

Foraging and parental behaviour of a saker falcon pair raising five fledglings

Potravné a rodičovské správanie páru sokola rároha odchovávajúceho päť mlád'at

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Abstract: The population restoration of regionally extinct raptors is often challenging, especially in the initial establishment of the population. The endangered saker falcon (*Falco cherrug*) became extinct as a breeding species in Bulgaria since 1997 but has recently been reintroduced. The first breeding occurred in 2017, and currently six breeding territories are occupied. We investigated the parental behaviour of a breeding pair that successfully raised five fledglings in 2025. We aimed to quantify parental provisioning by sex, describe prey handling and food-transfer behaviour, and estimate prey demand. A total of 56 prey deliveries were recorded during 90.7 h of observation. European ground squirrels (*Spermophilus citellus*) were the primary prey, accounting for 85% of provisioning by the male and 92% by the female parent. In 46 food-provisioning events with ascertained hunting individual, the male captured the prey in 72% of the cases (female in 28%). Male-to-female food transfers were recorded in 15 cases, of which 8 were in the air and 7 in the nest. All but one prey items were brought to the nest decapitated. The female fed the chicks in 85% of cases (male in 15%). The average feeding duration was 14 ± 3.84 min. Based on the observed provisioning rates, we estimated that the pair and their offspring may have preyed on approximately 600 sousliks during the entire breeding season. Future research needs to focus on whether territorial pairs in Bulgaria are resident throughout the winter, on studying hunting behaviour outside the breeding season, and on assessing the number of sousliks gained by, or lost to, kleptoparasitism.

Abstrakt: Obnova populácie regionálne vyhynutých dravcov býva často náročná, najmä v počiatočnej fáze jej zakladania. Ohrozený sokol rároh (*Falco cherrug*) v Bulharsku ako hniezdiaci druh v roku 1997 vyhynul, no nedávno bol reintrodukovaný. K prvému hniezdeniu došlo v roku 2017 a v súčasnosti je obsadených šesť hniezdných teritórií. Skúmali sme rodičovské správanie hniezdného páru, ktorý v roku 2025 úspešne odchoval päť mlád'at. Naším cieľom bolo kvantifikovať prinášanie potravy rodičmi podľa pohlavia, opísať manipuláciu s korisťou a správanie pri jej odovzdávaní, ako aj odhadnúť celkovú spotrebu koristi. Počas 90,7 hodiny pozorovania bolo zaznamenaných celkovo 56 prinesení koristi. Hlavnou korisťou bol sysel pasienkový (*Spermophilus citellus*), ktorý tvoril 85 % potravy prinesenej samcom a 92 % potravy prinesenej samicom. Zo 46 prípadov zásobenia potravou so zisteným loviacim jedíncom ulovil samec korisť v 72 % prípadov (samica v 28 %). Odovzdanie potravy zo samca na samicu bolo zaznamenané v 15 prípadoch, z ktorých 8 prebehlo vo vzduchu a 7 v hniezde. Všetky kusy koristi, s výnimkou jedného, boli na hniezdo prinesené bez hlavy. Samica krmila mlád'atá v 85 % prípadov (samec v 15 %). Priemerná dĺžka kŕmenia bola $14 \pm 3,84$ min. Na základe pozorovaných frekvencií prinášania potravy sme odhadli, že pár a jeho potomstvo mohli počas celej hniezdnej sezóny uloviť približne 600 sysľov. Budúci výskum sa musí zamerať: na to, či sú teritoriálne páry v Bulharsku stále počas celej zimy, na štúdium loveckého správania mimo hniezdnej sezóny a na posúdenie počtu sysľov získaných alebo stratených v dôsledku kleptoparazitizmu.

Key words: raptors, behaviour, food provisioning, food preparation, European ground squirrel

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Introduction

Classical animal behavioural studies, though increasingly overlooked in recent decades, remain an important research field in conservation biology of diurnal birds of prey (Gaibani & Csermely 2007). However, in some aspects of diurnal raptor research, recent technological developments are quickly replacing laborious fieldwork (López-López 2016). Video and trail cameras, although not without disadvantages (López-López 2022), are increasingly used to study nesting ecology of raptors (Chavko et al. 2014, García-Salgado et al. 2015, Drewitt et al. 2025). A well-executed installation of a tailored trail camera is a delicate and highly site-specific task (Caravaggi et al. 2020), but a low-cost method that over a single breeding season may provide tens of thousands of exceptionally high-quality photographs and reveal various aspects of the nesting ecology (Abushin 2025, Deikumah et al. 2025, Maciorowski et al. 2026). Despite these advantages, in some cases, high-tech solutions are not feasible, and traditional observational studies remain the best option.

The existing scientific literature provides little information on some behavioural parameters of the saker falcon (*Falco cherrug*), which is an endangered Eurasian raptor species, with population decline primarily attributed to electrocution, poisoning, habitat loss and unsustainable levels of offtake for falconry at breeding, passage and wintering sites (BirdLife International 2021). Its current breeding range is vast but fragmented, stretching from the Carpathian basin to eastern Mongolia and China. In Bulgaria, the population is currently very small, with most pairs nesting on inaccessible cliffs. The species, once a localised breeder across the country, declined due to anthropogenic factors and went extinct as a breeder at the end of the 20th century (Ragyov et al. 2014). A reintroduction program began in 2011, with 160 juveniles released over 12 years (Dixon et al. 2019). The first breeding was recorded six years after the start (Lazarova et al. 2021, Daskalova et al. 2024), and as of 2025, three breeding pairs and three single territorial males had been established. The foraging ecology

of territorial birds is a high-priority research topic (Arkumarev et al. 2025) and was recently reviewed for the family *Falconidae* (Leonardi 2020). The European ground squirrel (*Spermophilus citellus*) (hereinafter *sousliks*) is the preferred prey of the saker falcon in Bulgaria (Baumgart 1971, Arkumarev et al. 2025). Even though it is a keystone species, this rodent is undergoing an accelerating decline across the country, with nearly two-thirds of its locally fragmented populations already lost or on the brink of extinction (Martínková et al. 2026). The scarcity of the primary food source influences how falcons allocate energy during reproduction. The division of duties between the sexes during breeding is evident, with males primarily responsible for food provisioning and guarding the territory (Baumgart 1991, Bagyura et al. 2004). When prey is abundant, foraging is done close to the nest, usually within less than three kilometres (Bold et al. 2024). Newly established saker falcon pairs may have frequent confrontations with neighbouring raptors or common ravens (*Corvus corax*), but are aerially dominant, and the females join in cooperative attacks (Puzović 2008, Angelov et al. 2023). Falcons usually "prepare" the food before carrying it to the nest, and often prey is decapitated (Pikula et al. 1984, Platt 1989), mammal stomach and intestines removed (Baumgart 1991), larger birds are often plucked (Bagyura et al. 1994), and the prey may be partially consumed (Leonardi 2020). Males give a food-delivery call from far away on approach to the nest (may be related to the risk of kleptoparasitism, e.g., Baumgart 1991), to which the female responds (Becsý 1978, Cramp & Simmons 1980). Food transfers are always from male to female (Platt 1989) and occur in the air, on trees, or on cliffs (Becsý 1978). The male is said to feed the young only in exceptional cases (Bagyura et al. 2004) but see Daskalova et al. (2024). The average feeding time is 9 to 16 min, varying with the age of the young (Daskalova et al. 2024).

The female performs almost all brooding until the nestlings achieve homeothermy at around 10 days of age (Baumgart 1991, Daskalova et al. 2024), and the termination of brooding is related to weather (Village

1990). While the male is away hunting, the female, being in or near the nest, is guarding the nest and its immediate vicinity (Daskalova et al. 2024), and her calls are mostly related to the male's approach and transfer of prey (Leonardi 2020). Females are said to start hunting in the fourth week after hatching of nestlings (Bagyura et al. 1994), or "at least 2–3 weeks after hatching" (Cramp & Simmons 1980), while recent data from a lowland territory in Bulgaria noted regular hunting by the female with the end of brooding but always near the nest (Daskalova et al. 2024). The female primarily feeds the chicks (Chavko et al. 2014, Daskalova et al. 2024), and during and after feeding, adults are known to consume uneaten prey remains, e.g., larger bones and skin (Becsý 1978). Food in excess is cached, e.g., to one side of the nest ledge (Drewitt et al. 2025), or taken and cached away, while less attractive, or inedible parts are sometimes dropped at a distance (Bagyura et al. 1994).

Cainism may occur in broods experiencing starvation (Ellis et al. 1999, Leonardi 2020), whereas inter-sibling aggression is considered rare (Baumgart 1991, Milobog et al. 2010), but competition is intense once chicks start to feed themselves and can lead to brood reduction (A. Dixon, pers. comm.). Nestlings start attempts for autonomous feeding around 20 days of age (Daskalova et al. 2024). Intimate knowledge of nesting ecology is vital to implementing conservation measures for extremely small founder populations of the saker falcon, where pair-to-pair differences may arise. Notably, more data are needed on food preparation and provisioning by each sex, and on the level of partners' involvement in feeding the young.

In this study, we present quantitative behavioural data collected from a hide in front of an active nest of a pair of saker falcons in Bulgaria, which fledged five young. By recording specifics in the behaviour of birds, we aimed to (i) quantify parental provisioning by sex; (ii) describe prey handling and transfer modes; (iii) estimate prey demand for a successful breeding pair; and (iv) document nestling behaviour and aggression. There are only a handful of similar recent studies on the saker falcon, also done with a single pair (Bagyura et al. 2004, Angelov et al. 2023, Daskalova et al. 2024), while older studies were reviewed by Baumgart (1991).

Materials and Methods

The study area was located in the Balkan range Mts. of Bulgaria. Two of the territories occupied by pairs were not suitable for installing trail cameras or collecting prey remains; thus, a more traditional approach was needed

to gather knowledge of their foraging behaviour during the nestling stage. The studied pair of saker falcons was nesting on a cliff in a forested region, in a stick nest built by long-legged buzzards (*Buteo rufinus*), and was the only breeding raptor species on the cliff (Fig. 1). The territory has been occupied by a pair for at least the past four years, successfully producing young in each year, alternating between different cliff nests built by buzzards and common ravens. The current nest was placed on a two-meter-long horizontal ledge, well protected from rain by an overhanging rock shelter. The nearest grasslands with healthy colonies of sousliks were located within about 2 km of the nest at an elevation approximately 500 m lower than the nest.



Fig. 1. The male saker falcon feeding its offspring with a souslik in a rocky-ledge nest.

Obr.1. Samec sokola rároha kŕmiaceho svoje potomstvo syslom v hniezde na skalnej rímse.

The nest was observed from a hide made of a camouflaged net at 40 meters using a telescope (20-60x60) over 14 days during the nestling stage (16–19 and 24–26 April, and for 7 days between 2 and 20 May in 2025). The hide was in a forest, allowing visibility only through the tree trunks and branches to the nest and a part of the cliff around it. On average, 6 hrs. 29 min. $\pm$ 2 hrs. 13 min. of observations were conducted per day (Georgiev et al. 2025), totalling 90 hours 40 min. On two days, a second observation point was established 1 km from the nest to record airborne male-to-female food transfer and interactions with other species. Five researchers participated, always with a single observer in the hide conducting the observations.

Notes were kept on the following behaviours: nest guarding, brooding, food provisioning, food-delivery calls, food transfers, prey composition, food preparation,

feeding of nestlings by the male or female, autonomous feeding of nestlings, satiation of nestlings, and food caching.

The number of sousliks consumed by the study's saker falcon pair during the whole breeding season was estimated. The calculations assumed that the environmental conditions were optimal during the nestling stage, which typically lasts 42 days. To avoid overestimation and account for lower prey biomass in the early nestling stage, we assumed that during our observations, we detected 75% of the daily food provisioning by sousliks, even though our observations covered only 50% of daylight hours. Again, to avoid overestimation, we assumed that daily consumption of sousliks outside the nestling period is 50% lower than during the nestling period and accounted for juvenile dispersal in late summer.

AI was used only to improve and correct the English grammar.

Results

Individual identification, age and phenology

The observed parent individuals (Fig. 1, 2) were ringed with Darvic PVC colour rings with an alphanumeric code for individual identification, which revealed their origin as released as juveniles (male in 2015, female in 2019) via hacking approximately 40 km from their current nesting site. Incubation was documented on 9 March and confirmed complete (5 eggs) on 14 March, possibly earlier. On 16 April, five hatchlings were present, aged 1–5 days (Bagyura et al. 2025a). All five nestlings were observed on 20 May, fledged successfully, and perched on various locations away from the nest ledge, with three of them on the top of the cliff.

Food provisioning

Over 14 days, we recorded 56 food deliveries, for 6 hours 29 min $\pm$ 2 hours 13 min of observations per day, averaging 4 deliveries per day. In 46 (out of 56) food-provisioning events in which the hunting individual could be ascertained, the male captured the prey in 72% of cases ($n = 33$) and the female in 28% ($n = 13$); all prey consisted of sousliks. Female provisioning increased from 24% to 33% after the third week since hatching. As the male approached the nest when carrying prey, he always vocalised intensely from more than a kilometre away. On the contrary, when the female was carrying food and the male was not around, no calls were heard. Only the nestlings began producing begging calls as they saw the approaching adult. When the female was in the

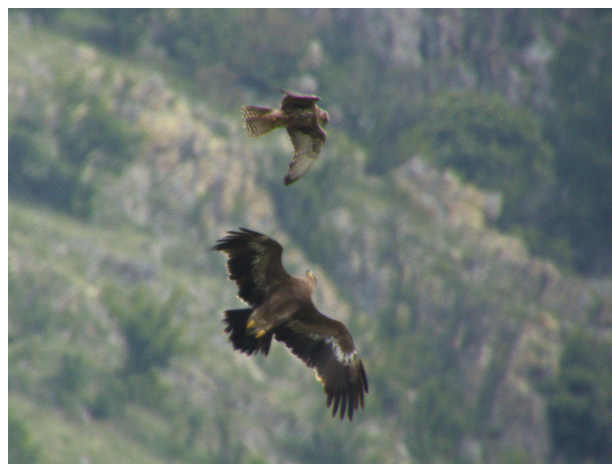


Fig. 2. Female saker falcon mobbing a wandering non-breeding third calendar year steppe eagle (*Aquila nipalensis*) over a souslik colony in the study area in 2025.

Obz. 2. Samica sokola rároha útočiaca (mobbing) na túlavého nehniedzdiaceho orla stepného (*Aquila nipalensis*) v 3. roku života nad kolóniou sysľov v šľudovanom území v roku 2025.

nest, upon noticing the male approaching with prey, she began calling, and her calls intensified as he drew closer. She assumed a posture with wings slightly extended and feathers ruffled. Eventually, the female took off and performed a food-begging flight, initially descending slowly and slightly towards the male with a flutter-glide flight, also known as “sandpiper flight” (Cade 1960), characterised by rapid, shallow wing beats, a fanned tail, and continued vocalisation. Male to female food transfers were recorded in 19 cases, of which 45% occurred in the air ($n = 8$) at distances more than a kilometre from the nest, to within a hundred meters from the cliff. Food transfers in the nest occurred in 37% ($n = 7$) of cases, always within a minute after the male started feeding the nestlings and the female landed in the nest and usurped the feeding of the chicks. The remaining 21% of transfers ($n = 4$) were away from the nest, either in the air or at a perch.

Food preparation and prey composition

A total of 56 prey items were recorded in the diet. In 36 prey deliveries (64%), we identified that the prey brought to the nest was prepared, i.e., all were headless, in 31 cases: each souslik, a pigeon (*Columba livia domestica*), a cuckoo (*Cuculus canorus*), and two thrushes (*Turdus merula* and *T. viscivorus*). The only exception was a starling (*Sturnus vulgaris*) brought in without any parts removed. In three other cases, the male brought partially eaten sousliks. In the last 17 cases, due to bad visibility or feeding the nestlings with previously cached prey,

we were not sure whether the prey was decapitated. The female fed the chicks in 85% of the cases ($n = 34$) and the male in 15% ($n = 6$). The duration of a feeding bout was recorded in 22 cases, equalling 14 ± 3.84 minutes. In five cases, while both adults were in the nest, the female took the prey from the male, who was intending to feed chicks or was feeding the young and fed them herself. Usually, the pelts were given to the young, piece by piece. However, in 8 cases, when an adult finished feeding the young, it was observed to swallow the remaining, often largely complete, pelt of the sousliks. In three instances when the chicks were well satiated, an adult brought a souslik to the nest, which was immediately taken away, to possibly cache or eat it nearby.

Nestling behaviour

The first attempts at autonomous feeding were recorded at two weeks of age. By age 16–20 days, the larger chicks were occasionally observed taking a large piece of the prey and moving away from the rest, while the remaining chicks continued to be fed by an adult. In the last 9 days prior to fledging, the juveniles were feeding almost exclusively autonomously. In three cases, at the late nestling stage, the juveniles attacked once the male and twice the female when the adults wanted to take uneaten prey from the nest. The female was attacked on separate occasions by attempts to peck on the bill by one and three juveniles at nine and five days before fledging. The male was attacked more aggressively by one, two, and three juveniles on three separate occasions within a period of 10 minutes, five days before fledging. The adults made no efforts to defend themselves. No aggression was noted between the nestlings. Throughout the study, the juveniles showed satiation, rejecting additional food provided by the parents on five of the 14 observational days (36%, $n = 14$).

Estimated souslik consumption

Based on 49 sousliks recorded as prey in 14 days (3.5 daily), the estimated number of sousliks consumed during the nestling period is $(42 \text{ days} \times 3.5 \text{ sousliks/day}) / 0.75 = 196$ individuals. We then estimated a minimal number of sousliks consumed over the entire season of souslik activity, defined as 214 days (1 March–30 September). This yields $3.5 \text{ sousliks a day} / 0.75 = 4.66$; reduced by 50% = 2.33 sousliks per day. Multiplying this value by the remaining 172 days (214 days in total – 42 days during the nestling period) yields $172 \text{ days} \times 2.33 = 400.8$ sousliks. When we add the nesting period estimate, it gives a total of approximately 600 sousliks consumed by a successful pair raising five fledglings.

Discussion

We recorded the pair of saker falcons' exclusive reliance on sousliks as they successfully raised five fledglings. The results highlight the crucial role of males in raptor species exhibiting biparental care (López-López et al. 2022). Shortfalls in food provisioning by the male may result in greater female participation in hunting at the expense of nestling and adult condition, and an increased risk of nest depredation (Jenkins 2000). The female saker falcon accounted for 28% of the hunted prey, but this figure may be slightly overestimated due to instances when she was absent from the nest, and food transfers may have occurred far away and thus went undetected. Considering also the record number of fledged young, we surmise that the pair was not food-stressed and the female was not significantly pressed to hunt. We are also unable to draw any conclusions about the extent of cooperative hunting.

From a conservation perspective, the high reliance on sousliks prompts discussion of the importance and availability of pasturelands with sufficient colonies of sousliks, a preferred prey item, during the initial population establishment phase of the ongoing reintroduction. As the reintroduced saker falcons in Bulgaria were not satellite-tagged (Dixon et al. 2016) and were hacked from tree nests in the lowlands (Lazarova et al. 2021), there was uncertainty about which nest site they would choose. Our study provided a strong evidence that the reintroduced saker falcons are capable of occupying high-quality territories and achieving excellent breeding performance, as evidenced by: 1) cliff nest site that is wide, comfortable and well protected from adverse weather (Henderson et al. 2021, Bagyura et al. 2025b), away from human disturbance and free from avian competitors; 2) approximately average laying date for Bulgaria (authors, unpublished data); 3) record high number of five successfully fledged young; 4) parents able to supply an abundant amount of the preferred prey (sousliks); 5) frequent records of afternoon satiation of the nestlings; 6) breeding success during 2022–2025 (the period of the territory occupation) averaged 3 fledglings (1, 4, 2 and 5, respectively), which is suggestive of high territory quality (Reynolds et al. 2019); and finally 7) lack of changeovers of the territory holders during the last four years, suggestive of high adult survival.

In falcons, adults adjust their hunting effort in accordance with the number of nestlings (Olsen & Tucker 2003). The decline in food provisioning in the second half of the day, which we observed, was probably due to satiation of the nestlings (Village 1990), as evidenced

by their unwillingness to feed in the late afternoon. Even though the female provided only 28% of the food, she contributed 85% of the beak-to-beak feeding of nestlings. Given that in falcons, the females have the primary role of feeding the young (Leonardi 2020), and since the nest contained the near maximum number of five young, it could be that the 15% share of beak-to-beak feeding by the male was normal, and it occurred exclusively when the female was absent from the nesting cliff.

Contrary to some Central European populations (Chavko et al. 2014; Bagyura et al. 2025b), saker falcons in Bulgaria rely heavily on sousliks when they are abundant (Georgiev et al. 2025), and we documented for the first time that all sousliks brought as prey were decapitated, as observed also for gyrfalcons (*Falco rusticolus*) and peregrines (Cade 1960, Platt 1989). In falcons, the heads of prey species are a preferred body part (Feng et al. 2022) and often consumed first, probably due to their high-fat content (Kohl et al. 2015). The near absence of diagnostic skeletal parts from pellets collected at nests in Moldova, Ukraine, Mongolia and Kazakhstan (Nedyalkov et al. 2012, Nedyalkov et al. 2014, Bold et al. 2025) suggests that they are often completely digested (Duke et al. 1975, Bagyura et al. 1994), as often only teeth are found in pellets (A. Dixon, pers. comm.). For some falcon and hawk species, it has been suggested that prey heads may account for a large part of males' diet during the nestling stage (Bond 1936, Cade 1960, Newton 1986), a pattern that may also apply to saker falcons. The removal of uneaten parts (bird heads, legs, and primary feathers) before bringing food to the nest reduces prey mass and may allow falcons to increase the overall provisioning rate (Sodhi 1992).

The dietary studies of saker falcons in Bulgaria consistently demonstrate a strong specialisation on sousliks during the breeding season (Baumgart 1971, Undzhian & Braun 1984, Daskalova et al. 2024, Arkumarev et al. 2025, Georgiev et al. 2025). Our rough estimate of 600 sousliks consumed per year by a pair of saker falcons with five nestlings provides important insight into the species' foraging requirements. However, this number should be considered carefully and, hopefully, will stimulate further research. In the second part of the period, an unknown proportion of the souslik population would be juveniles. Our result aligns with the estimation of 520 individual vertebrates (mostly small rodents) in the diet of a breeding pair (adults and nestlings) of common kestrels (*Falco tinnunculus*) (Geng et al. 2009), highlighting the important nutritional role of small mammals in raptors that preferentially target this prey (Torre et al. 2024).

In the future, such an estimate may be useful for population modelling of the species inhabiting souslik-rich habitats. However, it is noteworthy that such numbers of sousliks may be consumed by a reproducing pair only where high-density souslik populations are present within their foraging range. As part of the reintroduction process, early saker falcon colonists appear to occupy the best territories in terms of souslik abundance, and the availability of such sites is key to the success of species restoration.

Based on our results, we recommend further research. First, to study whether the territorial pairs in Bulgaria are resident throughout the winter and, if not, for what period they are absent from the breeding territory. Second, to conduct surveys on the hunting behaviour outside the breeding season and identify the share of pigeons (feral vs loft) in their diet, as it may reveal important data on illegal persecution (Bagyura et al. 1994, Stamenov et al. 2025). Finally, to assess the number of sousliks gained by or lost to kleptoparasitism. We conclude that we have provided anecdotal evidence that hunting territories with high souslik densities are crucial breeding sites for newly reintroduced saker falcons in Bulgaria.

Competing interest

The authors declare no competing interests. The study was conducted under the appropriate permits and in accordance with current ethical standards.

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