ECOLOGIA BALKANICA
2021, Vol. 13, Issue 1 June 2021 pp. 9-16

# *Copulatory Behavior of the Egyptian Vulture (Neophron percnopterus) in the Eastern Rhodopes, Bulgaria*

***Vladimir D. Dobrev[1,2*], Emil S. Yordanov[1,2], Georgi S. Popgeorgiev[2,3]***

1 – University of Plovdiv "Paisii Hilendarski", Faculty of Biology, Department of Ecology and Environmental Conservation, 24 Tzar Assen Str., 4000, Plovdiv, BULGARIA
2 - Bulgarian Society for the Protection of Birds / BirdLife Bulgaria, Leonardo da Vinci str.5, PO box 562, 4000 Plovdiv, BULGARIA
3 - National Museum of Natural History, Bulgarian Academy of Sciences, 1 Tsar Osvoboditel Blvd., 1000 Sofia, BULGARIA
*Corresponding author: vd.dobrev@gmail.com

**Abstract.** Copulatory behavior has been reported in many raptor species, possibly because their copulations are typically conspicuous and frequent. Vultures are single-brooded and long-lived birds in which pair bonds may be maintained from one year to the next. The copulatory behavior was studied in three out of the four vulture species that breed in Europe. However, a more detailed explanation of the exclusive copulatory behavior of the Egyptian vulture regarding the frequency of copulation is missing. Here we provide the first data from the Balkans on the different aspects of the copulatory behavior of the Egyptian vulture and compare it with previous studies on the species and other conspecifics. The study was carried out in the Eastern Rhodopes mountain, Bulgaria, the stronghold of the species in the Balkans. We observed 4 pairs from vantage points and 5 with trail cameras. We recorded 137 copulation attempts in total. The majority of the copulation attempts were successful (86%, n=68) with a mean duration of 17.6±11.8 sec. The daily pattern of copulation frequencies we found suggests a bimodal distribution. Regarding the seasonal pattern of copulation frequencies, two peaks were observed – at the beginning of the breeding season and before the laying. The presence of the male around the female increased with time and before the laying. In terms of conspicuousness, the number of copulation attempts increased with the linear distance from the nests of the observed pairs to the copulation site which was always visible and exposed.

**Key words:** Egyptian vulture, copulations, sperm competition, territory ownership signals, paternity assurance.

## Introduction

The behavior of raptors during the breeding season is way more studied in comparison to any other period of their lives. The breeding cycle in the raptor species starts with the pre-laying period when birds mate, occupy a territory, build a nest, display and defend their territory, copulate actively (Newton, 1979). Copulatory behavior has been reported in many raptor species, possibly because their copulations are typically conspicuous and frequent

(Negro & Grande, 2001). Vultures are single-brooded and long-lived birds in which pair bonds may be maintained from one year to the next (Cramp & Simmons, 1980). They exploit unpredictable trophic resources and thus need to spend a lot of time away from the nest foraging, which might affect the copulation behavior of the species (López-López, 2014). In three of the four vulture species that breed in Europe, the copulatory behavior was studied in terms of frequency, rate, pattern and conspicuousness (Negro & Grande, 2001). The Griffon vulture, a colonial species, differs in some main copulatory aspects compared to the Egyptian and the Bearded vultures, namely the low copulation frequencies and the lack of mate-guarding (Margalida & Bertran, 2010). In contrast, in both the Egyptian vulture and the Bearded vulture, a high frequency rate has been observed with an intensive presence of the male in the nest before the laying (Donázar et al., 1994; Bertran & Margalida, 1999). However, a more detailed explanation of the exclusive copulatory behavior of the Egyptian vulture regarding the different hypotheses about the frequency of copulation is missing. In this paper (1) we provide the first data from the Balkans on the different aspects of the copulatory behavior of the Egyptian vulture and compare it with previous studies on the species and other conspecifics, (2) explain the copulation patterns of the species in the context of the different hypothesis interpreting the frequent copulations.

**Material snd Methods**

The study was carried out in the Eastern Rhodopes mountain, Bulgaria which is the stronghold of the species in the Balkan peninsula (Velevski et al., 2015). The observations were carried out between 2008 and 2020. Four pairs were observed for 386 h during the pre-laying period from vantage points to detect copulations outside of the nest and in the breeding territory (Bibby et al., 1992). A breeding territory was defined as the territory actively defended by the pair and presumably it can't be fully covered from vantage points. However, this approach is considered relevant (Donázar et al., 1994). Observations were made in good weather conditions, in the majority of the cases lasted from early morning until dusk, and binoculars 10 x and 20 x 60 telescopes were used at a distance of at least 600 m away of the nest. This distance is considered appropriate for observation in order to avoid disturbance over the pair and eventually affect the behavior of the birds (Zuberogoitia et al., 2008). To detect copulations in the nest that are considered rare (Donázar et al., 1994), we monitored the other five pairs in their nests with mounted trail cameras (n = 5) for 2656 ± 104.83 h. Trail cameras were mounted at the beginning of March, before the return of the birds from Africa. Natural materials such as stones, leaves and branches were used as camouflage to prevent disturbance over the birds. The trail cameras were set to take 1 still image when activated by movement, with an interval of 30 seconds between shots. To avoid disturbance of the birds and to save battery voltage, trail cameras were not set to take a video and thus the duration of the detected copulations was not registered. Sex identification of the observed individuals was based on the slight difference in the pigmentation of the head at the beginning of the breeding season - more orange in most males and yellowish in the females (Cavallo et al., 1997). Furthermore, we also used the plumage patterns of individuals to identify the sex in a given year (Zuberogoitia et al., 2018). We recorded the time, duration (in sec), and location of copulations, the duration of the time when adults were present together or separately in the breeding territory (in mins). A copulation was considered successful when a cloacal contact was registered (Hunter et al., 1996). All others were considered unsuccessful. The data for the copulations were pooled together for all years. The daily pattern of copulation frequency was estimated as the number of copulation attempts divided by 60 for each time frame of 1 hour between 6 AM and 7 PM (copulation attempts per hour) for both the directly observed and those pairs monitored with trail cameras. In addition, to describe the seasonal variation in the copulation frequency, the

number of copulations was combined in time in periods of 7 days dating backwards from egg-laying (day 0). Then, for each 7 days period, the copulation frequency was estimated as the number of copulation attempts divided by the total hours of observation. The clutch size in this species is between one and three eggs, and incubation starts as soon as the first egg is laid (Mendelssonhn & Leshem, 1993). In four of these pairs, the beginning of incubation was identified by direct observations and in the five remaining pairs using the trail camera shots. To account for the conspicuousness, the location of copulation sites were identified precisely, plotted and the distance to the nests was measured with Measure Tool in ArcGIS 10.2 (ESRI, 2014). We used descriptive statistics to describe copulations, One-way ANOVA with an LSD test to compare the duration of copulations between the different pairs and $\chi 2$ test to compare the daily pattern of copulation frequencies between directly observed pairs and pairs monitored with trail cameras in the nests. All test were performed in STATISTICA for Windows, Release 7.0 (StatSoft, 2004). The statistical significance was set at $p < 0.05$.

**Results**

We observed 79 copulation attempts for the four pairs observed from vantage points. Almost all copulation attempts were registered in the breeding territory (94%, n = 74) and the rest were detected in the nest (6%, n = 5). The majority of the copulation attempts were successful (86%, n = 68) with a mean duration of 17.6 ± 11.8 sec. A significant difference in the copulation duration was observed between two pairs ($F = 2.31$, $p = 0.04$). In the five pairs observed with trail cameras, 58 copulation attempts were registered. Nevertheless, except for 1 copulation attempt, the rest were observed in only one pair. The first recorded copulation occurred on day -25 before the laying of the first egg and copulation attempts continued until day -2. Nonetheless, copulations were observed until day +3 in the pairs observed with trail cameras, before laying the second egg. The pre-laying period lasted for 18.5 ±8 .3 days in all observed pairs. The daily pattern of copulation frequencies between day – 25 and day 0 suggests a bimodal distribution (Fig. 1).

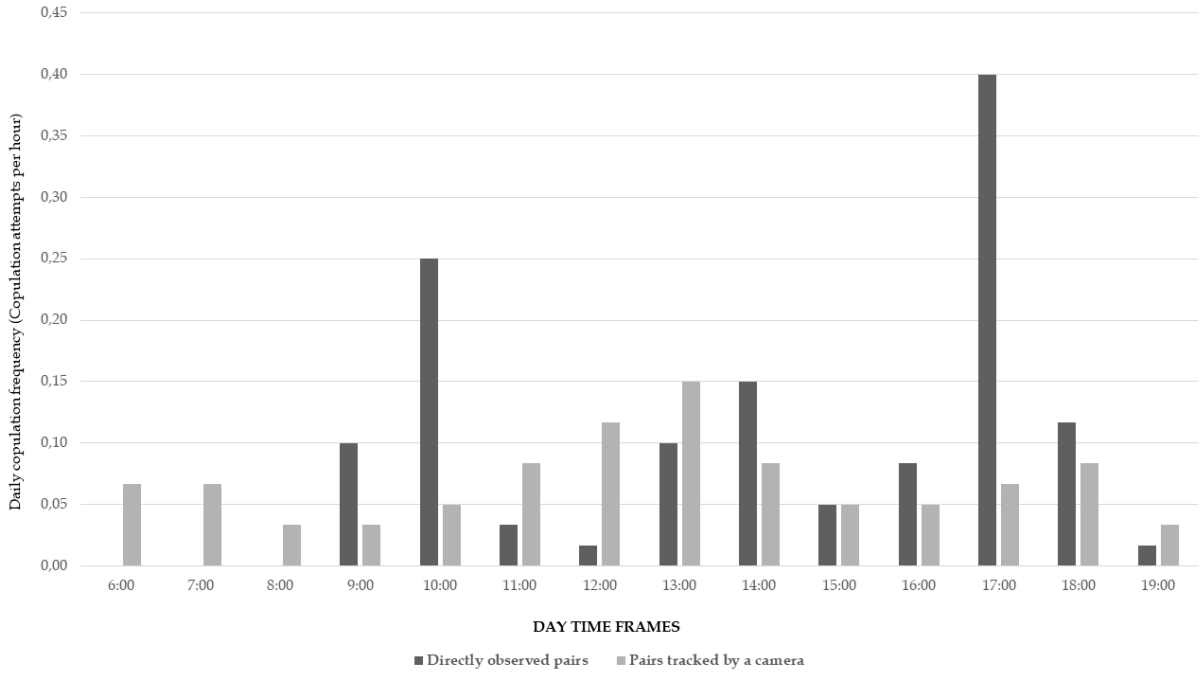


**Fig. 1.** The daily pattern of copulation frequencies of nine pairs of Egyptian vulture during the pre-laying period (day +3 to -25, n = 137 copulation attempts).

The copulation rate is high and two maximum peaks were observed just before noon (between 09:00 and 11:00), and in the late afternoon between 17:00 and 18:00 in the pairs observed from vantage points. We found a significant difference in the daily pattern of copulation frequencies between pairs observed from vantage points and pairs observed with trail cameras ($\chi 2$, $p < 0.05$).

During the pre-laying period, 125 copulation attempts were registered. Another 12 copulation attempts were registered between the laying of the first and the second egg. The copulation pattern of the observed pairs during the period suggest 2 peaks between days -1 – -7 and days -15 – -21 with values of 0.44 (n = 29.41 hours of observation) and 0.57 attempts hr-' (n = 82.16 hours of observation) accordingly. In contrast to the pairs observed from vantage points, the trail cameras detected copulations with high frequency at day 0, in the hours after laying of the first egg, and day +3, both beyond the fertile period. As a sequence, the frequency obtained during the post-laying period was 0.077 attempts hr-'(n = 26 hours of observation) (Fig. 2).

Mate attendance increased with time and was intensive prior to the laying. We didn't observe the females left unattended by their partners between day -10 and day 0. In terms of conspicuousness, the number of copulation attempts increased with the growth of the linear distance from the nests of the observed pairs. In addition, all observed pairs had concrete preferences towards the sites for copulation, choosing the same spot in most of the cases. Also, all sites were on top of a cliff or a hill and conspicuous (Fig.3).

**Discussion**

The Egyptian vulture is a territorial bird that starts copulating very soon after arrival in the breeding territory and like other raptor species copulations are frequent over extended period of time (Negro et al., 1992). Our research confirmed the results of previous studies on the species' copulatory behavior and found that the proportion of successful copulations is 86% and the rate of copulations is high (n = 137) (Donázar et al., 1994).

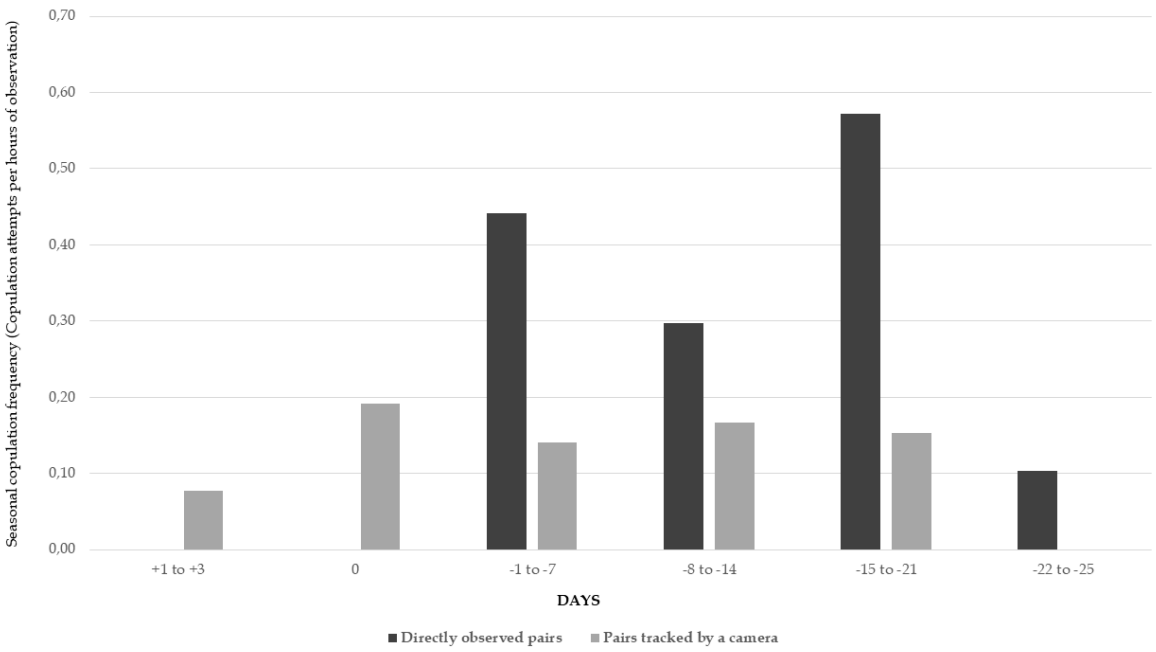


**Fig. 2.** Seasonal pattern of copulation frequencies of nine pairs of Egyptian vulture during the pre-laying period.

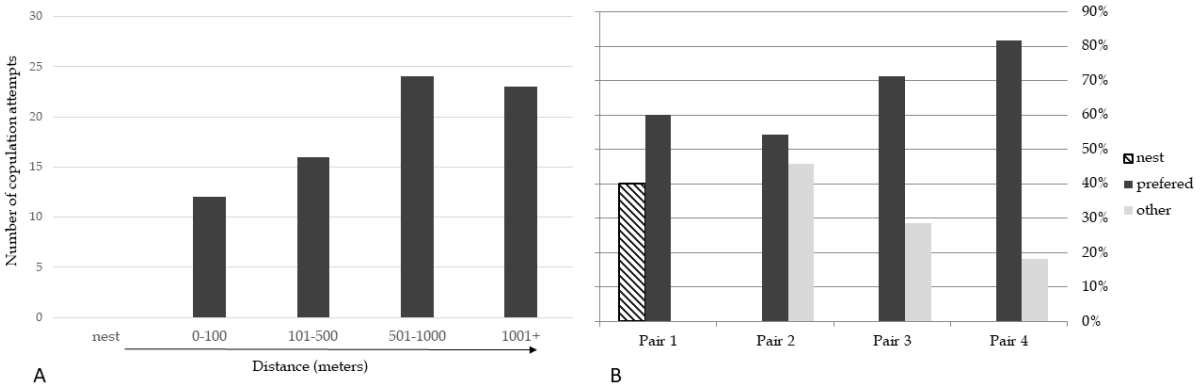


Fig. 3. A. Linear distances between nests of four Egyptian vulture pairs and their copulation sites; B. Proportion of copulation attempts at different copulation sites of the four Egyptian vulture pairs observed directly.

The proportion of successful copulations of the Egyptian vulture is similar across Europe and higher compared to sympatric species such as the Bearded vulture (Bertran & Margalida, 1999). Also, the duration of the successful copulation we report in our study is slightly higher than the reported for the species before (Donázar et al., 1994). In contrast with Donázar et al. (1994), we detected also copulation attempts after the onset of incubation. The fertile period of the species is unknown (Robetson, 1986). Nevertheless, copulations of the species exceeding the laying date and therefore beyond the fertile period of the Egyptian vulture should also play a role in strengthening the bond in the pair except for the fertilization itself (Birkhead & Møller, 1987). In addition, copulation attempts in the post-laying period, eve rare, are also observed in the Bearded vulture (Bertran & Margalida, 1999). In contrast with other studies on solitary and territorial vulture species, we recorded 63 copulation attempts of 3 different pairs that occurred in the nest (Donázar et al., 1994; Bertran & Margalida, 1999). Nevertheless, it seems that the majority of the pairs do not copulate in the nest, and it is most probably typical for some pairs and unusual in general. All pairs that we observed copulating in their nest had a large nest sites compared with the mean size of the nests described in the Egyptian vulture (Balaban & Yamaç, 2019). Furthermore, these pairs occupy high Egyptian vulture density areas where competition is more severe and territory defense and signaling should be more intensive (Newton, 1979; Harmata, 1982; Negro & Grande 2001).

We found that the daily pattern of copulation frequencies is bimodal in contrast to previous studies on the species and in line with sympatric species such as the Bearded vulture (Negro & Grande, 2001). Our results demonstrate a significant difference between the data on the daily copulation patterns in pairs observed by trail cameras and by direct visual observation. In the first case the bimodal distribution is very discrete. The analysis of the direct observations data indicates two very prominent peaks. The first peak in the bimodal distribution is observed in the late morning hours when the thermal uplifts start and when the activity of the scavengers is expected to increase (Mundy et al., 1992). The second peak in the copulations that we observed was in the late afternoon, just before dark. This finding supports the sperm competition hypothesis where the male bird should be more prone to copulate in the very last possible hours of the day to ensure paternity and to dilute the sperm of possible competitors (Birkhead &

Møller, 1987; Birkhead et al., 1988). During the pre-laying period raptors are predominantly mating and building the nest (Newton, 1979). We found high copulation rate of the Egyptian vulture in the days before the egg laying (from -7 to -1). We suggest this behaviour has to ensure the fertilization of the eggs on one hand and the paternity on other hand. As proved also in other species such as the Bearded vulture, extra copulations are possible. This would be more feasible in areas where the population of the Egyptian vulture is abundant and there are many neighboring pairs which would make the extra pair copulations possible. The Eastern Rhodopes mountain harbors the majority of breeding Egyptian vultures in Bulgaria (Arkumarev et al., 2018). Even though we didn't register extra-pair copulations in the recent study, such observations in the area exist.

Our results suggest that the Egyptian vulture performs a paternity guarding strategy based on frequent copulations and solid attendance of the male around the female during the whole pre-laying period similarly to other studies for the same (Donázar et al., 1994) or sympatric species (Bertran & Margalida, 1999). In our study, the time that both birds spend together prior to egg laying varied from 82.2% to 100%. Hence, the mate attendance reduces the risk of extra-pair copulations (Birkhead & Møller, 1987).

Copulation behaviour, however, could be some kind of advertisement (Ellis & Powers, 1982; Simmons, 2000; Village, 1990) or expression of territory ownership (Negro & Grande 2001). Usually, raptor copulations take place in prominent or conspicuous places (Bertran & Margalida, 1999). Our results support the hypothesis because all the pairs of Egyptian vultures we observed had a clear pattern in terms of conspicuousness – they were all mating on exposed places visible from far away and from their direct conspecifics and other competitors. The hypothesis is suggested by Negro & Grande (2001) to explain the high daily copulation rates of raptors over extended periods. Specifically, if repeated copulations have a function related to territoriality or the signaling of breeding status one would expect raptors to copulate preferentially in the defended breeding area, and copulations to be conspicuous, to convey information to potential signal receptors (Negro & Grande 2001). Furthermore, all the pairs we observed, used the same spot for copulation in the majority of cases. Raptors tend to copulate in the area where intruders (i.e. conspecifics and other birds) are not tolerated (Negro et al., 1992; Robertson 1986). As a pronounced territorial bird, the copulation behavior of the Egyptian vulture seems to serve as a signal of a territory ownership and to convey information to competitors (Negro & Grande, 2001).

In summary, our results suggest that the Egyptian vulture guarantees paternity using the strategy of high copulation rate and intensive attendance in the breeding territory, around the nest and the female during the pre-laying period. Furthermore, we suggest that copulatory behavior is related to the territorial displays and signaling of territory occupancy and used to convey messages to conspecifics.

**Acknowledgements**

The current research was financed by National program "Young scientists and Postdoctoral candidates" funded by the Bulgarian Ministry of Education and Science. The use of trail cameras to monitor the Egyptian vulture in Bulgaria in the period 2012–2020 was implemented under the LIFE+ project "The Return of the Neophron" (LIFE10 NAT/BG/000152), LIFE project "Egyptian Vulture New LIFE" (LIFE16 NAT/BG/000874) funded by the European Union and co-funded by the A. G. Leventis Foundation and MAVA Foundation. We would like to express our gratitude to Dobromir Dobrev, Ivaylo Angelov, Vanya Angelova and Volen Arkumarev who contributed with the field observations and logistics.

**References**


Arkumarev, V., Dobrev, V., Stoychev, S., Dobrev, D., Demerdzhiev, D., & Nikolov, S. (2018). Breeding performance and population trend of the Egyptian Vulture *Neophron percnopterus* in Bulgaria: conservation implications. *Ornis Fennica, 95*(3), 115–127.

Balaban, S. & Yamaç, E. (2019). Nest characteristics of Egyptian vulture (*Neophron percnopterus*) in Middle and Upper Sakarya Region, Turkey. *Biological Diversity and Conservation, 12*(3), 126–131. doi: 10.5505/biodicon.2019.70299.

Bertran, J. & Margalida, A. (1999). Copulatory behavior of the bearded vulture. *Condor, 101*, 164–168. doi: https://doi.org/10.2307/1370459.

Bibby, C., Burgess, N., & Hill, D. (1992). *Bird Census Techniques*. University Press, Cambridge.

Birkhead, T.R. (1998). Sperm Competition in Birds. *Reviews of reproduction, 3*, 123–129. doi: 10.1530/ror.0.0030123.

Birkhead, T.R., Atkin, L., & Møller, A.P. (1987). Copulation behaviour of birds. *Behaviour*, 101–138. doi: 10.1163/156853987X00396.

Birkhead, T.R., Pellatt, J., & Hunter, M. (1988). Extra-pair copulation and sperm competition in the Zebra Finch. *Nature, 334*, 60–62. doi: 10.1038/334060a0.

Cavallo, D., De Vita, R., Eleuteri, P., Belterman, R.H.R., & Dellómo, G. (1997). Sex identification in the Egyptian Vulture by flow cytometry and cytogenetics. *Condor, 99*, 829–832. doi: 10.2307/1370498.

Cramp, S. & Simmons, K.E.L. (1980). Birds of Europe, Middle Easte and North Africa. Vol. II. Oxford University Press, Oxford.

Donázar,J. A., Ceballos, O., & Tella, J.L. (1994). Copulation behaviour in the Egyptian Vulture *Neophron percnopterus*. *Bird Study, 41*, 37–41. doi: 10.1080/00063659409477195.

Ellis, D. H., & Powers, L. (1982). Mating behavior in the golden eagle in non-fertilization contexts. *Journal of Raptor Research, 16*, 134–136.

ESRI. (2014). ArcGIS Desktop: Release 10.2. Redlands. CA: Environmental Systems Research Institute.

Harmata, A.R. (1982). What is the function of undulating flight display in golden eagles? *Raptor research, 16*(4), 103-109.

Hunter, E.M., Davies, L.S., & Miller, D. (1996). Sperm transfer in the Adélie Penguin. *Condor, 98*, 410–413. doi: 10.2307/1369158.

López-López, P., García-Ripollés, C., & Urios, V. (2014). Food predictability determines space use of endangered vultures: implications for management of supplementary feeding. *Ecological Applications, 24*(5), 938–949. doi: 10.1890/13-2000.1.

Margalida, A. & Bertran, J. (2010). Copulatory behaviour in the colonial Eurasian Griffon vulture *Gyps fulvus*. *Journal of Ethology, 28*, 179–182. doi: 10.1007/s10164-009-0169-5.

Mendelssonhn, H., & Leshem, Y. (1983). Observations on reproduction and growth of Old World Vultures. In S.R. Wilbur and J.A. Jackson (Eds.): *Vulture biology and management*, (pp. 214–241). University of California Press. Berkeley.

Mundy, P.J., Butchart, D., Ledger, J., & Piper, S. (1992). *The vultures of Africa*. Acorn Books, Randburg.

Negro, J., Donazar, J.A., & Hiraldo, F. (1992). Copulatory behaviour in a colony of Lesser Kes-trels: sperm competition and mixed reproductive strategies. *Animal Behavior, 43*, 921-930. doi: 10.1016/S0003-3472(06)80005-9.

Negro, J. & Grande, M. (2001). Territorial signaling: a new hypothesis to explain frequent copulation in raptorial birds. *Animal behavior, 62*, 803–809. doi: 10.1006/anbe.2001.1811.

Newton, I. 1979. *Population ecology of raptors*. T. & A.D. Poyser, London.

Robertson, A. (1986). Copulations throughout breeding in a colonial accipitrid vulture. *Condor, 88*, 535–539. doi: 10.2307/1368290.

Simmons, R.E. (2000). *Harriers of the World*. Oxford: Oxford University Press.

StatSoft Inc. (2004). STATISTICA (*Data analysis software system*), Version 7. Retrieved from www.statsoft.com.

Velevski, M., Nikolov, S. C., Hallmann, B., Dobrev, V., Sidiropoulos, L., Saravia, V., Tsiakiris, R., Arkumarev, V., Galanaki, A., Kominos, T., Stara, K., Kret, E., Grubač, B., Lisicanec, E., Kastritis, T., Vavylis, D., Topi, M., Hoxha, B., & Oppel, S. (2015). Population decline and range contraction of the Egyptian Vulture *Neophron percnopterus* on the Balkan Peninsula. *Bird Conservation International, 25*, 440–450. doi: 10.1017/S0959270914000343.

Village, A. (1990). *The Kestrel.* London: T. & A.D. Poyser.

Zuberogoitia, I., Zabala, J., Martinez, J.A., Martinez, J.E., & Azkona, A. (2008). Effect of human activities on Egyptian vulture breeding Success. *Animal Conservation, 11*, 313–320. doi: 10.1111/j.1469-1795.2008.00184.x.

Zuberogoitia, I., Zabala, J., & Martinez, J.E. (2018). Moult in birds of prey: a review of current knowledge and future challenges for research. *Ardeola, 65(2)*, 183–207. doi: 10.13157/arla.65.2.2018.rp1.

Received: 17.01.2021
Accepted: 23.02.2021