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Migratory Movements and Mortality of Peregrine Falcons Banded in Greenland, 1972–97

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ABSTRACT. In 1972 we initiated a long-term study of Peregrine Falcons *Falco peregrinus* in West Greenland to evaluate population status and describe general breeding ecology. The study area encompassed approximately 6050 km^2, spanning the area from the edge of the inland ice cap westward to the coast. From 1972 to 1997, we banded 1896 peregrines (1771 nestlings, 125 adults). Encounters of banded peregrines (n = 114) outside the study area occurred at locations from Greenland to Uruguay. In contrast to the equal sex ratio recorded in broods at banding, the sex ratio of nestling encounters was significantly skewed toward females. The majority (54%) of encounters involved capture and release by other falcon researchers, particularly those operating banding stations along the Eastern Seaboard and in southern Texas. Peregrines from Greenland appeared to reach wintering areas by late October or early November. Although male peregrines wintered significantly farther south than females, there was no significant difference in the mean date of capture along the East Coast of the United States in the hatch year (mean = 9 October ± 2.5 days for males and 9 October ± 1 day for females). Spring migration appeared to commence in early April, with breeding birds back on the study area by late May or early June. Despite the extensive recent use of satellite telemetry, long-term banding continues to play an important role in studies of peregrine migration, natal dispersal, and survival.

Key words: Arctic, bird banding, bird ringing, *Falco peregrinus*, Greenland, migration, Peregrine Falcon

Тезис. В 1972 мы начали программу мониторинга сокола-сапсана *Falco peregrinus* в западной Гренландии с целью оценить состояние популяции и описать экологию размножения вида. Район исследований составил примерно 6050 кв. км от края ледникового щита до западного побережья. С 1972 по 1997 год мы окольцевали 1896 птиц (1771 птенцов и 125 взрослых особей). Эти птицы были встречены от Гренландии до Уругвая (n = 114). По сравнению с сбалансированным соотношением самцов и самок при кольцевании, на гнездовьях впоследствии отмечались преимущественно самки. 54% находок были отловлены и отпущены на станциях вдоль восточного побережья Северной Америки и в южном Техасе. Сапсаны из Гренландии достигают зимовок к концу октября или началу ноября. Хотя самцы сапсана отмечались на зимовках существенно южнее самок, мы не отметили достоверной разницы в средней дате их появления вдоль восточного побережья США в их год вылупления (в среднем 9 октября ± 2,5 дня для самцов и 9 октября ± 1 день для самок). Весенний перелет начинается в раннем апреле и птицы появляются в местах гнездования в конце мая или начале июня. Несмотря на широкое использование спутниковой телеметрии, многолетние наблюдения окольцованных птиц остается одним из главных методов отслеживания миграции, разлета и выживания соколов-сапсанов.

Ключевые слова: Арктика, кольцевание птиц, *Falco peregrinus*, Гренландия, миграция, сокол-сапсан

RÉSUMÉ. En 1972, nous avons entrepris l'étude à long terme des faucons pèlerins *Falco peregrinus* dans l'ouest du Groenland dans le but d'évaluer l'état de la population et de décrire l'écologie générale de la reproduction. L'aire visée par l'étude comptait environ 6 050 km^2, s'étendant ainsi du bord de la calotte glaciaire de l'arrière-pays jusqu'à la côte ouest. Entre 1972 et 1997, nous avons bagué 1 896 faucons pèlerins (1 771 oisillons, 125 adultes). Des faucons pèlerins bagués (n = 114) ont été repérés à l'extérieur de l'aire visée par l'étude, dans des endroits allant du Groenland jusqu'en Uruguay. En contraste avec la proportion égale des sexes enregistrée dans les nichées au moment du baguage, la proportion des sexes chez les oisillons repérés tendait considérablement plus du côté des femelles. La majorité (54 %) des repérages ont fait l'objet de captures et libérations de la part d'autres chercheurs spécialisés dans les faucons, surtout ceux situés aux postes de baguage du littoral est et du sud du Texas. Les faucons pèlerins du Groenland semblaient atteindre les aires d'hivernage vers la fin d'octobre ou le début de novembre. Même si les mâles hivernaient beaucoup plus au sud que les femelles, aucune différence importante n'a été relevée dans la date moyenne de capture sur le littoral est des États-Unis pendant l'année de l'éclosion (moyenne = 9 octobre ± 2,5 jours chez les mâles et 9 octobre ± 1 jour chez les femelles). La migration printanière semblait commencer vers le début d'avril, les oiseaux reproducteurs étant de retour dans l'aire visée par l'étude vers la fin de mai ou le début de juin. Malgré l'utilisation récente et

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fréquente de la télémétrie satellitaire, le baguage à long terme continue du jouer un rôle important dans l'étude de la migration, de la dispersion natale et de la survie du faucon pèlerin.

Mots clés : Arctique, baguage d'oiseaux, baguage, *Falco peregrinus*, Groenland, migration, faucon pèlerin

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INTRODUCTION

In 1965, raptor experts from around the world met to develop a research and management agenda to address the widespread and precipitous declines of Peregrine Falcon *Falco peregrinus* populations in North America and Europe (review by Hickey, 1969). The peregrine subspecies nesting below the boreal forest, *F. p. anatum*, was believed to have been extirpated from eastern North America, but very little was known of the population status of *F. p. tundrius* (review by Kiff, 1988), the subspecies breeding in Arctic and sub-Arctic areas (White, 1968). The Greenland Peregrine Falcon Survey began in 1972 to augment information collected from other North American studies (Cade et al., 1988).

Peregrines were known to breed in Greenland when declines were being reported throughout the United States and Canada (Salomonsen, 1950–51), and it was thought that the island's remoteness might have protected the population to some degree from the factors lowering reproductive success elsewhere. The Greenland survey, conducted annually from 1972 to 1997, initially focused on determining the size and trend of the population (Burnham and Mattox, 1984; Mattox and Seegar, 1988) and the presence of environmental contamination (Walker et al., 1973; Springer et al., 1984). Subsequent work contributed to an understanding of peregrine foraging behavior (Meese and Fuller, 1989; Rosenfield et al., 1995), migration and dispersal (Fuller et al., 1998; Restani and Mattox, 2000), and habitat use (Wightman and Fuller, 2005, 2006).

This paper focuses on the spatial and temporal patterns of migration of peregrines banded as nestlings and adults in West Greenland. It analyzes in more detail the migration and mortality factors reported in a preliminary way by Burnham and Mattox (1984) and Mattox and Seegar (1988). It also provides insight into the movements of male peregrines and therefore extends the work of Fuller et al. (1998), who described the migration of 16 adult females marked with satellite transmitters. We do not repeat the information previously reported on natal dispersal (Restani and Mattox, 2000) or analyze encounters of adults banded on the study area and subsequently sighted there; the latter topic will be treated in a future manuscript on breeding site fidelity, survivorship, and lifetime reproductive success.

STUDY AREA AND METHODS

The study area, located in the widest part of ice-free land in West Greenland, encompassed approximately 6050 km^2, extending 110 km from the edge of the inland ice cap westward toward the coast (49˚55′ W to 52˚30′ W) and 55 km from north to south (66˚40′ N to 67˚15′ N). Most of the study area was rolling tundra (elevation up to 1120 m) interspersed with nearly 1000 lakes and five glacial outflow rivers. Vegetation was dominated by willow (*Salix glauca*), dwarf birch (*Betula nana*), heaths (*Empetrum*, *Ledum*, *Cassiope*, spp.), and grasses (*Calamagrostis*, *Festuca*, *Poa*, spp.) (Feilberg et al., 1984). Climate was typical of low Arctic regions, with June–August temperatures ranging between 0˚C and 15˚C. See Burnham and Mattox (1984) for a more detailed description of the study area.

From June to August, 1972 to 1997, a variable number (two to five) of two-person teams equipped with rock-climbing gear backpacked across the tundra and visited all cliffs more than 25 m high that provided potential nesting habitat for Peregrine Falcons (Burnham and Mattox, 1984). At times each year, the area was also traversed by kayak, small aircraft, and helicopter. Teams observed cliffs for signs of breeding activity (e.g., nestling feedings, brooding). If breeding activity was not evident after a minimum of 4 h of observation, the cliff was considered inactive. Observers recorded the presence of adult peregrines and attempted to classify individuals by sex at cliffs occupied by lone adults as an index of population density and breeding opportunity (Gould and Fuller, 1995; Restani and Mattox, 2000). They also recorded the exact location of each cliff (using GPS) and a description of the cliff, eyrie ledge, and climbing conditions (Wightman and Fuller, 2005).

Banding teams either rappelled or free-climbed to eyries that contained young. Nestlings were individually marked with a Danish Zoological Museum numbered band on the left tarsus and an alphanumeric color band on the right tarsus (except in 1972, 1976, and 1982–85, when nestlings received only a Danish band). Sex was assigned to nestlings on the basis of size (usually relative to siblings), and age was estimated following Moritsch (1983) and Cade et al. (1996). Banding teams used spotting scopes and binoculars to note the presence of bands or to read the alphanumeric codes on the bands of attending adults. Adult peregrines were captured at nest cliffs by early-season trapping teams from 1983 to 1997. Each unmarked bird was banded with a numbered Danish band on the right tarsus and an alphanumeric color band on the left tarsus (i.e., the opposite of the protocol for nestlings). Prey remains were collected for several years to describe food habits (Rosenfield et al., 1995), as were nestling blood samples for environmental contaminants (Springer et al., 1984; Jarman et al., 1994) and parasite analyses (Taft et al., 1998).

The Danish Zoological Museum in Copenhagen provided the following information on peregrines we banded that were subsequently encountered: date, location (place name and latitude/longitude), and specific circumstances if known (e.g., whether the bird was captured, sighted, or shot). In this paper we use the following terminology of the U.S. Geological Survey (USGS) Bird Banding Lab: 1) encounter: any handling of a banded bird, alive or dead; 2) recovery: any encounter with a banded bird known to be dead; 3) foreign recapture: capture and release of a bird previously banded under a different permit; and 4) sighting: the reading and reporting of a band number on a live bird without actually capturing the bird. We obtained banding information from the USGS Bird Banding Lab for foreign recaptures of peregrines within our study area.

Using the Robinson projection in ArcGIS (ESRI, 2013), we plotted encounter locations to depict the migratory routes (i.e., flyways) and wintering areas of peregrines we banded in West Greenland. On the map, we excluded encounters within the study area. We used the haversine formula to estimate great-circle distances between locations of banding and encounter.

To examine the progress of migration and general location of wintering destinations, we fitted a quadratic function to a plot of encounter latitudes by dates (see also Schmutz et al., 1991). For this analysis, we excluded terminal encounters (i.e., band only found) and recoveries of skeletal or badly decomposed remains because ambiguous dates rendered the relationship between latitude and date suspect. We used a Mann-Whitney U test to determine whether males and females wintered at similar latitudes for the time period suggested by the curve (November through March; Schmutz et al., 1991; McGrady et al., 2002). We used chi-square tests for analyses examining the sex ratios at time of banding vs. at time of subsequent encounters, for both nestling and adult age classes.

We used a t-test to evaluate whether the chronology of migration along the East Coast of the United States was similar for the two sexes. For this analysis, we tallied the number of birds captured and released during autumn migration at trapping and banding stations located from Long Island, New York, through Virginia. Live captures provided an unambiguous date in contrast to peregrines found dead or injured during migration. We used this information, along with encounters within our study area, to evaluate the frequency of mis-sexing nestlings at time of banding.

When necessary, we log-transformed data to achieve homogeneity of variances (Levene's test) prior to statistical analyses involving parametric tests. All analyses were conducted with SPSS (2010). We have reported untransformed values in the Results. Unless indicated otherwise, all results are mean ± 1 SE, with statistical significance assigned at $p < 0.05$.

RESULTS

From 1972 to 1997, we banded 1896 peregrines within the study area (Table 1). Cliffs occupied by peregrines were at elevations lower than 610 m, and the vertical height of cliff faces varied from 25 m to 215 m. The annual increase in the number of cliffs visited and number of peregrines banded through the 1980s reflected both an increase in survey effort and an apparent increase in the size of the breeding population. The sex ratio of nestlings banded (837 males, 868 females, 66 unknown) did not differ from parity ($\chi^2 = 0.25$, df = 1, $p = 0.619$). We also banded 125 breeding adults (21 males, 104 females). The sex ratio of banded adults was biased towards females ($\chi^2 = 29.40$, df = 1, $p < 0.001$) for two reasons. First, females did most of the incubating and therefore were easier to catch at the eyrie. Second, we targeted females for tagging with satellite transmitters (see Fuller et al., 1998) because the equipment available was too heavy and bulky for attachment to males.

Encounters of banded peregrines (n = 114) outside the study area extended from Greenland to Uruguay (Fig. 1). We received encounter reports concerning seven adults and 106 nestlings (six nestlings were encountered twice; one report lacked location coordinates). The sex ratio of nestling encounters (35 males, 70 females, 1 unknown) was significantly skewed toward females, in contrast to the equal-sex ratio recorded in broods at banding ($\chi^2 = 9.22$, df = 1, $p = 0.002$). Of all encounters within (n = 115) and outside (n = 114) the study area, we know of only five (2.2%) nestlings that were incorrectly sexed at banding. We captured 12 peregrines on the Greenland study area that had been banded elsewhere (i.e., foreign recaptures); most had been banded along the mid-Atlantic coast during migration (Table 2).

Of the 114 encounters outside the study area of peregrines banded in West Greenland, 54% involved capture and release by other falcon researchers (Table 3), particularly those operating banding stations along the Eastern Seaboard and in southern Texas. The encounter rate reported in this study is low (ca. 6%) because it included only encounters with banded birds outside the study area. Thus, natal dispersers (n = 42, discussed in Restani and Mattox, 2000) and adults banded and later encountered within the study area (n = 73) were excluded from the calculation. Incorporating these on-study area captures and sightings increased our overall encounter rate to approximately 12% (229 of 1896 banded). The majority (65%) of encounters outside the study area occurred within the first year after banding. Thereafter, the number of annual encounters remained low (< 5% per year) until encounters ceased 12 years after banding (Fig. 2).

Peregrines from Greenland appeared to reach wintering areas by late October or early November (Fig. 3). Male peregrines (n = 7) wintered significantly farther south than females (n = 21) (mean = 17.2˚ ± 3.2˚ S vs 20.3˚ ± 2.2˚ N; Mann-Whitney U = 1.00, $p < 0.001$). This spacing difference in mean latitude represented a mean flight distance of more than 4100 km. No difference existed in the mean

TABLE 1. Numbers of Peregrine Falcon cliffs where banding took place, nestlings banded, and adults banded in West Greenland, 1972–97.

Year	Cliffs	Nestlings	Adults
1972	9	13	0
1973	9	24	0
1974	5	15	0
1975	5	10	1
1976	4	10	0
1977	4	9	0
1978	6	17	0
1979	6	18	0
1980	10	30	0
1981	12	32	0
1982	13	34	0
1983	19	51	14
1984	22	68	6
1985	33	98	7
1986	35	98	14
1987	36	112	5
1988	41	116	5
1989	48	139	13
1990	57	157	11
1991	73	190	10
1992	44	121	7
1993	45	111	9
1994	31	85	7
1995	42	119	10
1996	22	66	2
1997	20	28	4
Total	122[1]	1771	125

[1] Represents number of different cliffs.

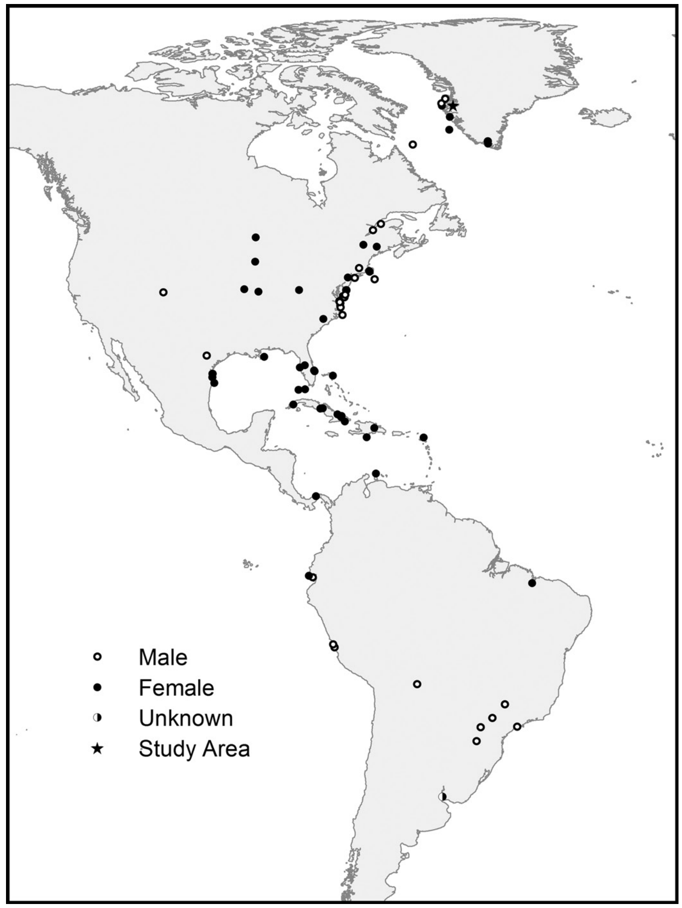

FIG. 1. Locations of encounters outside the study area of Peregrine Falcons banded in West Greenland, 1972–97.

date of capture along the East Coast of the United States in the hatch year for males (mean = 9 October ± 2.5 days) and females (9 October ± 1 day) on their first southward migration (t = 0.144, df = 42, p = 0.886). Only two adults were captured and released during autumn migration (both along the East Coast), and only one was captured and released during spring migration (at Padre Island, Texas). Spring migration appeared to commence in early April, with breeding birds back in the study area by late May or early June.

DISCUSSION

Peregrine Falcons from West Greenland migrated south during autumn predominantly along the Atlantic Flyway of North America. Some peregrines also used the Mississippi and Central Flyways, and evidence suggested that use of a particular flyway was flexible and not necessarily similar for siblings. For example, we banded four nestlings from a single brood on 29 July 1983. During their first autumn migration, two of the nestlings were caught four days apart at the same location in Virginia (Atlantic Flyway), whereas a third sibling was caught four days later in Iowa, 1487 km to the west-northwest (Mississippi Flyway). Encounters of peregrines from Greenland also revealed that some individuals, mostly males, migrated offshore during autumn. For example, a male banded in 1979 was observed aboard a vessel 195 km southeast of Montauk, New York. Early researchers hypothesized that such shipboard sightings represented birds that had been blown off course by storms rather than an oceanic route for male peregrines. However, an oceanic route has since been confirmed by tracking satellite-tagged peregrines, some of which have made long distance ocean crossings and island hopped during migration (Fuller et al., 1998; McGrady et al., 2006; Franke et al., 2011).

Male peregrines fledged in Greenland wintered significantly farther south than females. The southernmost female was reported from 3˚ S and the northernmost male from 2˚ S. The southernmost recovery of a peregrine banded in Rankin Inlet, Nunavut—also a male—took place in Uruguay (33˚ S; Court et al., 1988). Male peregrines from other populations in northern Canada also wintered farther south than females, with the farthest south female wintering at 8˚ N and the farthest south males at 37˚ S and 38˚ S (Schmutz et al., 1991: Fig 5; J.K. Schmutz, pers. comm. 2013). Only one of 16 females satellite-tagged in Greenland wintered in South America; her wintering site was in Venezuela at the relatively high latitude of 10˚ N (Fuller et al., 1998; M.R. Fuller, pers. comm. 2013).

Competition between the sexes has been invoked for other bird species as one possible mechanism driving

TABLE 2. Foreign recaptures of Peregrine Falcons banded in the United States and encountered on the West Greenland study area, 1972–97. All were females.

Date banded	Banding location	Age at banding[1]	Date encountered	Distance migrated (km)
13 October 1976	Cape May, New Jersey	HY	29 June 1983	3471
1 October 1980	Cape Charles, Virginia	HY	1 July 1984	3637
5 October 1982	Chincoteague Is., Virginia	AHY	7 July 1983	3594
11 October 1989	Chincoteague Is., Virginia	HY	18 June 1991	3579
10 October 1989	Assateague Is., Maryland	HY	19 July 1992	3578
28 April 1990	S. Padre Is., Texas	AHY	26 June 1990	5481
13 October 1988	N. Padre Is., Texas	HY	30 June 1991	5421
21 April 1992	S. Padre Is., Texas	SY	15 June 1993	5502
26 September 1991	Assateague Is., Virginia	HY	5 July 1995	3547
19 October 1991	Assateague Is., Virginia	SY	1 August 1994	3565
22 October 1991	Cape May, New Jersey	HY	2 August 1994	3464
30 October 1992	Cape Cod, Massachusetts	HY	5 August 1994	3054

[1] AHY = after hatch year, HY = hatch year, SY = second year.

TABLE 3. Circumstances of encounters outside the study area of Peregrine Falcons banded in West Greenland, 1972–97.

	Male	Female	Unknown	Total
Number banded	858	972	66	1896
Total number (%) encountered	36 (4.2)	77 (7.9)	1 (1.5)	114 (6.0)
Captured and released	18 (2.1)	44 (4.5)	0 (0)	62 (3.3)
Found dead	7 (0.8)	11 (1.1)	1 (1.5)	19 (1.0)
Found injured	5 (0.6)	9 (0.9)	0 (0)	14 (0.7)
Shot	4 (0.5)	7 (0.7)	0 (0)	11 (0.6)
Color band read	1 (0.1)	1 (0.1)	0 (0)	2 (0.1)
Other	1 (0.1)	4 (0.4)	0 (0)	5 (0.3)
Circumstances unknown	0 (0)	1 (0.1)	0 (0)	1 (0.1)

geographic segregation during winter, with the larger more dominant sex migrating shorter distances from the breeding area than the smaller sex (Kerlinger, 1989; Alerstam et al., 2003). We lacked sufficient encounters during spring migration and data on arrival times at breeding cliffs in Greenland to ascertain the sex-specific pace of spring migration. However, Court et al. (1988) reported that males and females arrived at breeding cliffs in northern Canada at the same time. If Greenland peregrines had a similar pattern, then males must have left their more distant wintering areas before females, migrated faster, or taken more direct routes.

White et al. (1989) suggested that, in addition to the latitudinal sexual segregation we observed, peregrines may partition habitat by sex where wintering ranges overlap. For example, females vastly outnumbered males in their study areas in coastal Ecuador and Peru. Moreover, only 2% of all peregrines observed wintering along the Mexican coast were males (McGrady et al., 2002). Some of the *F. p. tundrius* females satellite-tagged by Fuller et al. (1998) in northern Canada wintered well into South America, thereby overlapping the winter ranges of males from Greenland. Whether males and females from these two different breeding populations subdivided winter habitat remains unknown.

For decades, researchers have described the impressive migratory concentrations of peregrines along the East Coast during autumn. Nearly half of the encounters of Greenland peregrines (50 of 114) occurred in this area from late September through October. In fact, we obtained encounter

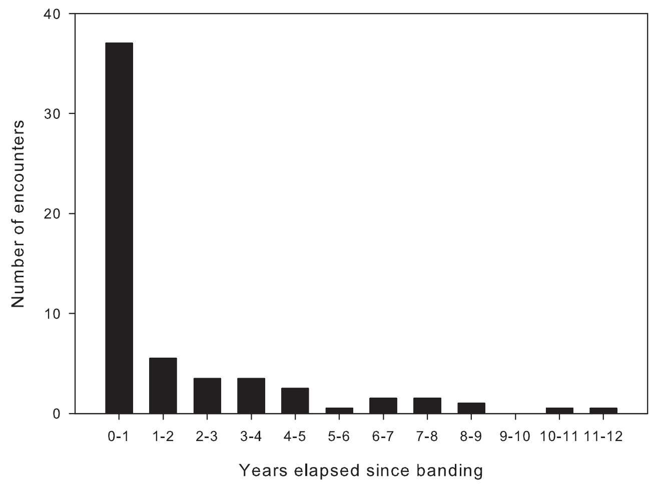

FIG. 2. Number of encounters outside the study area of Peregrine Falcons banded in West Greenland, 1972–97, by years elapsed since banding.

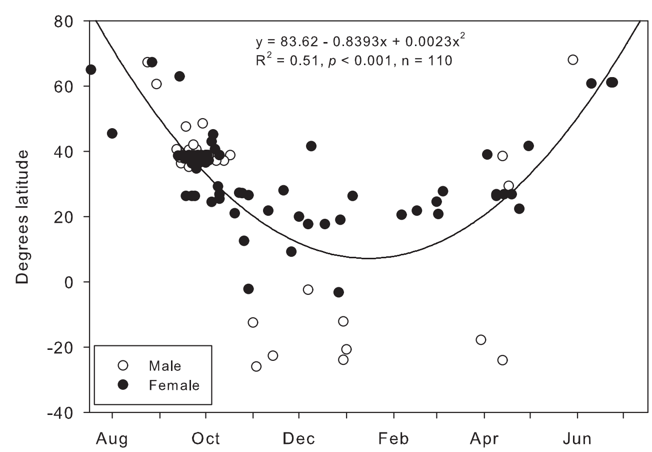

FIG. 3. Encounters outside the study area of Peregrine Falcon nestlings and adults banded in West Greenland, 1972–97, by latitude and date. X-axis labels represent mid-month values.

reports of six individuals that were captured and released twice in either the same or different areas. The mean date of capture along the mid-Atlantic coast for hatch-year peregrines, both males and females, was 9 October, which was similar to dates reported by Ward et al. (1988; 5 October), Ward and Berry (1972; 3–7 October), and Worcester and Ydenberg (2008; 4–6 October). We did not find any difference between sexes in mean passage date between New York and Virginia, a finding similar to that of Ward et al. (1988) at Assateague Island off Maryland and Virginia. However, other studies have reported that males migrated earlier than females (Texas: Hunt et al., 1975; Sweden: Kjellén, 1992; Wisconsin: Mueller et al., 2000). The sample of adults encountered outside the Greenland study area (n = 7) was too small to allow comparisons of migratory timing between juveniles and adults.

Whereas autumn concentrations along the East Coast were impressive, spring was noteworthy for its lack of peregrines (Ward et al., 1988). Our data supported these observations; only one Greenland peregrine was encountered along the East Coast during spring migration (in Massachusetts). In contrast, a well-known spring concentration has existed in southern Texas (Yates et al., 1988), and the majority (6 of 11, or 55%) of encounters of Greenland peregrines during spring migration occurred along the Central Flyway. Moreover, three of 12 foreign recaptures within our study area were birds that originated in southern Texas. A female satellite-tagged in Mexico revealed at least one northern route: she left Mexico, traveled to southern Texas, and then used the Mississippi Flyway before veering east from North Dakota toward West Greenland (McGrady et al., 2002).

The large number of encounters of peregrines banded in Greenland helped reveal the timing of the species' annual cycle and its distribution from the Arctic to South America. Peregrines appeared to depart breeding areas and initiate autumn migration in mid to late September (see also McGrady et al., 2002). They reached the mid-Atlantic coast by early October and arrived at wintering areas by late October. Some crossed the Gulf of Mexico to South America, while others wintered on islands within the Caribbean. Movements of satellite-tagged peregrines from breeding areas at 62˚ N in Canada also reflected similar timing in departure from the breeding areas and arrival at the wintering areas (Franke et al., 2011). Female peregrines from Greenland wintered predominantly near 20˚ N, which was comparable in latitude to a wintering area identified in Mexico by McGrady et al. (2002). Greenland peregrines appeared to begin spring migration in April and had reached 30˚ N by mid-May. Breeding cliffs in Greenland were occupied by late May or early June, which is similar to the timing reported by McGrady et al. (2002) for a peregrine that was satellite-tagged in Mexico and bred elsewhere in Greenland and by Court et al. (1988) for peregrines breeding in northern Canada.

It is clear that banding stations on the eastern and southern coasts of North America, which accounted for more than half of the encounters we reported, have contributed greatly to our understanding of the timing and distribution of peregrine migration. Recoveries and reports of injured peregrines accounted for an additional 29% of encounters. Another 10% (n = 11) of encounters resulted from shooting. Shooting occurred throughout the annual cycle and all along the route from breeding to wintering areas. One peregrine was shot in Greenland, three in the United States, four in the Caribbean, and three in South America. Approximately 1% of the 1896 peregrines we banded in West Greenland were ultimately shot, which was a much lower percentage compared to the persecution directed toward Common Ravens *Corvus corax* (estimated at 9% in Greenland, Restani et al., 2001).

Finally, approximately twice as many peregrine females as males were encountered outside the study area. This pattern held for both live encounters (e.g., captures/releases) and recoveries of dead birds. Our sample of male encounters was large enough to allow us to infer several patterns of movement, which included estimating passage rates along the East Coast of North America and identifying wintering areas well south of those used by females. Much previous information on peregrine migration has been female-biased because of potential sex-biased trapping techniques at banding stations and the technological constraints of early-generation satellite transmitters, which were too heavy for males. Despite the extensive recent use of satellite telemetry, we believe that long-term banding—because of its low cost, limited effect on survival, and capacity to yield large sample sizes—continues to play an important role in studies of peregrine migration (this study), natal dispersal (Restani and Mattox, 2000), and survival (Gould and Fuller, 1995).

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