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Secretive flight behaviour of Golden Eagles *Aquila chrysaetos* in the vicinity of their nest

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Abstract
During breeding, most birds have to visit and leave the nest regularly to forage or to provision young. Nesting activity may help competitors or predators to locate the nest and offspring, selecting for parents to behave secretively. The present study reports observations of secretive flight behaviour of Golden Eagles *Aquila chrysaetos* during a long-term study in Norway based on more than 1500 hours of observation in the nesting areas of 16 pairs of eagles. By a combination of absence from the nest and secretive flights, the eagles seemed to avoid being observed near their nest, as shown by observations of 14 cases of secretive flights from 10 nesting areas. Silhouettes against the sky near the nest seemed to be avoided by the eagles, either by downhill flight in the forest below the nest and skyline, or by a fast approach to the nest, the latter either by a sideway descent or by falling like a stone from a high altitude above the nest within a few seconds. Secretive behaviour may help to avoid long-distance discovery and nest predation, in particular by intruding non-territorial eagles, but also by other raptors and Ravens *Corvus corax*, as well as to avoid disturbance by humans. Secretive behaviour creates serious challenges for monitoring of Golden Eagle populations, where each pair of eagles usually have several nest sites and where often less than 50% of the pairs are breeding in a given year.

INTRODUCTION

In many raptors, including the Golden Eagle *Aquila chrysaetos*, the duration of a breeding attempt takes almost four months (Watson 2010). The adult birds have to visit and leave the nesting area many times before the young are fledged, which may help their enemies to locate the site, increasing the risk of predation both on the adult birds and on their eggs and offspring. Therefore, we would expect the adults to avoid attention by behaving secretively.

The historic persecution of raptors and eagles in particular, has been well documented (Watson 2010). In Norway, a shooting prize for eagles was initiated in 1845. The population was reduced but to avoid extermination, eagles were protected by law in 1968 (Gjershaug et al. 2024). Hunting and persecution of eagles by humans for thousands of years has certainly contributed to their secretive behaviour in general (Watson 2010). However, the secretive behaviour may have been selected in response to nest predation even before exposure to human persecution. For instance, in the Steller's Sea Eagle *Haliaeetus pelagicus*, which mostly nest in trees, nest predation by bears is a serious mortality factor (Masterov et al. 2018). Nest predation of Golden Eagles by other mammals, including Eurasian Lynx *Lynx lynx*, probably also occurs (Warensjø 2000). In birds, nest predation is often the main cause of nest failure (Ricklefs 1969, Martin 1993), which selects for various behaviours to minimize reproductive losses. Large raptors may be more secure from nest predation than smaller species of birds given their body size and large powerful talons. However, during the demands of increased hunting for prey as the young grow, one or both members of a pair may leave the nest and its content unattended for longer periods of time. In particular, when the nestlings are small and have a conspicuous white downy plumage, they are easily spotted from above and vulnerable to predation by other raptors including Goshawks *Accipiter gentilis*,

Table 1. Fourteen observations of flight behaviour of Golden Eagles in vicinity of their nest in ten different territories in southeast Norway during 2014-2024. Approximate distances between the observer and the eagle nest (DN) and length of eagle secretive flight (LF) are indicated in meters.

Territory	Date	Year	DN	LF	Description of flight behaviour
1	3 June	2014	1000	50	Falling vertically down to the nest from a high elevation
2	7 June	2016	100	100	Falling vertically down to the nest from 100-200 m height
3	7 May	2018	600	50	Falling vertically down from canyon ridge to the nest
4	21 April	2019	2000	700	Leaving nest in a horizontal flight among tree tops and perching in a tree on a hilltop, well below the skyline. Returned to the nest horizontally among tree tops
5	24 June	2020	150	500	Making a fall down and within a canyon, while calling
3	28 March	2022	1000	1000	Appearing among the trees on the upper rim of a canyon, then diving down into the canyon and down to the nest
6	5 April	2022	1800	10	Flying or gliding towards the nest horizontally, perching in a tree just above the nest. Leaving nest horizontally, only seen once as a glimpse against the sky
5	17 April	2022	400	500	Low approach to nest area, soaring under the nest site, back and forth among treetops
1	2 July	2022	1800	150	Flying horizontally towards the nest, soaring a few times under the nest and, and then settling in a tree. Later flew into the nest. Later the bird was briefly glimpsed in the sky above nest
7	18 April	2023	1000	50	Falling vertically down to the nest from a high elevation
4	19 March	2024	1200	50	Falling vertically down 50-60 m to the nest
8	15 April	2024	2700	2000	A two km descending linear stoop to the near nest area
9	23 April	2024	600	1600	Male approaching nest among the tree-tops in a strip of spruce forest, then ascending above the tree line to make 2-3 circles with a view inside a hidden cavity above the treeline containing the female on the nest. The bird then descended to another strip of spruce, where it left among the treetops, all within 5 min (Figure 1)
10	30 May	2024	500	500	Approaching nest area with prey, circling 2-3 times and dropping vertically down to nest (Å. Kamben, pers. comm.)

possibly Gyrfalcons *Falco rusticolus*, Eagle Owls *Bubo bubo* and even by corvids such as Ravens *Corvus corax*), although the extent of losses to predation is unknown. Other raptors, including solitary Golden Eagles that intrude into the nesting area, may disturb breeding and even kill the nestlings (Haller 1996). In addition to nest predation, harassment by corvids and especially by flocks of Ravens may result in breeding failure (Walker 2009, H. Dunker, unpubl. data). Consequently, it is important also for large bird species, such as the Golden Eagle, to evolve behaviours that avert attention away from the nest and nest contents to avoid detection by avian and mammalian predators, as well as from humans.

The present study reports observations of the secretive flight of Golden Eagles recorded in the vicinity of the nest during a long-term study in south-east Norway. The behaviour of parents when approaching the nest has been recorded in some other birds of prey (Draheim et al. 2012). However, to the best of our knowledge, secretive behaviour has not been described in nesting Golden Eagles (Ellis and Schmitt 2017), but understanding patterns of nest visitation may be of crucial importance for population monitoring.

METHODS

The present data of Golden Eagles were collected during 2014–2024 in a study area with forested hills

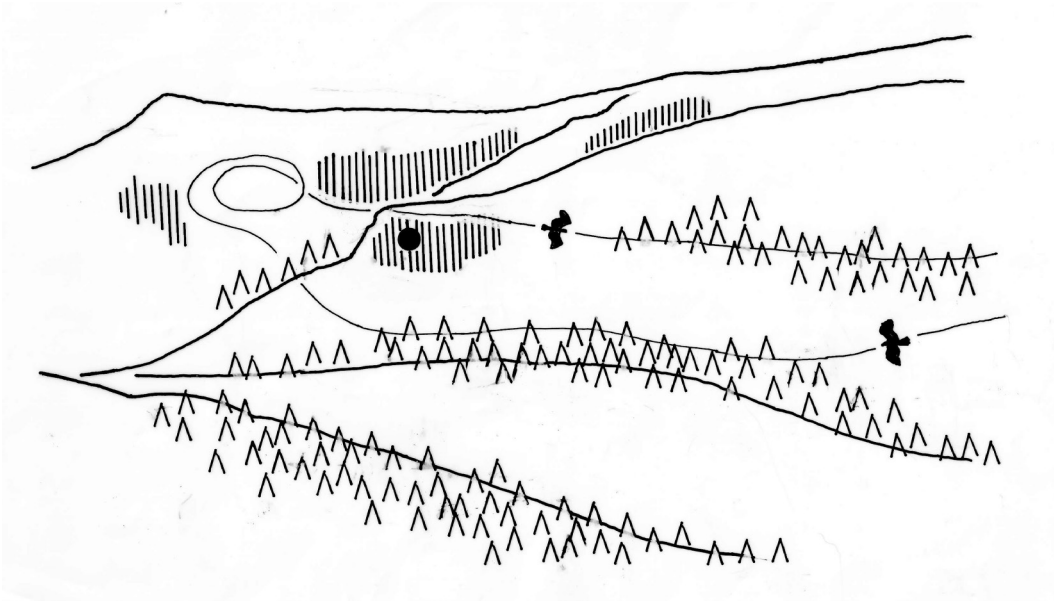

Figure 1. Sketch of the flight behaviour of a male Golden Eagle observed when he visited the vicinity of the nest on 23 April 2024, with a total duration of less than 5 min. The female was incubating in a hidden cavity and seen by the male only while circling. Large black dot = nest location, vertical stripes = major vertical cliffs, tree symbols = sparse stands of spruce towards the treeless alpine zone. The flight route is marked with a thin line.

in southeast Norway. The study area was situated within the municipalities of Sør Aurdal, Nord Aurdal, southernmost Øystre and Vestre Slidre, and the valley of Etnedal. Sixteen territories of eagles were mostly situated within an 80 km distance of the main valley of Valdres. The valley is a region with high levels of precipitation and deep snow cover in winter. The study area covers about 2550 km^2 of mostly forested undulating hills. The area is characterized by valleys with a north-south orientation, mostly with south and east-facing cliffs. The hills lie mostly between 200 and 1000 m a.s.l. and are divided at intervals by valleys about 1–5 km wide and 200 m deep. The study area was dominated by forest stands of Norway spruce *Picea abies*, with large clearcuts from timber harvest, but also included some small alpine areas at 1000–1500 m a.s.l. Observations were made during visits to 16 eagle territories, while the 14 cases of secretive flight behaviour were recorded in 10 of the territories with breeding in cliffs. Table 1 shows approximate distances between the observer and the focal eagle nest, and the span of distances of the respective secretive flights from the respective focal nest. Table 2 includes monthly variation in rates of eagle observations in all 16 territories in 2022.

The average distance between the observer and the focal eagle nest was about 1000 m with a range from 100 to 2700 m (Table 1). The span of eagle flight distances, from the nest, during the recorded "secretive flight behaviour" averaged about 500 m with a range from 50 to 2700 m (Table 1). The observer used green/brown clothes without using any camouflage. There were no observed indications that the eagles noticed or changed their flight behaviour because of the presence of the observer.

The observation bouts were conducted between 11:00 and 14:00 because wind speeds usually increased around 12:00–13:00 and were suitable for eagle flight activity. From 2014–2024, the bouts consisted of more than 1500 hours of observations, mostly during sunny days with good conditions for detecting flying eagles at distances up to a 6 km range with 20 x 80 binoculars, and with a view of at least 180°. Flight behaviour was recorded during continuous observation of the focal eagles, both when an eagle arrived or left the nest site. In 2022, we also studied the seasonal variation of eagle observations by comparing the daily number of observations in all territories from early February to the end of July with the respective number of days with field work (Table 2). All field work and accompanying notes were completed by the first author.

RESULTS

A total of 14 observations were made of eagles approaching their nest, and for three of these occasions, the eagle was also observed leaving the nest (Table 1). Among the 14 described and distinctive cases of nest approaches, seven cases concerned a vertical stoop from an elevation of 50–150 m above the nest (Table 1). In these cases, the eagle "fell" almost like a stone in a rapid stoop that lasted for only a few seconds. Most approaches and departures from the nest and the nesting area occurred sideways or from below the height of the nest but among the tops of the trees. In one case, an adult eagle approached the nest area carrying prey, and after 2–3 circles "fell down" vertically to the nest (Å. Kamben, pers. comm., observation 14; Table 1). Thus, most eagles seemed to avoid being seen silhouetted against the sky in vicinity of the nest. In only one case of secretive flight, a prey was brought to the nest, and in

Table 2. Observations of Golden Eagles during 59 days of field work from 1 February to end of July 2022. Most days in the field consisted of midday observations of eagles from 11:00–14:00, surveying potential breeding areas and the surrounding skyline from sites with at least 180° field of view during sunny days.

Month	N days	N observations in total	Average per day
February	7	16	2.3
March	14	25	1.8
April	13	26	2.0
May	8	4	0.5
June	9	1	0.1
July	8	8	1.0

only one other case, the eagle was heard calling when it was approaching the nest.

During the field work, 4 of 16 pairs of eagles were rarely seen even though at least two of these pairs showed regular breeding. Infrequent observations may have been due to short daytime visits of an adult to the nesting area, which lasted only a few minutes, where the eagle briefly soared above the nest at a distance of 50–100 m, apparently to watch the female, nest contents, and potential enemies (Figure 1). The other two pairs that were seldomly seen among the 16, had no known nest that was used for breeding. However, rare observations of assumed fledglings indicated that successful breeding occurred at unknown nest sites (H. Dunker, unpubl. data). In another four pairs, the adults were sometimes seen but with uncertainty about breeding status.

When we compared the number of eagle observations during the different months of breeding in 2022, we recorded about two observations per day in February, March and April but then only about 0.5 observations per day during the following three months (Table 2).

DISCUSSION

The main finding was that breeding pairs of Golden Eagles behave secretively when approaching and leaving their nesting area. However, in spite of extensive field work (1500 hours in ten years), we recorded relatively few observations of flight behaviour of the focal eagles in vicinity of the nest (Table 1). The rarity of relevant observations may explain why secretive flight behaviour in vicinity of the nest, to our knowledge, has not been previously described in the Golden Eagle (Ellis & Schmitt 2017).

Observations of secretive flights

The present study shows that the adult birds can behave secretively both when approaching and leaving the nest (Figure 1). Secretive flight behaviour at the nest is likely to be widespread among raptors, but few studies have reported the relevant details. A rapid vertical drop seems also to be used during hunting, and would be a low-energy, quick approach both to the nest or to capture prey. The vertical fall in Golden Eagles was not mentioned in a review by Ellis and Schmitt (2017). According to Masterov et al. (2018), Steller's Sea Eagles use a similar steep descent with a flip from wing to wing, resembling a falling dry leaf. A similar secretive behaviour was reported in White Hawks *Leucopteris albicollis* breeding in a neotropical forest where prey exchange and prey consumption by adults took place 30–40 m or even more distantly from the nest (Draheim et al. 2012). Moreover, the female White Hawk always covered the eggs completely with leaves before slipping silently off the nest.

Observations of adult Golden Eagles during the nestling period (May–July) were only 25% of the rate during the previous three months (February–April). Reduced activity suggests that the eagles avoided being seen near the nest particularly when the nestling(s) were conspicuously white in plumage coloration in contrast to the darker nest material. The seasonal changes were most apparent in June, when the rate of observations was only 0.1 per day.

Why are Golden Eagles secretive in vicinity of the nest?

We suggest that the main threat to the Golden Eagles that has selected for its cryptic behaviour in our study area and elsewhere, has been disturbance and predation from lone eagles that are intruders (Haller 1996). Negative effects of intruders has also been observed for the Black Eagle *Aquila verrauxii* in Zimbabwe (Gargett 1990) and was emphasized as the most important source of losses by Walker (2017) in case of the Golden Eagle. Gargett (1990) recorded 177 cases of antagonistic intraspecific encounters in three years, and Haller (1996) recorded 39 victims of intraspecific fights during 1970–1994.

Golden Eagles may suffer from predation on eggs and nestlings by other animals, including carnivores, large raptors and corvids. However, in our study area, losses to predators are probably limited due to the sparse occurrence of Goshawks and to the apparent absence of two other large raptors that can be found in south-east Norway, the Gyrfalcon and the Eagle Owl. Additional studies are needed to know to which extent nest predation is important, including losses to other Golden Eagles and corvids.

Consequences for monitoring of Golden Eagles

The secretive behaviour of the Golden Eagles reported here will easily affect the confidence in estimating the size of the breeding population of the Golden Eagle. Despite good intentions and a careful study protocol (Gjershaug et al. 2018), problems will always exist with locating unknown nesting areas (Dunker 2021) and

unknown nests (Warensjø 2010). Another problem is that the nestlings may hide in crevices and cavities and be difficult to detect from visits on the ground or even from an aircraft, making monitoring unreliable (Warensjø 2010). The problem of detecting young seems not to have been communicated sufficiently in field protocols for Golden Eagles (Walker 2017).

Some eagles may conduct daytime visits of short duration to the nesting area that last for only a few minutes (Figure 1). We suggest that shy eagles may consist of older birds that may also breed infrequently or at unknown nesting areas or nests. Short nest visits may be explained by a more frequent "sit and wait" hunting strategy among older eagles, in combination with long-distance hunting movements. Radio-tracking studies have shown that another top-predator, the Eagle Owl, can move as far as 2.5 km, and 1.5 km higher than the nest area, to hunt Rock Ptarmigan *Lagopus muta* (Arlettaz 1988), or up to 5 km from the nest to hunt fish (Bayle 1986). Long-range hunting may explain the often seen circling behaviour of Golden Eagles at high altitudes, probably to make a long-distance gliding descent towards far away prey or to scavenge carcasses of large mammals. This might also lead to fewer nest visits by such birds than by other eagle pairs which do more "flight-hunting" at shorter distances from the nest.

Our study population of Golden Eagles can be roughly divided into 50% "regular breeders" and 50% "rare breeders". About 25% of the rare breeders are seldom seen and only breed at intervals of several to many years, often at unknown nest sites (H. Dunker, unpubl. data). It is possible that the few observations of the adult eagles in some nesting areas might reflect an extreme shyness among the oldest eagles of the population. Individuals with a low-quality territory and an unusually large hunting area may also make observations accordingly rare (Moss 2010, Whitfield et al. 2007). According to Moss (2010), the Golden Eagle pairs occupying the relatively few high-quality territories in a study area in Sweden represented only 43% of the total number of successfully breeding pairs in the population.

We conclude that Golden Eagles in Norway may behave secretively in vicinity of their nest. A rapid approach to the nest may reduce nest predation by intruding eagles, carnivores, other raptors and corvids, and also reduce losses to human persecution. In addition to the problem of locating all nests in a given territory, and great individual variation in behaviour, secretive behaviour causes serious problems for accurate monitoring of breeding populations of Golden Eagles.

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