

CORRELATES OF HUNTING RANGE SIZE IN BREEDING MERLINS¹

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Abstract. I studied variables affecting size of hunting range in breeding Merlins (*Falco columbarius*) from May to July, 1987-1990 in Saskatoon, Canada. Males were monitored during most of the breeding season, whereas females were observed only in the fledging period when they hunt. During the incubation period, the abundance of total prey birds (<100 g) and House Sparrows (*Passer domesticus*, the primary prey) was negatively correlated with hunting range size of males whereas in the nestling period, only total bird abundance was negatively correlated with the hunting range size. Most males changed their range sizes from the incubation to nestling period inversely with changes in prey abundance on their ranges. For females, both body mass and House Sparrow abundance were negatively correlated with hunting range size. I found no significant effect of clutch/brood size and intruder density on hunting range size of Merlins. Similarly, no clear seasonal pattern emerged in the size of hunting ranges of males.

Key words: Merlin; *Falco columbarius*; breeding; radio-tracking; hunting ranges; prey abundance.

INTRODUCTION

Various studies have demonstrated that food abundance as well as intrusion pressure from conspecifics and heterospecifics affect hunting range size in insects (Hart 1987), fish (Dill et al. 1981, Norman and Jones 1984), reptiles (Simon 1975), birds (Village 1982, Temeles 1987), and mammals (Mares and Lacher 1987). Some studies examined the effect of other variables such as season, habitat, age, body mass, and energetic requirements on hunting range size (Schoener and Schoener 1982, Prescott and Middleton 1988, Cave et al. 1989, Adriaenssen and Dhondt 1990, Finck 1990, Grahn 1990, Piper and Wiley 1990, Tidemann 1990). However, the effect of all such variables on hunting range size in a breeding bird has not been examined.

Consequently, I studied the effect of stage of the breeding cycle, prey abundance, intruder density, clutch/brood size, and body mass on hunting range size of breeding Merlins (*Falco columbarius*). I examined the hunting-range variation within an individual in relation to stage of the breeding cycle. For other variables, I examined hunting-range variation among individuals. Breeding Merlins were ideal for this study

because size of their hunting range can be estimated by radio-tracking (Warkentin and Oliphant 1990), and assessment of prey abundance is relatively easy (see Zach and Smith 1981).

METHODS

The research was conducted in Saskatoon, Saskatchewan, Canada (52°07'N, 106°38'W), from May to July, 1987-1990. The study area is described by Sodhi et al. (1992). Merlins first nested in the city in 1963 and increased steadily in number since 1971 (Sodhi et al. 1992). During the study, nesting density of Merlins was higher (19.7-24.6 pairs/100 km²) than recorded elsewhere (Sodhi et al. 1992).

Merlins were captured near their nests using either mist-nets or dho-gaza nets (Clark 1981) and radio-tagged. Detailed methods are reported by Sodhi and Oliphant (1992). Merlins were not followed during the first day of radio-attachment but continuously monitored thereafter during the first and last four daylight hours (i.e., periods of maximum foraging activity; unpubl. data) on fair-weather days. Overall, 768 hours of radio-monitoring was performed.

I radio-tracked 30 Merlins (1987: two males, one female; 1988: five males, one female; 1989: five males, six females; and 1990: six males, four females). Due to transmitter failure, data from two males (1987) and one female (1990) were incomplete and therefore excluded from the analyses. As each male was not followed during

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the entire breeding cycle, this resulted in 12, 14, and five males being monitored during the incubation, nestling, and fledging periods, respectively. Females were followed during the fledging period only, when they began providing food for the young. Each Merlin was tracked (located every 3 min) for a total of 24 hr during the incubation and 16 hr each during the nestling and fledging periods. I adjusted observation days during the nestling and fledging periods so that all monitored Merlins of the same sex were followed when they had chicks of similar age (± 7 days). Nestling ages were estimated following Sodhi (in press).

Hunting ranges were estimated by using the minimum convex polygon method (Mohr 1947), using all plotted locations of each Merlin. Prey abundance on the hunting ranges was estimated by making bird counts on 1-km, randomly selected, transects (except for one female in 1987). I counted all birds, seen or heard, within 90 m on each side of a transect. I sampled all transects only once during a breeding period. Repeat transect surveys (after 7 days) done in June 1990 in six hunting ranges (on six 1-km transects) showed that bird diversity and abundance did not differ significantly (chi-square tests, $P > 0.10$). For males that were observed for more than one breeding period, I repeated the transect counts. Surveys were made within the first four daylight hours during fair weather. In Saskatoon, Merlins feed almost exclusively on birds less than 100 g in weight (Oliphant and McTaggart 1977, Sodhi et al. 1990). I therefore only considered birds in this size class as potential prey. Since predators may adjust their hunting range sizes based only on the abundance of the principal prey (Temeles 1987), I performed two analyses, one with the abundance of all birds (< 100 g) and another with the abundance of House Sparrows (which represented about 65% of the diet by number of breeding Merlins; Oliphant and McTaggart 1977, Sodhi et al. 1990).

To minimize chances of nest desertion (Oliphant 1974), clutch and brood sizes were determined by climbing nest trees during the early nestling period. Clutch sizes were taken as the number of hatched young plus unhatched eggs. As I did not have any information on number of eggs and chicks before the nest investigations, my clutch and brood-size estimates are minimal. The clutch and brood sizes of the studied Merlins ranged from 2–5 and 1–5, respectively.

When a male was monitored for more than one breeding period, it was captured and weighed again during the subsequent breeding period (except for two males). During the incubation and nestling periods, body masses of males ranged from 158 to 195 g, whereas those of females ranged from 228 to 261 g during the fledging period.

Intruder pressure can be derived from two sources, neighbors and non-neighbors (floaters) (Meyers et al. 1979, 1981; Temeles 1987, 1990). As Merlins in the study area were not individually color-marked, it was not possible to determine if the ten agonistic encounters observed between hunting Merlins involved neighbors or floaters. To compute an index of intruder density, I counted the number of active Merlin nests within a 1-km radius of the nest of each radio-tracked Merlin (observed range: 0–4), thus restricting analyses primarily to neighbors. I used active Merlin nests within 1 km of a nest to compute intruder density because preliminary analyses showed that hunting ranges among Merlins nesting more than 1 km from each other did not overlap extensively.

I refer to breeding Merlins hatched outside Saskatoon as immigrants and breeding Merlins hatched within Saskatoon as residents (Newton 1988) (sample sizes of immigrants: incubation = 3, nestling = 4, fledging/male = 1, fledging/females = 8).

As my results were based on directional predictions, I used one-tailed statistical tests. Correlations among hunting range sizes and studied variables (prey abundance, clutch/brood size, intruder density, and body mass) were not calculated for males during the fledging period due to insufficient sample sizes. To assess the relative importance of studied variables in explaining hunting range size variation in Merlins, I used Kendall's partial rank-order correlation analyses (Siegel and Castellan 1988:254–262). I report SE with means.

RESULTS

Nine resident males were radio-tracked for more than one breeding period. Of eight resident males observed for both the incubation and nestling periods, five increased and three decreased their range sizes from the incubation to nestling period (Fig. 1). Four males were radio-tracked both during the nestling and fledging periods; all these

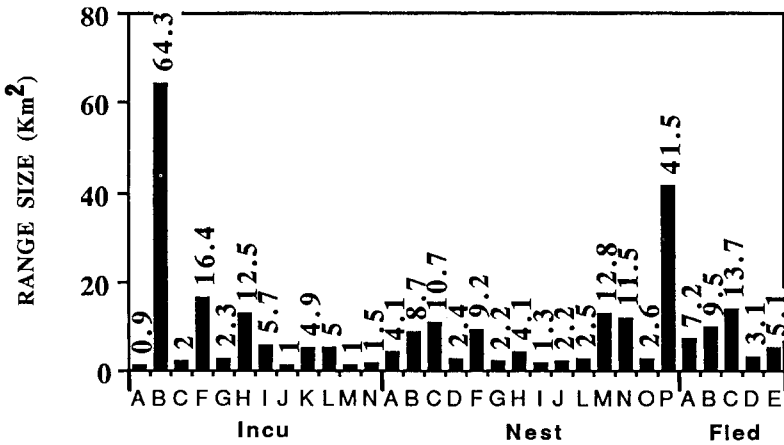


FIGURE 1. Hunting range size of male Merlins during different breeding periods. Letters represent individual males. Note that B, F, H, and P are immigrants. Incu = incubation, Nest = nestling period, Fled = fledging period.

increased their range sizes from the nestling to fledging period (Fig. 1).

Three immigrant males were radio-tracked for more than one breeding period. All decreased hunting range size from incubation to nestling period (Fig. 1). One immigrant male was also radio-tracked during the fledging period; it increased range size from the nestling to fledging period (Fig. 1).

For the following correlations, data from different years were combined because yearly sample sizes were small. During incubation, hunting range size of males was negatively correlated with both House Sparrow abundance ($T = -0.52, n = 12, P = 0.009$) and total bird abundance ($T = -0.43, P = 0.02$). I performed partial correlation analyses to assess the relative importance of other variables (clutch size, intruder density, and male body mass) in determining hunting range sizes. If House Sparrow and total bird abundance had an independent effect on hunting range size of males, I expected these correlations to remain significant when other variables were controlled statistically. Partial correlation analyses revealed that both House Sparrow and total bird abundance significantly correlated with hunting range sizes of males independently of the clutch size, density of Merlin nests, and male body mass (Table 1).

In the nestling period, hunting range size of males was negatively correlated with total bird abundance ($T = -0.47, n = 14, P = 0.01$), but not with House Sparrow abundance ($T = -0.25, P = 0.11$). Total bird abundance significantly correlated with hunting range size of males inde-

pendently of the brood size, density of Merlin nests, and male body mass (Table 1). Correlations between hunting range size and both total bird abundance ($T = -0.41, n = 23, P = 0.003$) and House Sparrow abundance ($T = -0.39, P = 0.006$) were significant from pooled data for the breeding periods (Fig. 2).

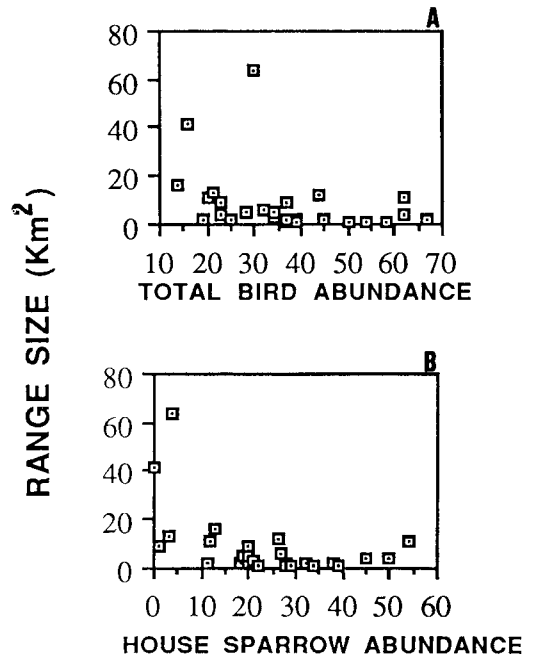


FIGURE 2. Relationship between the hunting range size of male Merlins and prey abundance (A: total bird abundance, and B: House Sparrow abundance). For this figure, data were pooled from the incubation and nestling periods.

TABLE 1. Kendall's partial rank-order correlation analyses to assess the relative importance of different variables in determining hunting range size of Merlins in different breeding periods. The table is based on two-tailed tests (except simple correlations). HRS = hunting range size, HSA = House Sparrow abundance, and TBA = total bird abundance.

Simple correlation	Controlled variable								
	Clutch/brood size			No. of active nests within 1 km			Body mass (g)		
	T	n	P	T	n	P	T	n	P
Incubation									
HRS vs. HSA (-0.52)	-0.56	12	<0.01	-0.53	12	<0.02	-0.57	11	<0.01
HRS vs. TBA (-0.43)	-0.51	12	<0.02	-0.45	12	<0.05	-0.43	11	<0.05
Nestling									
HRS vs. TBA (-0.47)	-0.45	14	<0.02	-0.53	14	<0.01	-0.51	12	<0.01
Fledging*									
HRS vs. HSA (-0.65)	-0.78	11	<0.01	-0.66	11	<0.01	-0.63	11	<0.01

* Data from females; there were too few males to conduct a test.
 Other simple correlations: *Incubation*: HRS vs. clutch size $T = -0.29, n = 12, P = 0.10$; HRS vs. active nests $T = -0.03, n = 12, P = 0.44$; HRS vs. body mass $T = 0.00, n = 11, P = 0.50$. *Nestling*: HRS vs. brood size $T = 0.26, n = 14, P = 0.09$; HRS vs. active nests $T = 0.11, n = 14, P = 0.29$; HRS vs. body mass $T = -0.20, n = 12, P = 0.18$. *Fledging*: HRS vs. brood size $T = 0.37, n = 11, P = 0.06$; HRS vs. active nests $T = 0.21, n = 11, P = 0.18$; HRS vs. all birds $T = -0.34, n = 11, P = 0.08$.

Of 11 males studied both during the incubation and nestling periods, five decreased range size with a concomitant increase in total bird abundance on their ranges (Table 2). Four increased range size from the incubation to nestling period as bird abundance declined in their ranges. The other two males either increased or decreased range size parallel to bird abundance changes in their ranges (Table 2).

For females during the fledging period, two correlations were significant and negative, one between range size and House Sparrow abundance ($T = -0.65, n = 11, P = 0.003$; Fig. 3) and another between range size and body mass ($T = -0.59, P = 0.006$). Partial correlation analyses revealed that both House Sparrow abundance and body mass independently correlated with hunting range size of females (Tables 1 and 3).

DISCUSSION

Both male and female Merlins had smaller ranges in rich prey areas. The majority of males changed their range size from incubation to the nestling period inversely with changes in prey abundance on their ranges. Earlier studies also documented hunting ranges in birds to be smaller in rich prey areas (e.g., the Eurasian Kestrel, *F. tinnunculus*, Village 1982; New Holland Honeyeater, *Phylidonyris novaehollandiae*, McFarland 1986;

Northern Harrier, *Circus cyaneus*, Temeles 1987; Fairy Wrens, *Malurus* spp., Tidemann 1990). However, food abundance did not significantly explain hunting range size variation in the Sanderling, *Calidris alba* (Myers et al. 1979); Rufous-sided Towhee, *Pipilo erythrophthalmus* (Franzblau and Collins 1980); and Willow Flycatcher, *Empidonax traillii* (Prescott and Middleton 1988). Temeles (1987) found that the importance of food abundance in explaining hunting range size variation in the Northern Harrier changed between years. These studies suggest that the importance of food abundance as a determinant of range size

TABLE 2. Potential prey abundance (birds <100 g) recorded on 1-km transects in hunting ranges and range size of male Merlins tracked during both the incubation and nestling periods.

Bird	Incubation		Nestling	
	Birds	Range size (km ²)	Birds	Range size (km ²)
A	58	0.9	23	4.1
B	30	64.3	37	8.7
C	67	2.0	62	10.7
F	14	16.4	23	9.2
G	19	2.3	37	2.2
H	44	12.5	62	4.1
I	32	5.7	39	1.3
J	36	1.0	45	2.2
L	34	5.0	25	2.5
M	54	1.0	21	12.8
N	50	1.5	20	11.5

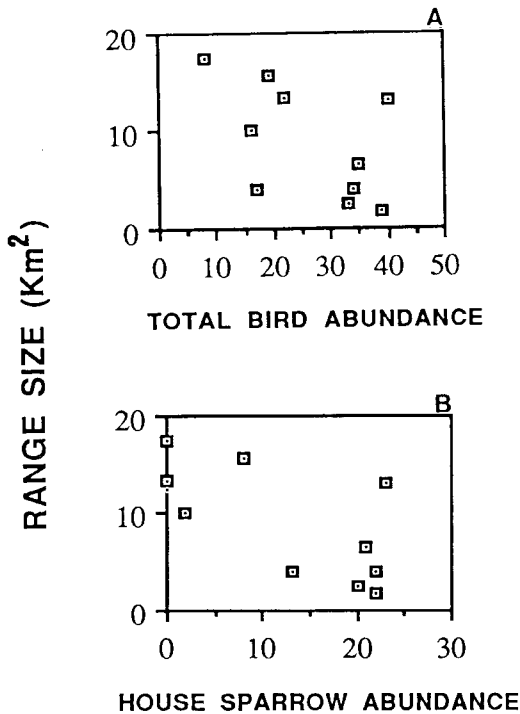


FIGURE 3. Relationship between the hunting range size of female Merlins and prey abundance (A: total bird abundance, and B: House Sparrow abundance).

varies among different species or in the same species between years.

Data on seasonal variation in hunting range size of individual males showed no clear pattern. Some males decreased their range size when food demands at the nest were high (i.e., during the nestling period), suggesting that males track prey abundance on their ranges not food demands at the nest. All males increased their range size from the nestling to fledging period. This may result from intersexual competition as females also hunt during the fledging period. A decline in prey abundance on ranges may also cause this increase in range sizes in the fledging period. However, of five males observed, prey abundance on the range of only one declined from the nestling to fledging period.

Hunting ranges of male Little Owls (*Athene noctua*) decrease in size as the breeding season progresses (Finck 1990). In male Eurasian Sparrowhawks (*Accipiter nisus*), however, hunting ranges are smaller during the pre-laying and incubation periods and increase in size thereafter (Marquiss and Newton 1981). Similarly, hunting

TABLE 3. Kendall's partial rank-order correlation analysis to determine the relative effect of different variables on hunting range size of female Merlins during the fledging period. The table is based on two-tailed tests. HRS = hunting range size and BM = body mass.

Controlled variable	HRS vs. BM (-0.59)		
	T	n	P
Brood size	-0.56	11	<0.02
No. of active nests*	-0.59	11	<0.01
Total bird abundance	-0.64	10	<0.01
House Sparrow abundance	-0.56	10	<0.02

* Within 1 km of a nest.

ranges of breeding Northern Harriers increase in size from incubation to the fledging period (Temeles, pers. comm.). Temporal variation in male hunting range size in different species may also be affected by food contribution by mates and nest and mate guarding requirements (Martindale 1982, Moller 1990).

The number of Merlin nests within a 1-km radius of a Merlin nest did not significantly explain hunting range size variation. This may be because breeding Merlins do not defend hunting ranges for exclusive use (Sodhi and Oliphant 1992) and therefore, neighbors may exert minimum pressure on hunting range sizes of each other (Brown 1964). I also failed to find any significant effect of clutch or brood size on hunting range sizes.

Heavier females had smaller hunting ranges. Smaller ranges may benefit females by: (1) permitting a bird to become familiar with rich food locations (Zach and Falls 1976), (2) saving energy by searching a smaller area for food (Andersson 1978), and (3) allowing them to guard the fledglings more efficiently. Alternatively, heavier females may have had males with higher quality ranges providing relatively more food for the young and, thus, the females may have required smaller areas to obtain food.

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