fourth nest on 4th June. On 10th June it was observed that the bird started nesting again, when its points came clearly from one place, although in the days before it had been moving in a small area, in the immediate vicinity of the future nest, and did not move away from it. The GPS signals could not pinpoint the nest so clearly, presumably due to the higher and denser vegetation the signal was not accurate. The bird's transmitter recorded several accelerometer peaks during the nesting, which was unusual compared to the three previous nesting occasions. The bird usually left the nest for a short period at dawn, sometimes for a greater distance than on the longer third nesting. On the morning of 20th June, it made a slightly longer circuit south of the nest, but returned. On 22nd June, the 15th–18th day of the incubation, we noted that the transmitter data showed an unusual pattern, something had happened to the bird (accelerometer showed transmitter turning over, then sudden movements, temperature data drop) in the afternoon of 21st June. Around noon on 22nd June, KMNPD conservation officers first scanned the area with a drone (it was possible that the transmitter harness had broken – but the drone could not detect the cause of the strange signals) and then went to the nest location in person. The remains of the bird were found near the nest, 3 metres away, most probably surprised by a predator, presumably a Red Fox *(Vulpes vulpes)*, on the nest. There were no eggs in the nest, but at least one egg imprint was observed. The egg was either taken by the predator that killed the hatching female, or by another nest predator, no egg remains were found. The transmitter harness was chewed through in three places, and the transmitter itself showed minor tooth marks.

Discussion

Main findings on the nesting of the tagged bird:

– For the first time ever, a Great Bustard was recorded trying to nest four times in one year. Data from a previous Hungarian study (Németh *et al*. 2009) based on age determination of rescued eggs suggested that this was possible, but this is the first data at the individual level to support this.

– In this year, the number of laid eggs presumed from direct and indirect evidence for this female was 7 in total. Studies carried out on a larger scale in Spain (Morales *et al*. 2002) have shown that the average Great Bustard female in Spain has a productivity of 0.14 ± 0.09 chicks per year, and the high number of eggs produced in one breeding period suggests a significant energy investment in case of this Pannonian individual.

– The Great Bustard is very sensitive to disturbance, as evidenced by the nesting attempts of this specimen. It is not known what caused exactly the abandonment of the nests, except for the fourth nesting attempt, but some disturbance is suspected, as indicated by the presence of nests contaminated with faeces of the bird. Experience has shown that nesting birds contaminate the nest when they are suddenly forced to do so by some drastic disturbance and do not return (Szél, pers. comm.). This rules out the possibility that the nest was abandoned because of a possible infertility of the eggs or because of unfavourable weather or biological conditions for the subsequent fostering of chicks. For the first and third nests, the bird used a field that was not cultivated by the farmer that year, so no significant human disturbance can be assumed, and started the second nest in a field adjacent to the first with similar conditions. There were quite a large number of Roe Deer on these fields, presumably due to lack of disturbance, and the bird may have been disturbed by the continuous movement of larger animals near the nest at night. On arable lands and grasslands affected by agricultural works, farming operations may cause more significant disturbance to the nesting female bustard (Németh *et al*. 2009, Janó & Végvári 2016).

– Although the bird was already a mature female when the transmitter was placed, so she must have been an experienced specimen, she used a total of only two narrow nesting locations in this period. She used the surroundings of the first site three times in succession, despite the fact that each time her nesting could have been disturbed by some external, possibly non-human factor. The fourth nesting site was visited several times during the year, but only the fourth time did the bird decide to nest there. The literature mentions that females have a preference for certain locations (Alonso *et al.* 2000), and this was also demonstrated by this individual during the first three nesting attempts, too.
– The predation on nesting females as a threat factor described in the national (Faragó 2004) and international conservation plans (Nagy 2009) has been confirmed this case, highlighting the need for predator management in Great Bustard habitats. It should be noted that predator management in this area of the KMNPD is also carried out within the framework of the LIFE project to protect the Great Bustard by hunting methods [monitoring of Red Fox, Badger *(Meles meles)*, Golden Jackal *(Canis aureus)* and Wild Boar *(Sus scrofa)* populations, burrow hunting and trapping as necessary, preferably before the reproduction season of the predator species, and trying to maintain a target number zero for Wild Boar].
– Also confirmed the presence of negative nest predation pressure on breeding success. Of the 7 eggs laid, at least one most probably have been consumed by a nest predator, but it is also possible that even the egg predator discovering the nest could have caused the female to leave the nest. Predator management using the above-mentioned hunting methods also includes population control of nest predators (Hooded Crow *Corvus cornix*, and Magpie *Pica pica*) control with live-catching traps.

All in all, the unique fate of this female Great Bustard underline the relevance of efforts that have characterised conservation work so far. The loss of experienced females will reduce the already low population growth potential. Based on this case study, the need to integrate predator and egg predator population control into game management is of paramount importance in Great Bustard habitats, but from a game management perspective, the need for Roe Deer management around typical nesting sites may also arise. An important lesson is that nesting bustards could invest considerable energy in egg laying, more than previously thought, and that conservation efforts could achieve more significant results by increasing the success rate of the first nest. In the case of agricultural support schemes in Great Bustard habitats, it would be advisable to implement measures of as little disturbance as possible at the beginning of the nesting season (late March–May), and preferably to exclude all agricultural work in Great Bustard nesting sites. Detection of such nesting sites as early as possible, preferably by remote sensing, could be an important conservation objective for the species.

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