Trail cameras – insight into the breeding phenology of the Egyptian vulture (*Neophron percnopterus*) through the use of trail cameras in the Eastern Rhodopes, Bulgaria (2011 – 2018)

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Contents

Abstract

The Egyptian Vulture (*Neophron percnopterus*) is a widely distributed species in southern Europe, Africa and southern Asia but its population has declined throughout the major part of its Western Palearctic range. Even though it is a well studied species the habits during the breeding cycle and more precisely how the pair shares the duties (proportion of incubation, number of switches, food provisioning) remains poorly documented. We used trail cameras in 2 nets between 2011 and 2018 to study the breeding phenology and behavior of one pair of Egyptian vultures and to identify nest intruders in 2 nests. In our study both sexes seem to contribute equally to the nest arranging since there wass no significant difference (W = 3, p = 0,2), however the contribution of the female is significantly less important than male's in the nest building (W = 0, p = 0,01). The rate of copulation seen in the nest seems to be the same throughout the years (H = 4, df = 4, p = 0,41). Both sexes seem to contribute equally (5,88 ± 0,724 SD hours per day on average for the female and 5,75 ± 0,824 SD on average for the male) to the incubation task across the entire period. Only 27% of the food delivered to the nest would be found in the remains at the end of the breeding season. We didn't find any replacements of breeding birds in the 2 studied pairs during the study period. However, we managed to draw main plumage and facial characteristics that can be used for identification of sexes in breeding pairs, and to confirm birds in consecutive years. Finally we suggest that instalation of artificial barriers for the predators and other pilot instalments such as electric fences could prevent nest ravage by predators (such as the Beech marten).

Introduction

The Egyptian Vulture (*Neophron percnopterus*) is a widely distributed species in southern Europe, Africa and southern Asia. However, its number has declined throughout the major part of its Western Palearctic range (Iñigo *et al*. 2008; Botha *et al.* 2017) and the species is considered as globally 'Endangered' since 2007 (BirdLife International 2012). As in most of Europe, the species is decreasing in the Balkans, where it became extinct in several range states (Bosnia and Herzegovina, Croatia, Serbia), and went through a rapid population decline of about 4-8% annually in the rest of its range in the peninsula (Iñigo *et al.* 2008, Velevski *et al.* 2015).

The biology and ecology of this medium-sized scavenger are being studied to help in its conservation (Dobrev *et al.* 2016, Oppel *et al.* 2017). In that context, the breeding parameters, behaviour and the diet represent pivotal knowledge.

Just as in any other raptor; the breeding cycle of the Egyptian vulture is known to be divided in five main stages: pre-laying, laying, incubation, chick-rearing and post-fledgling (Newton 1979). During the breeding cycle, this loyal scavenger sustains exclusive breeding territories, which are used over a long period of time, and defended from intruders (Elosegi 1989, Carlon 1998). Like in most raptor species, during the pre-laying period the main activities are nest building and copulation (Newton 1978). The nest building also includes the maintenance of the nest, both activities can play an important role, representing a significant effort invested from the birds during the pre-laying period (Hoy *et al.* 1994). Usually that task is performed mostly in the morning and in most of the cases the male bird is responsible (Etxebarria et al. 2019). He can build the nest himself, while the female is responsible for the maintenance (Newton 1978). The copulation behaviour in the breeding territory was described in detail by Donázar (1994), who found the Egyptian vulture to have a high rate of copulation, beginning 25 days before laying and being uncommon after the laying of the first egg.

Then, general facts have been documented by Newton (1977), who stated the clutch to count two eggs, even more in certain ranges (Angelov *et al.* 2013), which are usually laid with 2 to 4 days interval, and then incubated during around 40-42 days by the parents (Cramp 1980, Mendelssohn 1983, Elosegi 1989).

Furthermore, females invest more in the incubation compared to males and both sexes generally invest the same effort in nestling attendance and food provisioning (Etxebarria *et al.* 2019).

However, the habits during the breeding cycle and more precisely how the pair shares the duties (proportion of incubation, number of switches, food provisioning) remains poorly documented.

The Egyptian vulture is an opportunistic species with a diverse diet, including the usage of tools and hunting small preys (Cramp and Simmons 1983, Van Lawick Goodall 1968, Dobrev *et al.* 2016). The species carries food remains to the nest in the bill rather than by regurgitation, thus prey remains can be used for diet analysis (Dobrev *et al.* 2016). However, using this method alone has proven to have biases in other raptor species, as sampling of prey remains collected at the nest tends to overestimate larger prey species in the composition (Margalida *et al.* 2007, Sánchez *et al.* 2008). According to Margalida *et al.* (2007) direct observation is the best method for an accurate and unbiased estimate of diet, and no difference in the frequency or composition

of food items was found when direct observation was compared to video camera. Thus, the use of cameras in the nest is known as highly valuable for a complete picture of diet composition.
The aim of this paper is to describe the breeding behavior and phenology of the Egyptian vulture during the breeding cycle using motion-sensor cameras and to try to calculate the proportion of food that can be identified after the breeding season (bones, shells, feathers, etc.) and the food that leaves no remains (soft tissues) in order to assess more accurately the food composition brought to the nest.
A better understanding of diet composition and breeding behaviour in this endangered species can have significant conservation and management implications, such as supplementary feeding of breeding pairs and nest guarding (Oppel *et al.* 2016).
Furthermore, the use of cameras in the nest can account for the replacement rate in the pair and help to better understand the mortality in the adults and even some characteristics in the plumage to draw markers for building up a guide for the sexual dimorphism in the Egyptian vulture which remains poorly described (Grande *et al.* 2009, Nikolov *et al.* 2016).

Materials and Methods

Study area. The study was carried out in the Eastern Rhodopes, South Eastern Bulgaria, where the core of the population is. The selection of the pairs to be studied was made on two main criteria: accessibility and remoteness of the nest and the storyline of the pair (if it was successful or not during the pre-study period).

Data collection. Finally, just one breeding pair has been successfully monitored thanks to a trail camera placed in the nest during the breeding season. The other attempts have failed due to breeding or technical failures. In practice, the photo trap was installed from the beginning of March - during the pre-breeding season before the return of birds from Africa - until the end of August, in 2012,2013,2015,2016. Natural materials such as stones, leaves and branches were used as camouflage to avoid detection by the birds. A Scout guard trail camera was used and set to take one still image when activated by movement, with an interval of 30 seconds between shots. The infrared option was set off to avoid disturbance during the night. Once the camera is installed, the nest was accessed 2-3 times during the breeding season to change the battery pack and SD card. The first entry was delayed until after the chicks were 3 weeks old to decrease the risk of abandonment by the parents, and to ensure the chicks were sufficiently mature. In total, the pair was observed 102,5 ± 25,73 days per year.

The camera was collected after the breeding season, and a total of 67834 photos (16958,5 ± 5159,17 SD photos per year on average) were then individually analyzed for behavior, food delivery, food quantity and food identification.

Nest building. To describe it we considered 1) the time of the day when they are usually been seen involved in that activity, 2) the time spent per individual to arrange the nest, 3) number of materials deliveries per individual. For the latter, something unidentified was classified as material when it occurred during pre-laying and incubation, and as food during chicks-rearing.

Incubation. We analyzed 1) mean time spent incubating per individual and per day, at different stages (with 1 and 2 eggs), 2) mean time spent incubating per individual across the entire incubation period seen (average 45,8 ± 4,38 SD days of incubation, including laying on young chicks) , 3) proportion of the observable part of the day (average 14,3 ± 0,14 SD hours per day) during which the pair is seen incubating across the entire incubation period.

Food delivery. Food quantity estimated prey biomass by classifying food items by size: 1 - piece of food smaller than the bill 2 - piece of food bigger than the bill and smaller than the head, and 3 - piece of food larger than the head, and food items were separated into the categories of flesh - i.e. every kind of soft tissues that wouldn't be found in nest after the breeding season - flesh and bone, bone and unknown, with taxon identified if possible.

Of a total of 331 food deliveries, the size could be estimated for 294 (89%) and 169 were identified (51%).

The species diversity found thanks to the trail camera will be compared to the species diversity found within another study on the diet of the species (n =105) in the same nest but for the years 2006-2009, 2011 and 2012 (Dobrev *et al.* 2016).

Replacement rate. We compared photos of different birds between seasons to draw markers in order to proove whether a partner is being replaced in time or not. Simultaneously we compare plumage patterns in both sexes to find new clues for sexual dimorphism in the Egyptian vulture. We used photos from 2 nests between 2011 and 2016.

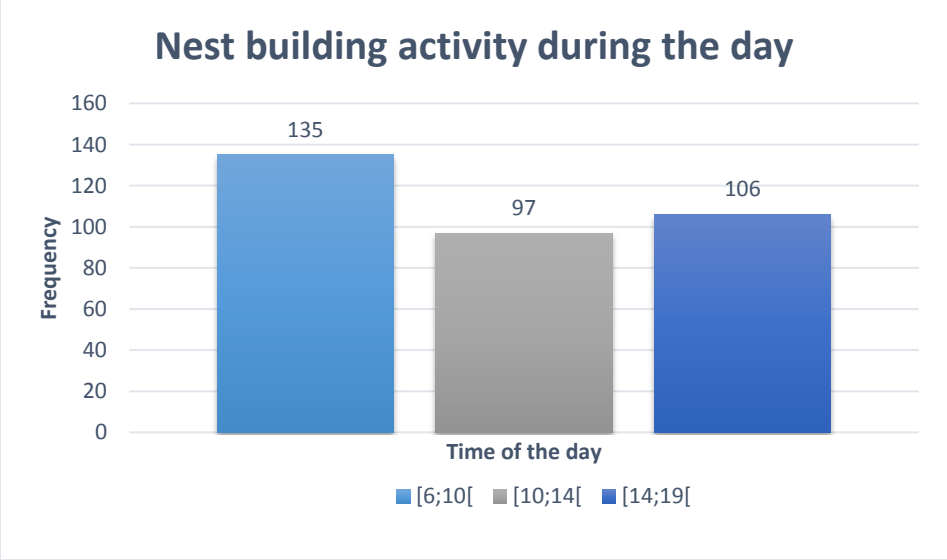
Nest visitors. We used the photos from 2 trail cameras in 2 different nests to make a list of other species visiting the Egyptian vulture nests and to give further recommendations to avoid nest disturbance by other species.

Results

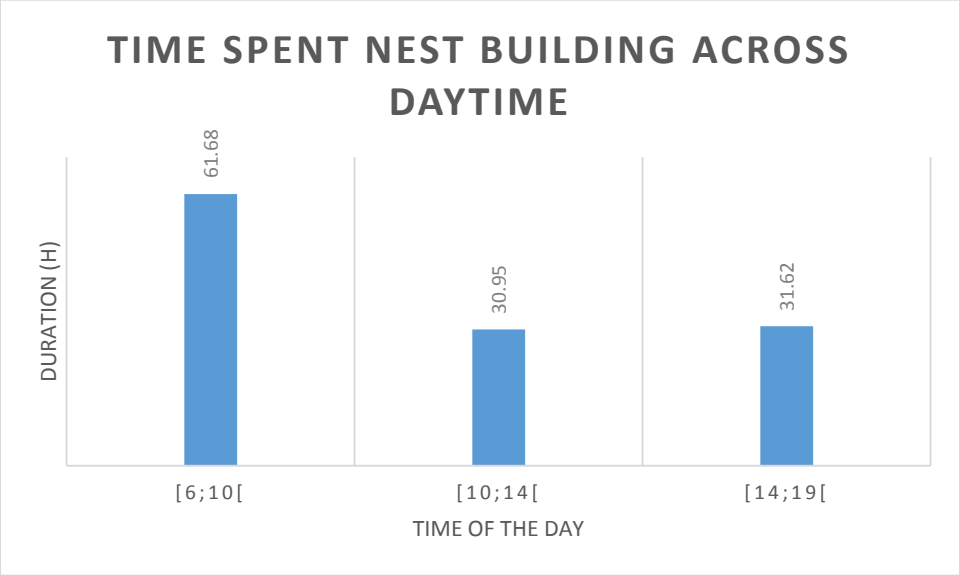
1. Pre – laying habits

a. Nest building

This activity was mainly seen before 2pm (69%) (Plot 1). Both sexes seem to contribute equally to the nest arranging since there is no significant difference (W = 3, p = 0,2). However, while the pair is delivering on average 29,3 (± 12,1 SD) objects – mainly branches and wool - per breeding season, the contribution of the female is significantly less important than male's (W = 0, p = 0,01).

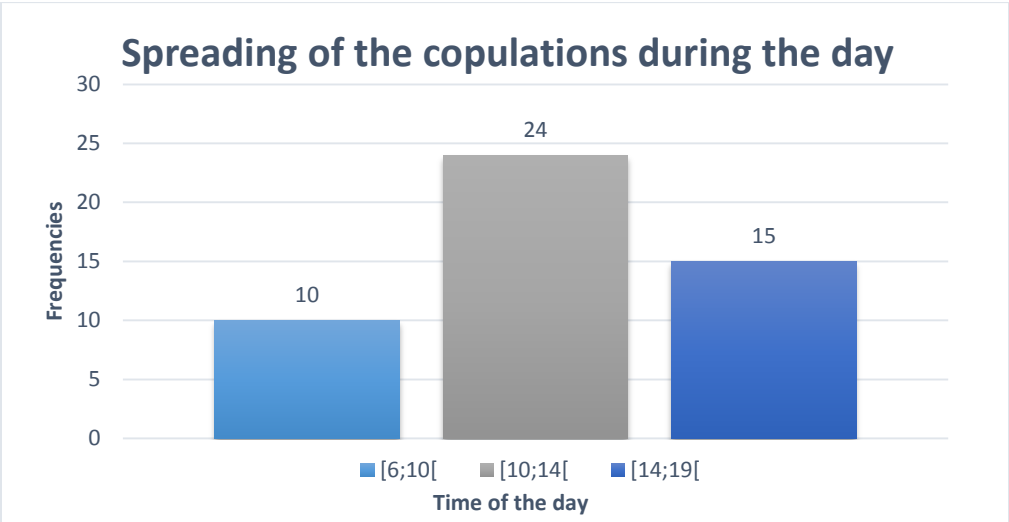


Plot 1. Repartition of the nest building across the day time.



b. Copulation

The rate of copulation seen in the nest seems to be the same throughout the years (H = 4, df = 4, p = 0,41). The behavior was seen for the first time in the nest around 12 days before the laying of the first egg and was only seen once after the laying in 2012. Copulations were mainly seen before 2pm (Plot 2).



Plot 2. Repartition of the copulations seen in the nest during the day

2. Incubation habits

Both sexes seem to contribute equally (5,88 ± 0,724 SD hours per day on average for the female and 5,75 ± 0,824 SD on average for the male) to the incubation task across the entire period since the difference is not significant (W =9, p = 0,89). However, when there is only one egg, the

female is more present (W = 16, p = 0,014). Another habit to highlight is the night incubation, which appears to be essentially held by the female (W = 16, p = 0,015 for the alternative tested as greater for the female) who is seen on average 88% of the time on the last photo before darkness and on the first picture in the morning.

We could also notice the number of switches (301,3 ± 47,9 SD times on average through the incubation period) to be similar across the years (p = 0,39).

3. Food deliveries

c. Diversity

For 89% of the food deliveries for which the size could be estimated, 8,5% were considered as smaller than the beak, 57,5% as bigger than the beak and smaller than the head, 34% as bigger than the head. Then, of the 169 food items identified with the trail camera, "soft tissues" represented 73%, "bone and flesh" and "bone" represented 11% and identified taxa 16%, which means that only 27% of the food delivered would be found in the remains at the end of the breeding season. Among identified taxa, four classes and seven species were identified (Table 1), while the remains allowed to identify twenty-eight species among 5 classes (Table 2). The direct observation with the photo trap seems to underestimate large mammals.

Classes	Species	Number of deliveries	% *	Number of species identified
Aves		**1**	**4%**	**1**
	Gallus gallus domestica	*1*	*4%*	
Mammalia		**18**	**67%**	**4**
	Talpa europaea	*8*	*30%*	
	Erinaceus europaeus	*6*	*22%*	
	Ovis aries	*1*	*4%*	
	Canis lupus	*1*	*4%*	
	unidentified	*2*	*7%*	
Pisces		**1**	**4%**	**0**
	unidentified	*1*	*4%*	
Reptilia		**7**	**26%**	**2**
	Testudo hermanni	*2*	*7%*	

Dolichophis caspius	*2*	*7%*
unidentified	*3*	*11%*

*Table 1. Number and proportion of the preys identified per class and species for the trail camera method. *the percentages are all out of the total number of the deliveries.*

Taxa	Remains	%*	Number of species
Actinopterygii	**1**	**1,0%**	**1**
Hypophthalmichthys molitrix	1	1,0%	
Amphibia	**2**	**1,9%**	**1**
Bufo bufo	2	1,9%	
Aves	**18**	**17,1%**	**13**
Accipiter gentilis	1	1,0%	
Athene noctua	1	1,0%	
Ciconia ciconia	1	1,0%	
Columba palumbus	1	1,0%	
Coracias garrulus	2	1,9%	
Corvus corax	1	1,0%	
Corvus corone	1	1,0%	
Corvus frugilegus	1	1,0%	
Falco tinnunculus	3	2,9%	
Gallus gallus domestica	2	1,9%	
Garrulus glandarius	2	1,9%	
Gyps fulvus	1	1,0%	
Pica pica	1	1,0%	
Mammalia	**48**	**45,7%**	**9**
Bos Taurus	8	7,6%	
Capra hircus	8	7,6%	
Capreolus capreolus	1	1,0%	
Erinaceus roumanicus	9	8,6%	
Felis catus	1	1,0%	
Felis silvestris	3	2,9%	
Meles meles	1	1,0%	
Sus scrofa	13	12,4%	
Vulpes vulpes	4	3,8%	
Reptilia	**36**	**34,3%**	**4**

Dolichophis caspius	1	1,0%	
Emys orbicularis	1	1,0%	
Eurotestudo hermanni	20	19,0%	
Testudo graeca	12	11,4%	
Unidentified	2	1,9%	
TOTAL	105		28

*Table 2. Number and proportions of preys identified per class and species for the remains. * The percentages are all out of the total number of remains.*

d. Habits

There is no significant difference between the food deliveries performed by the male and the female (W = 10, p = 0,67) and across the years (H = 5, df = 5, p = 0,42).

e. Chick-rearing

The chicks were found to be fed equally by the male and the female (W = 8,5, p = 1) and with the same rate across the breeding seasons (H = 3, df = 3, p = 0,39).

4. Replacement rate

We didn‘t find any replacements of breeding birds in the 2 studied pairs during the study period. However, we managed to draw main plumage and facial characteristics that can be used for identification of sexes in breeding pairs, and to confirm birds in consecutive years:

1. Colour of the beak
2. Facial mask
3. Shape and proportion of the beak and the head
4. Length of the tail
5. Brownish coverts

Some of them are illustarted in Table 3.

	Madzharovo1 nest	
Year	**Male**	**Female**
2012		
2013		

2015		
2016		

Madzharovo2 nest		
Year	**Male**	**Female**
2011		
2012		

2013		
2016		
2017		

Table 3. The Egyptian vultures in both pairs during the study period and the main distinguishing features we use to identify them and their sex

5. Nest visitors

The first nest was visited by 7 species before the incubation has started during the study period (Table 4):

- Grey Wagtail (*Motacilla cinerea*)
- Great Tit (*Parus major)*
- Griffon Vulture (*Gyps fulvus*)
- Blu Tit (*Cyanistes caeruleus*)
- Black Stork (*Ciconia nigra*)
- Common Raven (*Corvus corax*)
- Sombre Tit (*Parus lugubris*)

The second nest was visited by 12 species during the study period (Table 5):

- Balck Redstart (*Phoenicurus ochruros*)
- Common Raven (*Corvus corax*)
- Blue Rock Thrush (*Monticola solitarius*)
- Great Tit (*Parus major*)
- Edible Dormouse (*Glis glis*)
- Long-legged Buzzard (*Buteo rufinus*)
- Peregrine Falcon (*Falco peregrinus*)
- Beech Marten (*Martes foina*)
- European Robin (*Erithacus rubecula*)
- Forest Dormouse (*Dryomys nitedula*)
- Red Fox (*Vulpes vulpes*)
- Aesculapian Snake (*Zamenis longissimus*)

Instalation of artificial barriers for the predators and other pilot instalments such as electric fences could prevent nest ravage by predators (such as the Beech marten).

Madzharovo1 nest	
Species name	**Picture**
Common raven/ *Corvus corax*	
Great tit/ *Parus major*	

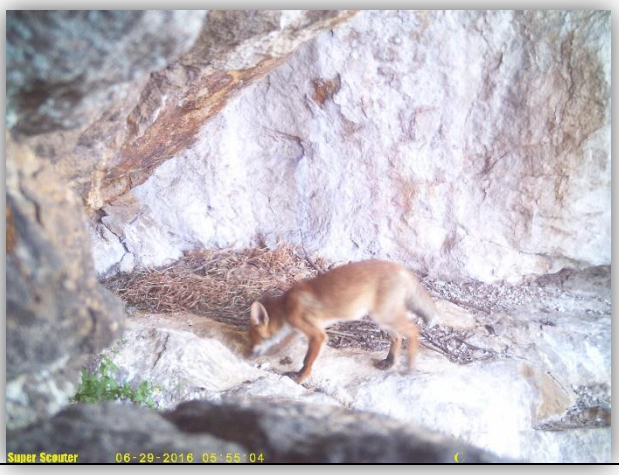
Sombre tit/ *Parus lugubris*	

Table 4. Some visitors in the Egyptian vulture nest

Madzharovo2 nest	
Species name	**Picture**
Common raven/ *Corvus corax*	

Great tit/ *Parus major*	
Black redstart/ *Phoenicurus ochruros*	
Blue Rock-thrush/Monticola *solitarius*	

Long-legged buzzard/ *Buteo rufinus*	
Peregrine falcon/ *Falco peregrinus*	
European robin/ *Erithacus rubecula*	

Beech marten/ *Martes foina*	
Red fox/ *Vulpes vulpes*	
Forest dormouse/ *Dryomys nitedula*	

Caspian whipsnake/ *Dolichophis caspius*	

Table 5. Some visitors in the Egyptian vulture nest

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