Ornis Norvegica

BirdLife NORWAY

Hunting success and efficiency of an urban Peregrine Falcon *Falco peregrinus* during the low light season in southwest Norway

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Cite this article
Time BE. 2025. Hunting success and efficiency of an urban Peregrine Falcon *Falco peregrinus* during the low light season in southwest Norway. *Ornis Norvegica* **48**: 1–6. DOI: 10.15845/on.v48.3625

Keywords
hunting success
hunting efficiency
Jackdaw
Peregrine
urban

Received 13 March 2022
Accepted 7 August 2025
Published 30 September 2025

Abstract
In November-December 2019, a Peregrine Falcon *Falco peregrinus* hunted close to the center of Bryne, a small town in southwest Norway. During winter, several thousand corvids normally roosted together in the city's park area. The hunts took place in the dark, after sunset and before sunrise. In this 30-day study, the falcon used a sit-and-wait strategy to hunt roosting corvids. The hunt started each time from the top of a 43 m high antenna near to the park and my apartment. The falcon then brought prey items to a balcony on a tall office building in the city centre, and to the same plucking and eating site after each kill. Sensitive cameras documented the activity of the falcon and its prey which were always Jackdaws *Corvus monedula*. One camera was mounted by the antenna and two cameras were deployed on the balcony. The attacks were registered as successful if the falcon returned with prey, or otherwise as unsuccessful. The falcon made a total of 42 attacks. A subset of 18 attacks ended with a return to the balcony, of which 13 were successful, resulting in a hunting success of 31% (13/42). Overall, 54% of all kills occurred in the dark before sunrise, and most of the prey were killed in December (77%). The ratio of time spent on successful hunting to total hunting time was 79 to 308 minutes, giving a hunting time efficiency of 26%. On average, the falcon used 6 minutes per successful kill, with a range between 1 to 16 minutes.

INTRODUCTION

The Peregrine Falcon *Falco peregrinus* is admired for its beauty and flying abilities, but has also been the victim of anthropogenic disturbance, including capture for falconry and exposure to pesticides used in agriculture and crop production (Cade 1982, Ratcliffe 1993). After a dramatic decline in the sixties, populations of the species have gradually increased in numbers (Nygård et al. 2019). The Peregrine is currently listed as a species of Least Concern according to the IUCN red list, due to a wide geographic range, a large population size, and an increasing population trend. The Norwegian population is estimated at around 1,100 pairs (Shimming & Øien 2015).

Peregrines nest in coastal and rural areas with steep cliffs and mountains, a challenge for any ornithologist. Today, modern cameras with sensors are used when researchers try to reveal unknown aspects of the falcon's life. Camera monitoring is particularly applicable for Peregrine Falcons that have moved into the world's big cities. Urban falcons are on the rise where they are surrounded by gigantic man-made constructions and buildings with cornices, balconies and other protrusions like small mountain ledges, but large enough for resting or nesting. The bird of prey uses various methods in the hunt, including attacks from behind or from above at high speeds. In air diving, the speed can reach several hundred kilometers per hour which exposes the falcon to great stress.

Rural Peregrine Falcons usually hunt in daylight, but field studies show that Peregrines can also hunt at dusk and dawn (Ratcliffe 1993). However, urban falcons also seem to hunt at night, probably due to the availability of artificial light from office buildings and streetlights (Decandido & Allen 2009; Time 2016). Falcons kill and eat various animals, mostly birds. The prey list is long, but many urban falcons have become specialists that hunt doves and feral Rock Pigeons *Columba livia* (Rejt 2001). A 20-year study from urban sites in England

contains a list of 102 prey species (Dixon & Drewitt 2018).

Some Norwegian and Fennoscandian falcons move south-west towards England, while others migrate south to continental Europe after breeding (Svorkmo-Lundberg et al. 2006). Nevertheless, some Norwegian peregrines stop and survive in coastal areas with a milder climate and hunt only on a few species during winter. However, short day lengths, snow cover and low temperatures can create challenges for wintering falcons. Hunting requires energy so maybe birds of prey must change strategy and methods to optimize hunting success in nocturnal environments? The question of whether Peregrine Falcons hunt as effectively in the dark as in daylight has received little attention. Efficiency is more than the number of successful kills in relation to the number of hunting flights (hunting success), and is also about the time used to catch and kill a prey item in relation to the entire hunting time (hunting time efficiency).

In the autumn and winter of 2019, an adult female Peregrine hunted for corvids roosting in the Sandtangen park at Bryne, southwest of Norway after sunset and before sunrise. The falcon resided on Forum Jæren, a tall building in the center of the town. In a short period of thirty days, the female started to hunt from the top of a nearby radio antenna. After catching and killing a bird, the Peregrine then brought the prey directly to a nest box mounted on the building. A network of cameras recorded flight times and movements of the falcon. The monitoring system gave me the opportunity to register all prey, document the hunting methods, and for the first time calculate the hunting time efficiency of a Peregrine Falcon hunting in the dark in Norway.

METHODS

Forum Jæren is a 66 m high office building with three covered balconies. In 2015, a nest box was installed on the balcony on the 13th floor facing south. The internal dimensions of the nest box were 0.70 x 0.50 m. The box was never used as a nesting place, however from 2019 to 2022 it was utilized as a roosting site for plucking and resting. The office building is located 450 m from a large freshwater lake (Frøylandsvatnet) and a public park with coniferous and deciduous trees (Figure 1). Several thousand Hooded Crows *Corvus cornix* and Jackdaws *Corvus monedula* roost in the area during the non-breeding season (Svorkmo-Lundberg et al. 2006). The antenna is a metal construction, 43 m high with red warning lights on top. The mast is located near Sandtangen, and only 150 m from my apartment (Figure 2).

I scouted the antenna 3.5 hours/day for thirty days (07:30 to 09:30 and 16:00 to 17:30 for a total of 105 hours. To document the falcon attacking from the antenna in dark, I took pictures from my balcony with a DSLR camera, Nikon D4s with a 600 mm lens Nikon 1: 4 G ED VR ll (K1) attached to a solid tripod. The camera settings were always in Live View mode (Lv), auto-ISO, custom shutter speed, a continuous high series shooting mode (Ch) and manual focus. Inside the nestbox, I mounted a Cuddeback Long Range IR game camera (K2) that recorded landing times, prey and eating behavior. An additional game camera, Wildgame/Cloak 6 (K3) was mounted outside and 2 m from the nestbox to document the activity on the landing board. The camera clocks were synchronized to compare the activity on the box with the falcon's arrival and departure times from the antenna. The falcon landed with prey on a narrow board in front of the opening to the nestbox. I examined the box every day and put new memory cards in K2/K3.

The number of attacks recorded by the Nikon camera at the antenna K1 (42) were divided into three groups. (A) Successful. Departures from the antenna, catch and land on the box with prey. (B) Unsuccessful. Departure from the antenna and land on the box without prey. (C) Unsuccessful. Departure from the antenna and return repeatedly without prey.

In the dark, it was only possible to observe the falcon's departures and arrivals at the antenna. What happened next during each attack was impossible to document. The recorded hunting times were therefore considered maximum values. For the same reason, all departures from the antenna were considered real attacks in this study.

RESULTS

The observation period was 30 days, between 17 November and 16 December. At the same time, daylight was reduced from 9 to 7.5 h. The attacks took place after sunset from 16:22 to 17:09 and before sunrise from 07:33 to 08:27. Jackdaws were the only recorded prey species. Shortly before sunset, Jackdaws gathered in flocks in the center of Bryne and passed the antenna at high speed during the last 200-300 m in flight towards Sandtangen. In the morning, the flocks left the park before sunrise. The Peregrine made a total of 42 attacks from the radio antenna with a total flight time of 225 minutes, and a total hunting time of 308 minutes. Details of each attack and hunting times can be found in Appendix 1 & 2.

Group A: Overall, the falcon successfully captured prey in 13 of 42 attacks, for a hunting success of 31%. Relative to a total hunting time of 308 min, the falcon spent 79 minutes on successful hunting, for a hunting time efficiency of 26% (Appendix 2). The falcon used an average of 6 minutes per kill, ranging from 1 to 16 minutes. Group B: Five attacks ended in the nest box without prey. The total flight time was 48 minutes, with an average of 9.6 minutes, ranging from 6 to 19 minutes. Group C: Twenty-four attacks were unsuccessful. The

Figure 1. The public park Sandtangen seen from the top of the radio antenna. Several thousand corvids roosted here during the late fall (Photo: Harald Fjogstad).

Figure 2. The radio antenna on Bryne seen from the author's apartment. Forum Jæren is the tall building in the background (Photo: Bjarne Emil Time).

total time for these events was 98 minutes, with an average of 4 minutes, ranging from 1 to 49 minutes. Nine of the 24 unsuccessful attacks lasted 1 minute or less (38%) (Appendix 1). Ten of 13 prey were caught in December and about half of all killings, seven of 13 (54%) occurred during periods of darkness or low light before sunrise. Nine of 13 successful attacks started with one or more unsuccessful attacks.

DISCUSSION

The nest box at Forum Jæren became the most important plucking and resting site for a female Peregrine Falcon that hunted at Bryne in winter 2019. Jackdaws were the sole species of prey recorded during the study period.

Similar to the behaviour of Starlings *Sturnus vulgaris* and Dunlin *Calidris alpina*, Jackdaws gather in large

flocks to forage or roost to reduce predator attacks. Jackdaws have developed anti-predator strategies, but many birds were killed by the Peregrine Falcon in the artificial light at Bryne. Starting the hunt from the antenna probably gave the falcon an advantage over the prey due to a short attack distance and reflection of the city light from the plumage of Jackdaws, which made them highly visible to the falcon. Decandido & Allen (2009) studied Peregrine Falcons in New York hunting migratory birds late at night. At the Empire State Building, the dominant hunting methods were also pursuit or sit-and-wait ("still hunting") as observed for the female at Bryne.

Air diving or chasing fast Jackdaws in parallel flights are probably physically demanding hunting methods. If the attack failed, it is not inconceivable that the falcon had to take several short breaks on the top of the antenna. Hunting is governed by several factors, not the least hunger. However, attacks can also be a reflex to the sight of prey if based on a lower trigger level. Variation in stimuli may be the reason for many of the unsuccessful attacks I documented, but the results also indicate that it may be difficult to attack a flock.

In a study by Zoratto et al. (2010) about Peregrine Falcons hunting Starling flocks, the hunting success was low and estimated to be approximately 23%. Hunting sequences consisted of multiple attacks at short intervals. In a similar study, Buchanan & Herman (1986) found that Peregrines hunted Dunlin with 47% success rate. Both studies were conducted in daylight at the species' winter habitats. It is therefore remarkable that the falcon at Bryne hunted with such high hunting success in the dark (31%). Perhaps the falcon hunted more intensely at the end of the fall to provide enough energy for the next stage of the annual cycle (Treleaven 1980).

It is difficult to evaluate the different lengths of time the falcon spent attacking. Since I did not observe the whole sequence of events, I cannot exclude the possibility that the reason for the long successful and unsuccessful attacks that I documented were interrupted by the falcon losing the prey, starting to eat on the ground or changing tactics to soaring high in the air in readiness to deliver the attack when prey approaches (Ratcliffe 1993).

There are many data on the hunting success of the Peregrine (Lindberg 1975, Dekker 1980, Roalkvam 1985). Roalkvam (1985) also uses his data as a measure of the falcon's hunting efficiency. I have not found any information on hunting time efficiency of Peregrines in the literature, apart from my result (26%). Thus, my new findings for a bird hunting in an urban environment in southwest Norway provide a small contribution to the understanding of the hunting behavior of the Peregrine Falcon.

Acknowledgements. The study was financially supported by Stavanger Museum through Holger Holgersen's legacy. Thanks to Torgeir Nygård and an anonymous reviewer for comments and improvement of my article, and to Harald Fjogstad for technical support.

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Appendix 1. Records of 42 attacks (13+5+24) and 225 minutes of flight time (79+48+98) for an adult female Peregrine Falcon *Falco peregrinus* hunting Jackdaws *Corvus monedula* at Bryne, Norway during November and December 2019. All attacks started from the top of a 43 m high antenna. A subset of 18 attacks ended at the falcon's feeding site, a nest box on a balcony of an office building in the city. The hunts are divided into 3 groups for successful (A), and unsuccessful hunts (B, C). Flight times are in minutes.

A: Attack - capture - box B: Attack - no capture – box C: 1-3 attacks with return to the antenna - no capture

	GROUP A. SUCCESSFUL			GROUP B. UNSUCCESSFUL			GROUP C. UNSUCCESSFUL			
Date	**Departure**	**Attacks**	**Flight time**	**Departure**	**Attacks**	**Flight time**	**Departure**	**Attacks**	**Flight time**	**Flight time Sum**
Nov 18	16:48	1	4	–	–	–	16:42	1	2	6
21	-	-	-	17:09	1	6	16:43–16:56	3	5 (1+2+2)	11
23	08:10	1	2	–	–	–	–	–	–	2
24	–	–	–	16:43	1	6	16:22–16:42	3	8 (1+2+5)	14
25	–	–	–	16:33	1	4	16:32	1	1	5
26	08:10	1	14	–	–	–	08:05	1	1	15
30	-	-	-	17:05	1	19	16:53–16:59	3	5 (1+1+3)	24
Dec 01	08:11	1	2	–	–	–	08:05	1	2	4
02	16:42	1	6	–	–	–	16:41	1	1	7
04	16:41	1	5	–	–	–	16:23–16:38	2	14 (4+10)	19
05	08:25	1	9	–	–	–	07:33–08:24	3	49 (1+24+24)	58
06	08:14	1	5	–	–	–	–	–	–	5
10	08:13	1	16	–	–	–	08:12	1	1	17
11	09:02	1	1	–	–	–	–	–	–	1
12	08:27	1	8	–	–	–	08:18–08:24	2	4 (2+2)	12
14	16:27	1	6	–	–	–	–	–	–	6
16	08:26	1	1	–	–	–	08:12–08:25	2	5(3+2)	6
16	–	–	–	16:32	1	13	–	–	–	13
Total		13	79		5	48		24	98	225

Appendix 2. Foraging times of an adult female Peregrine Falcon *Falco peregrinus* hunting Jackdaws *Corvus monedula* at Bryne, Norway during November and December 2019. All attacks started from the top of a 43 m high antenna. Hunting time is the sum of flight time and Sit still time. Times are in minutes.

Date	Start hunting	End hunting	Sit still time	Flight time	Hunting time
18 Nov	16:42	16:52	4	6	10
21	16:43	17:15	21	11	32
23	08:10	08:12	-	2	2
24	16:22	16:49	13	14	27
25	16:32	16:37	-	5	5
26	08:05	08:24	4	15	19
30	16:53	17:24	7	24	31
01 Dec	08:05	08:13	4	4	8
02	16:41	16:48	-	7	7
04	16:23	16:46	4	19	23
05	07:33	08:34	3	58	61
06	08:14	08:19	-	5	5
10	08:12	08:29	-	17	17
11	09:02	09:03	-	1	1
12	08:18	08:39	9	12	21
14	16:27	16:33	-	6	6
16	08:12	08:32	14	6	20
16	16:32	16:45	-	13	13
Total			83	225	308

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