NESTING BEHAVIOR OF PEREGRINE FALCONS IN WEST GREENLAND DURING THE NESTLING PERIOD

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ABSTRACT - Time-lapse photography was used to study adult and nestling behavior at 2 Peregrine Falcon (*Falco peregrinus*) eyries in West Greenland during July and August 1974. During the first 10 d after hatching, nestlings at both eyries were brooded > 80% of the time. Brooding activity declined gradually during d 11-15 and was not recorded at either eyrie following d 20. The length of each feeding bout at 1 eyrie (Ringsϕ) diminished steadily throughout the nestling period. In contrast, the length of each feeding bout at the other eyrie (Lone Female) remained relatively constant. The rate of food delivery was consistently greater at Ringsϕ than at Lone Female. The Ringsϕ nestlings began to wander from the nest scrape on d 9-10, but spent most of their time on the scrape until d 24. The Lone Female nestlings also spent most of their time on the scrape during d 1-20, but they spent less time in bodily contact with one another than did the Ringsϕ nestlings.

Although the Peregrine Falcon (*Falco peregrinus*) has been the subject of numerous scientific investigations, few studies had been conducted in the Arctic prior to the 1970s. Following the reproductive decline of the peregrine throughout much of North America during the 1950s and 1960s (Hickey 1969), however, the need to evaluate the status of Arctic populations became apparent (Cade 1969).

In response, an intensive study was initiated in West Greenland in 1972. The primary focus of this long-term investigation was to determine the distribution, density and reproductive success of a nesting population of Peregrine Falcons (see Mattox et al. 1972; Walker et al. 1973; Burham et al. 1974; Mattox 1975; Mattox et al. 1980 and Burnham and Mattox 1984 for the results of this portion of the project). An additional effort was made to study the breeding behavior of the birds. Here, we present one aspect of that behavioral investigation: the use of time-lapse photography to record the activities of adult and nestling Peregrine Falcons at 2 eyries.

MATERIALS AND METHODS

The study was conducted on the west coast of Greenland at 2 cliffs located approximately 6 km WNW and 24 km WSW of Sondrestromfjord Air Force Base. The region ranges in elevation from sea level to 590 m, has a low-arctic climate, and is characterized by expanses of tundra interspersed with shallow ponds and lakes.

Two Peregrine Falcon eyries were studied intensively during July and August 1974 by T.D. Snowman and V.L. Cox, who established a base camp near the Ringsϕ eyrie. The Ringsϕ eyrie was two-thirds of the way up a 45-60 m cliff and overlooked 2 large and several smaller bodies of water to the SSE; there were 4 nestlings (2 ♂♂ and 2 ♀♀) at the eyrie. The Lone Female eyrie, 20 km to the WSW of Ringsϕ, was two-thirds of the way up a 24-30 m rock outcropping and overlooked a large lake to the S. On 23 July, 1 live (a ♂) and 2 dead nestlings were discovered at the latter eyrie. Because we believed there was little chance the single nestling would survive without the warmth of another bird, a second male nestling of about the same age was transplanted to the nest from a nearby eyrie on 29 July. At that time, both nestlings were approximately 12-13 d old.

Minolta super-8 movie cameras, housed within waterproof metal and Plexiglas cases, were secured with climbing pitons and slings 5 m from the nest scrape at Ringsϕ and 3-4 m from the nest scrape at Lone Female. Filming at Ringsϕ began 17 July, about 5 d after the eggs hatched, and continued through 6 August. During the first 17½ d, the camera exposed 1 frame/min; during the last 3½ d, the rate was increased to 1 frame/15 sec. From 13 July through 5 August, additional observations of adults and nestlings were made with an 8-25X spotting scope from a hidden location 140 m from the nest scrape. Filming at Lone Female began 23 July, about 6 d after the original clutch hatched, and ended 5 August. The camera exposed 1 frame/min throughout the period. The film at the Lone Female eyrie had to be changed every 60 h, requiring a 6-h, 20-km walk from Ringsϕ; incidental observations were made during these visits.

R. Fay, J.A. Hovis and K.L. Bildstein transcribed observations from the film using a film-editing machine and microfiche reader. Four adult behavioral patterns were recognized: 1) brooding, including close sitting or standing over the nestlings (Jenkins 1978); 2) feeding, including feeding bouts and food deliveries; 3) adult on eyrie but inattentive, including observations in which at least 1 adult was on or near the nest scrape but was not brooding or feeding the young; 4) adult not at eyrie, including observations in which neither adult was in view. We excluded from analysis adult behavioral patterns influenced by human activity when the film was changed.

We also recorded the absolute (on or off scrape) and relative (in contact with at least 1 other sibling or alone) location of nestlings.

RESULTS AND DISCUSSION

Adult Behavior. — Nestlings at the Ringsϕ eyrie were closely brooded during the first 10 d after hatching (Table 1). As the young began to acquire their second down at 10-14 d of age (Bent 1938), there was a gradual decline in brooding activity, with most brooding occurring at night or during

Table 1. Percent of time adult Peregrine Falcons engaged in various activities at 2 eyries in Greenland. Data were derived from 277 h and 199 h of film time at Ringsφ and Lone Female eyries, respectively.

Activity	Age of Nestlings[a]				
	3-5	6-10	11-15	16-20	21-24
Brooding	86/ND[b,c]	80/86	13/37	0/0	0/ND
Feeding	9/ND	10/4	8/5	6/3	1/ND
On eyrie, inattentive	1/ND	2/5	3/36	1/68	<1/ND
Not on eyrie	4/ND	8/5	75/22	93/28	98/ND

[a]Days since hatching.
[b]Ringsφ Eyrie/Lone Female Eyrie.
[c]ND no data.

periods of extreme temp or rain. No daytime brooding was recorded following d 15 of the nestling period; brooding at night was last observed when the young were 19-20 d old and was associated with cold, rainy and windy weather.

Most brooding activity at the Lone Female eyrie also occurred when the nestlings were < 10d old (Table 1). Thereafter, the young were left alone for increasing amounts of time; no brooding was recorded following d 14 of the nestling period.

A similar pattern in brooding activity was observed by Enderson et al. (1972) at 5 peregrine eyries along the Yukon River, Alaska. Nestlings were brooded >90% of the time during the first 6 d after hatching, approximately 88% of the time by d 10, and < 10% of the time by d 20. The occurrence of increased brooding activity during periods of inclement weather has been reported for the peregrine (Nelson 1970; Enderson et al. 1972), the Gyrfalcon (*F. rusticolus*) (Jenkins 1978) and the Sparrowhawk (*Accipiter nisus*) (Newton 1978).

Although adult birds could not be sexed accurately from the film, observations made with a spotting scope suggested that all brooding at Ringsφ was done by the female. Other studies also have found that males play a negligible role in brooding (Nelson 1970; Enderson et al. 1972; Harris and Clement 1975), a behavioral pattern that in part may be due to the difference in size between the sexes. Males apparently are too small to cover the nestlings properly and are probably less efficient brooders than are females (Nelson 1970), which are about one-third heavier.

The amount of time the Ringsφ adults spent feeding their young remained relatively constant throughout the first 20 d of the nestling period (Table 1). However, average length of each feeding bout diminished steadily during the period (Table 2). As the nestlings began to tear and shred food on their own, they probably required decreasing amounts of time to consume small prey items such as the Lapland Longspur (*Calcarius lapponicus*) and the Snow Bunting (*Plectrophenax nivalis*), which comprise the major portion of their diet (Harris and Clement 1975; Burnham and Mattox 1984). Also, as the nestlings grew increasingly aggressive with age, it became difficult for the adults to feed them at the eyrie. By the fourth wk of the nestling period, the adults were dropping prey at the eyrie and allowing the young to feed themselves. The tendency to avoid the young during the later stages of the nestling period has been observed for both peregrines (Sherrod 1983) and Gyrfalcons (Jenkins 1978).

The rate of food delivery at the Ringsφ eyrie was greatest when the nestlings were 6-20 d old (Table 2). At earlier ages, young took more time to consume lesser amounts of food (Enderson et al. 1972), were satiated more quickly (Newton 1979) and required fewer prey items. The limitations of time-lapse photography probably account for the low rate of food delivery recorded during the fourth wk of the nestling period. As the average length of each feeding bout decreased (Table 2), many food deliveries were too brief to be recorded on film (Jenkins 1978).

Table 2. Rate of food delivery and length of feeding bouts at 2 Peregrine Falcon eyries in Greenland.

	AGE OF NESTLINGS[a]				
	3-5	6-10	11-15	16-20	21-24
Rate of food delivery (prey/hr)					
Ringsϕ	0.8±0.1(2)[b]	1.3±0.2(5)	1.2±0.2(5)	1.4±0.3(5)	0.7±0.6(4)
Lone Female	ND[c]	0.9±0.1(3)	0.8±0.3(5)	0.6±0.1(5)	ND
Length of feeding bouts (min)					
Ringsϕ	6.7±5.0(21)	4.9±2.6(85)	3.7±2.0(95)	2.5±1.8(97)	1.4±0.9(22)
Lone Female	ND	2.8±2.3(40)	3.5±2.7(61)	3.0±2.2(47)	ND

[a]Days since hatching.
[b]Mean ± S.D.(N). N = number of days or number of feeding bouts.
[c]ND = no data.

Feeding activity at the Lone Female eyrie remained relatively constant during d 6-20 of the nestling period (Tables 1 and 2). Both the percent of time the Lone Female adults spent feeding young (Table 1) and the rate at which they delivered food to the eyrie, however, were lower (Table 2) than at Ringsϕ. These findings most likely were related to differences in the number and sex of the nestlings at each eyrie. The 2 male and 2 female nestlings at Ringsϕ undoubtedly required more food than the 2 males at Lone Female. That the average length of each feeding bout at Lone Female did not diminish as the nestlings matured (Table 2) is more difficult to interpret. Possible explanations include: 1) a greater parental diligence on the part of the Lone Female adults; 2) differences in the development and behavior of the nestlings at the 2 eyries; or 3) the failure of the cameras to record accurately the occurrence and duration of each feeding bout at the 2 eyries.

Nestlings at Ringsϕ were fed almost entirely by the adult female. The male was the primary hunter and provider of food, but was observed feeding the young only once, when they were 12-13 d old. Harris and Clement (1975) observed a similar division of parental duties for peregrines, whereas Herbert and Herbert (1965) and Nelson (1970) found that the male undertook a greater portion of the feeding responsibilities as the nestlings matured.

The aversion that adult falcons have towards being on the nest scrape together (Enderson et al. 1972; Harris and Clement 1975; Jenkins 1978) was further evidenced at the 2 eyries. The Lone Female adults were never filmed together. All of the 7 instances were the adults at Ringsϕ were filmed together occurred within the first 2 wks of the nestling period, all were associated with a food exchange or feeding bout and all lasted less than 1 min. Harris and Clement (1975) suggested that females may dominate males during the nestling period, tolerating their presence only in conjunction with the delivery of food. Neither of the females observed in this study appeared to be overtly aggressive towards their mate and the reason for each pair's general avoidance of one another remains unclear.

The Ringsϕ adults were rarely inattentive while on the eyrie (Table 1). Until the young were 10-15 d old, periods of inattentiveness occurred primarily between periods of brooding and feeding. This behavioral sequence also has been recorded for nesting Gyrfalcons (Jenkins 1978). With the cessation of brooding, the amount of time the Ringsϕ adults were on the eyrie and inattentive declined to $< 1\%$, and they spent 90% of the time away from the eyrie. In contrast, the Lone Female adults spent an increasing amount of time inattentive on the eyrie as the nestlings matured (Table 1). This probably re-

flects the fact that one of the Lone Female adults frequently perched away from the nest scrape but within the field-of-view of the camera.

Nestling Behavior. — Peregrine Falcons are semi-altricial (Nice 1962). At hatching, young are sparsely covered with down, and their eyes, although usually open, are weak and relatively non-functional (Brown and Amadon 1968). The young are dependent on their parents for food throughout the nestling period and for at least 6 wks after their first flight (Nelson 1970; Sherrod 1983). Time of first flight varies, but usually occurs when the nestlings are appproximately 30 (Herbert and Herbert 1965) to 43 d old (Nelson 1970).

The young at the Ringsϕ eyrie were relatively helpless and immobile during their first wk. They were not observed leaving the nest scrape until they were 9-10 d old (Table 3), at which time they could sit up and propel themselves short distances by hopping about on their wings. By the end of the second wk, the nestlings were actively shifting about as a group. They had begun to preen themselves and were able to grab food from the adult as often as it was offered to them. By d 15, the nestlings were tearing and shredding prey items and fighting aggressively over their food. They continued to spend most of the time in bodily contact with one another and on the nest scrape (Table 3). Vocalizations, identified as soft "kaks," were first heard at this time. During the fourth wk, the nestlings became increasingly mobile as they began to stand and stay off their wings. Thereafter, the amount of time they spent on the nest scrape and in contact with one another decreased rapidly (Table 3). When last observed, mid-way through wk 4, the nestlings appeared healthy and likely to reach fledging age. They were extremely active and aggressive, were able to feed themselves and remained outside of the field-of-view of the camera for long periods of time.

Transferring the additional nestling to the Lone Female eyrie did not appear to affect the development or behavior of either young. The nestlings, like those at Ringsϕ, spent the majority of the time on the nest scrape during d 11-20 (Table 3). The amount of time the Lone Female young spent in bodily contact with one another during this period, however, was lower than at Ringsϕ. The presence of only 2 nestlings at Lone Female may explain this difference; at any point in time each of the 4 Ringsϕ nestlings had a greater probability of being in contact with at least 1 of its siblings than did either of the Lone Female nestlings.

In conclusion, time-lapse photography proved an effective means of monitoring the activities of adult and nestling Peregrine Falcons in West Greenland. First, the technique generated relatively large amounts of data with minimal disturbance of the birds (Enderson et al. 1972). Second, the information derived from the films

Table 3. Percent of time nestling Peregrine Falcons were on the nest scrape or were in bodily contact at 2 eyries in Greenland.

	Age of Nestlings[a]				
	3-5	6-10	11-15	16-20	21-24
On nest scrape					
Ringsϕ	100	95	94	90	36
Lone Female	ND[b]	ND	73	78	ND
In bodily contact					
Ringsϕ	90	80	91	85	28
Lone Female	ND	ND	46	54	ND

[a]Days since hatching.
[b]ND = no data.

represents an important contribution to our knowledge and understanding of the Peregrine Falcon in the Arctic.

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