

NEST DISPERSION, DIET, AND BREEDING SUCCESS OF BLACK KITES (*MILVUS MIGRANS*) IN THE ITALIAN PRE-ALPS

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ABSTRACT.—We studied a population of Black Kites (*Milvus migrans*) from 1992–96 in a 100-km² study area in the Italian pre-Alps around Lake Lugano. Population density increased from 24 territorial pairs per 100 km² in 1992 to 38 in 1996. Nearest neighbor distances were variable, averaging 1288 m for solitary pairs ($N = 24$) and 306 m for colonial ones ($N = 151$). Regular spacing of nest sites was the rule within colonies, but inter-nest distance for solitary breeders increased as new pairs settled in the area. Nests occurred both in trees (58%, $N = 84$) and on cliffs (42%); 23% and 5% ($N = 84$) of the nests were originally built by Common Buzzards (*Buteo buteo*) and Ravens (*Corvus corax*), respectively. Mean laying date was 25 April ($N = 42$), mean clutch size was 2.29 eggs ($N = 42$) and mean number of fledged young was 0.97, 1.11, and 1.78 young per territorial, reproductive, and successful pairs, respectively ($N = 143, 95, 78$). The percentage of successful territorial pairs was 55% ($N = 143$). Diet was dominated by fish and birds, which accounted for 62% and 28% of 307 identified prey items, respectively. Compared with other European populations, this population showed an intermediate density and an average clutch size but the lowest fledging and breeding success ever recorded for the species. Reasons for the low success were unclear, but may have been related to low food availability or water pollution and consequent pesticide contamination.

KEY WORDS: Black Kite, *Milvus migrans*; coloniality; density; diet; breeding success; Italy.

Dispersión de nidos, dieta, y éxito reproductivo de *Milvus migrans* en los pre-Alpes Italianos

RESUMEN.—Estudiamos una población de *Milvus migrans* desde 1992–96 en un área de 100 kms en los pre-Alpes italianos alrededor del Lago Lugano. La densidad poblacional aumentó de 24 parejas territoriales por 100 kms en 1992 a 38 en 1996. La distancia mas próxima entre vecinos fué variable y promedió 1288 m entre parejas solitarias ($N = 24$) y 306 m entre las parejas coloniales ($N = 151$). Los espacios regulares de los nidos fueron la regla entre las colonias, pero la distancia entre nidos para los reproductores solitarios se incrementó a medida que se asentaron nuevas parejas en el área. Los nidos se encontraron tanto en árboles (58%, $N = 84$) como en riscos (42%), 23% y 5% ($N = 84$) de los nidos fueron originalmente construidos por *Buteo buteo* y *Corvus corax*, respectivamente. La media del día de la puesta fué el 25 de abril ($N = 42$). La media del tamaño de la nidada fué 2.29 huevos ($N = 42$) y la productividad media fué 0.97, 1.11, y 1.78 juveniles por territorio. Las parejas productivas territorialmente exitosas representaron el 55% ($N = 53$). La dieta fue principalmente dominada por peces y aves (62% y 28% respectivamente) de los 307 items de presas identificadas. Al comparar con otras poblaciones europeas, estas poblaciones mostraron una densidad intermedia y una nidada promedio, pero al mismo tiempo el mas bajo éxito reproductivo y reclutamiento registrado para la especie. Las causas de esto, son poco claras y pudieron estar relacionadas con la poca disponibilidad de comida o con la polución del agua y la consecuente contaminación por pesticidas.

[Traducción de César Márquez]

The Black Kite (*Milvus migrans*) is a medium-sized accipitrid that is distributed throughout the Old World and Australasia. It has been defined as an adaptable and opportunistic feeder (Geroudet 1965, Delibes 1975, Arroyo 1978, Jones and Maney

1990) and as one of the most numerous and successful birds of prey in the world (Brown and Amadon 1968). Despite its local abundance, the Black Kite was recently classified as a declining and vulnerable species in Europe (Viñuela and Sunyer

1994). Although populations were reported to be stable or increasing in western Europe between 1970–90 (e.g., Bustamante and Hiraldo 1993, Doumeret 1995), pronounced decreases have been observed in Portugal, eastern Europe, and Russia during the same period (Viñuela and Sunyer 1994, Bijlsma 1997). Recently, recorded cases of pesticide contamination (Hernandez et al. 1986, Jenni-Eiermann et al. 1996), nest robbing (García Ferré and de Juan 1983) and water pollution (e.g., Ceschi et al. 1996) in the species' core distribution areas point to an urgent need for quantitative monitoring of breeding populations (Viñuela and Sunyer 1994).

In Italy, both local population increases and declines have been reported (Petretti 1992, De Giacomo et al. 1993), but information is fragmentary and mainly nonquantitative (Viñuela and Sunyer 1994). During the 20th century, the species declined dramatically in the Po Plain. For example, one colony in Bosco Fontana, near the city of Mantova, declined from over 100 pairs in the 1930s (Arrigoni degli Oddi and Moltoni 1931) to <10 pairs in the 1970s (Micheli 1990). The largest Italian populations are currently concentrated in the pre-Alps (Micheli 1990). No quantitative estimates of density, diet or productivity have been published for these populations.

In this paper, we report the results of a 5-yr study on a Black Kite population in a pre-Alpine area of northern Italy. The aim of the research was to provide quantitative data on Black Kite density, nest dispersion, colony size, diet and productivity, and to compare them with estimates from other populations.

STUDY AREA

The study area was a 100-km² plot located along the Italian coast of Lake Lugano. It included two pre-Alpine valleys: the Ceresio Valley along the lake and the Ganna Valley further inland from the lake. Altitude ranged from 275–1125 m. The landscape was characterized by pre-Alpine mountains, mainly of sedimentary origin, ranging from 526–1125 m in peak elevation. Mountain slopes were covered by continuous deciduous woodland which accounted for 77% of the study area and was locally interrupted by a few open areas. These open areas resulted from human activities (regular burning or sheep grazing) and were covered by dry grassland, ferns, or various bushes, mainly common hazel (*Corylus avellana*). Dominant tree species included sweet chestnut (*Castanea sativa*), downy oak (*Quercus pubescens*), sessile oak (*Quercus petraea*), European hop-hornbeam (*Ostrya carpinifolia*), and locust (*Robinia pseudoacacia*). Forests were managed for timber production by stool shoot regeneration (cop-

pice system, Matthews 1989) on a 20–30 yr rotation basis. Single mature trees are often kept into the next rotation as seed bearers (coppice with standards system, Matthews 1989). Thus, even though single mature trees were present almost everywhere, most woodlots had been thinned or clearfelled in recent times (<40 yr), resulting in a homogeneous cover of second growth forest. Following the recent decline in coppice management throughout Europe (Matthews 1989), some woodlots were being converted to mature forest; nevertheless, mature woodland was confined to a few steep and often inaccessible slopes.

Cultivated fields, mainly grassland and maize (*Zea mays*) fields, were located on the valley floors and accounted for 3% of the land. Sixteen small villages, all confined to the valley floors, covered 13% of the study area. Thus, except for forestry operations, human activities were mainly confined to lowland and were virtually absent from the mountain slopes. The Lake Lugano water surface accounted for 6% of the study area which also included two smaller lakes (17 and 25 ha); overall, aquatic habitat covered 7% of the study area.

Climate was temperate continental, with wet springs and dry summers (Pinna 1978). Annual rainfall ranged from 1600–2100 mm, with two peaks, one in the spring and one in the autumn, and the former more pronounced than the latter (Belloni 1975).

METHODS

We censused Black Kite nests from 1992–96. The earliest territorial individuals were observed in the study area on 18 March. As soon as kites settled on their breeding territories, they started to perch in highly prominent positions, refurbish nests and carry out conspicuous aerial displays to signal territory ownership or to attract a mate (Viñuela 1993). Nests were censused by progressive, complete searches as new pairs arrived from migration and settled on territories. No pairs settled on territories after the middle of April, when some pairs were already laying eggs. All nests were found during the pre-incubation period, by watching the resident pair's territorial displays and nest material transfers. This also allowed us to census the nonbreeding sector of the territorial population (i.e., pairs that failed to lay eggs).

Nest dispersion was analyzed by means of the G-statistic (Brown 1975), calculated as the ratio of the geometric to the arithmetic mean of the squared nearest neighbor distances (NNDs). Values ranged from 0–1 with values ranging from 0.65–1.00 indicating a regular dispersion of nest sites (Brown 1975). Pairs were defined as solitary when they nested >700 m from their nearest neighbor. However, five nests belonging to two territories were defined as solitary despite having a NND <700 m. These were located on opposite sides of a mountain and the birds could not see their nearest neighbor while in their nest area; also, they were not seen to interact with the neighboring pairs during each of three 1-hr observation sessions during the pre-laying period (see Brown and Brown 1996). Apart from these five cases, all pairs <700 m from their nearest neighbor were defined as colonial, and all interacted regularly with their neighbors, mostly through contests caused by territorial intrusions.

Whenever possible, nest contents were checked three times: first during incubation to assess clutch size, second

Table 1. Density and extent of coloniality in a Black Kite population in the Italian pre-Alps between 1992–96.

VARIABLE	1992	1993	1994	1995	1996
No. of territorial pairs	27	33	35	39	41
Territorial pairs/100 km ²	24	30	32	36	38
No. of colonial pairs (%)	26 (96)	29 (88)	28 (80)	35 (90)	33 (80)
No. of colonies	6	6	6	7	5

just after hatching to estimate hatching success, brood size, and date of hatching, and third, when the nestlings were 40–45 d old to record the number of young raised (nestlings fledge at about 48 d old, Bustamante and Hiraldo 1993). We checked nest contents by climbing the nest tree, going down the nesting cliff with a rope or simply watching the nest cup from a distant vantage point with binoculars or a 20–60× telescope. To minimize disturbance, risk of desertion or nest predation by Ravens (*Corvus corax*), only nests that could be checked very rapidly were visited during incubation or early hatching. Thus, clutch size, laying date and number of laying pairs were assessed from a subsample of nests. Hatching date was calculated by backdating from the feather development of nestlings first observed when <15 d old and by comparison to reference information in Richard (1934), Cramp and Simmons (1980) and Hiraldo et al. (1990). Laying date was estimated by subtracting 29 d, the average incubation period (Viñuela 1993), from hatching date. Additional data were collected from a loose colony of three pairs 3 km from the border of the study area.

We collected prey remains found under nests during each nest visit and identified them to the genus or species level assuming the smallest possible number of individuals. Fish scales were identified following Steinmetz and Müller (1939) and Baliglinière and Le Louarn (1987); other vertebrate remains were identified by comparison to a reference collection.

Terminology followed Steenhof (1987) with a reproductive pair being one which laid eggs, a successful pair being one which raised at least one young until it was 40 d old and breeding success being the percentage of successful territorial pairs. Raptors generally nest in traditional nest areas year after year (Newton 1979); a nest area was defined as an area where more than one nest was found in the same or in different years, but where only one pair nested each year.

Stepwise logistic regression analysis (Norusis 1993) was employed to analyze among year differences in the probability of territorial pairs laying eggs and of eggs hatching. Logistic regression uses a linear combination of independent variables to explain the variance of a dependent dichotomous variable. To meet the assumptions of normality, NNDs were always log transformed prior to parametric tests. Means are given with ± 1 SE. All tests were two-tailed and statistical significance was set at $P < 0.05$.

RESULTS

Density and Nest Dispersion. The number of territorial pairs increased steadily from 27 in 1992 to

41 in 1996. Density correspondingly increased from 24 to 38 territorial pairs per 100 km² (Table 1). The loose colony outside the study area contained 3 pair in each of the five study years. The number of nest areas censused was 48. Of these, six were always occupied by solitary pairs, 37 by colonial pairs and five by pairs that switched from colonial to solitary nesting ($N = 3$), or *vice versa* ($N = 2$), during the study period. Territorial behavior was intense within 50–200 m of nests but was rarely observed at foraging areas.

The number of colonies censused was stable and ranged from five to seven. Colonies contained on average 5.0 nests (± 0.6 , $N = 30$). The percentage of colonial pairs ranged from 80–96% (Table 1). In particular, the number of pairs in large colonies (>5 pair) did not increase significantly through the years ($\chi^2 = 2.12$, $df = 4$, $P = 0.710$). Instead, the number of pairs in small colonies (≤ 4 pair) progressively decreased ($\chi^2 = 9.76$, $df = 4$, $P = 0.040$), except in 1995 (Fig. 1) when a new two-pair colony was created by settlement by a new pair near a previously solitary pair. The percentage of solitary pairs did not increase significantly over time ($\chi^2 = 4.92$, $df = 4$, $P = 0.301$, Fig. 1).

Mean NND was 306 m for colonial pairs (± 13.7 , $N = 151$) and 1288 m for solitary pairs (± 166 , $N = 24$). NNDs ranged from 60–690 m for colonial pairs and from 450–4250 m for solitary pairs. Mean NND of solitary pairs did not increase through the years (Kruskal-Wallis $\chi^2 = 1.95$, $df = 3$, $P = 0.583$, Table 2). For three large colonies (A, B, and C, Table 2), we tested the effect of year and colony on nest spacing by means of a two-way ANOVA: the interaction of year and colony was almost significant (partial $F_{8,98} = 1.86$, $P = 0.076$) and both year and colony significantly affected mean NND independently (respectively: partial $F_{4,98} = 11.01$, $P = 0.000$; partial $F_{2,98} = 20.78$, $P = 0.000$). Variation in NND within colonies among years was mainly caused by the progressive increase in territorial pairs in two colonies around the lake. New pairs

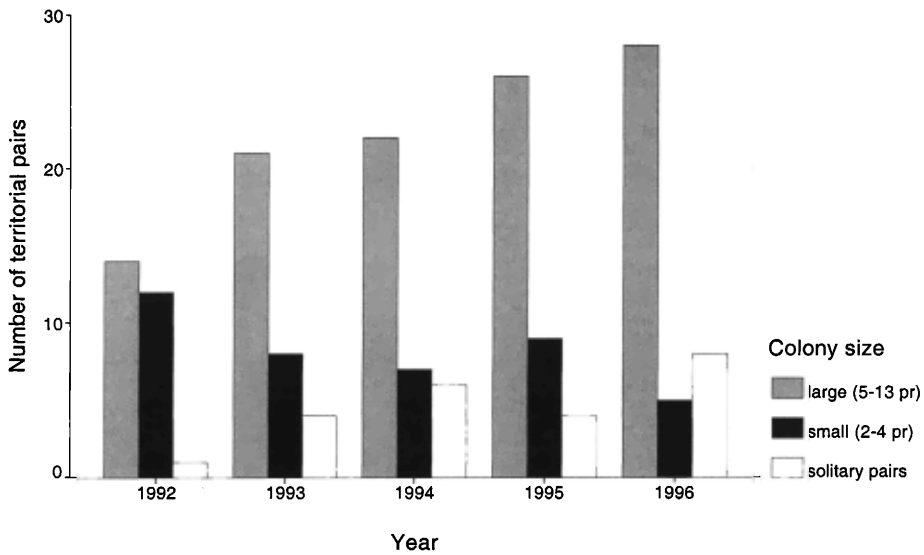


Figure 1. Number of Black Kite pairs breeding solitarily or in small (≤ 4 pairs) and large (≥ 5 pairs) colonies between 1992–96 in the Italian pre-Alps.

Table 2. Mean (\pm SE) Black Kite nearest neighbor distances for 24 solitary pairs and at seven colonies in the Italian pre-Alps between 1992–96.

NEST TYPE	MEAN NEAREST NEIGHBOR DISTANCE (m)					
	1992	1993	1994	1995	1996	1992–96
Solitary		934 \pm 161 (4) ^a 0.82 ^b	1203 \pm 199 (7) ^a 0.72 ^b	1304 \pm 332 (4) ^a 0.68 ^b	1508 \pm 437 (8) ^a 0.38 ^b	1288 \pm 166 (24) ^a 0.54 ^b
Colony A	394 \pm 40 (7) ^a 0.88 ^b	373 \pm 64 (8) ^a 0.67 ^b	288 \pm 49 (9) ^a 0.64 ^b	252 \pm 28 (12) ^a 0.79 ^b	241 \pm 33 (13) ^a 0.68 ^b	295 \pm 20 (49) ^a 0.67 ^b
Colony B	292 \pm 12 (7) ^a 0.96 ^b	169 \pm 24 (8) ^a 0.67 ^b	(7) ^a 0.89 ^b	167 \pm 15 (9) ^a 0.87 ^b	150 \pm 25 (8) ^a 0.67 ^b	183 \pm 10 (39) ^a 0.78 ^b
Colony C	679 \pm 24 (3) ^a 0.10 ^b	355 \pm 51 (5) ^a 0.85 ^b	290 \pm 23 (5) ^a 0.95 ^b	237 \pm 44 (5) ^a 0.75 ^b	174 \pm 23 (7) ^a 0.83 ^b	307 \pm 34 (25) ^a 0.59 ^b
Colony D	597 \pm 27 (3) ^a 0.99 ^b	597 \pm 27 (3) ^a 0.99 ^b	567 \pm 37 (3) ^a 0.98 ^b	567 \pm 37 (3) ^a 0.98 ^b	433 \pm 123 (3) ^a 0.74 ^b	552 \pm 29 (15) ^a 0.92 ^b
Colony E	401 \pm 3 (3) ^a 0.10 ^b	317 \pm 45 (3) ^a 0.93 ^b	640 \pm 0 (2) ^a	640 \pm 0 (2) ^a	640 \pm 0 (2) ^a	500 \pm 44 (12) ^a 0.83 ^b
Colony F	213 \pm 10 (3) ^a 0.99 ^b	206 \pm 0 (2) ^a	206 \pm 0 (2) ^a	206 \pm 0 (2) ^a		208 \pm 3 (9) ^a 0.99 ^b
Colony G				403 \pm 0 (2)		403 \pm 0 (2)
All nests	430 \pm 58 (27) ^a	394 \pm 48 (33) ^a	492 \pm 75 (35) ^a	388 \pm 63 (39) ^a	493 \pm 115 (41) ^a	441 \pm 36 (175) ^a

^a Sample size.

^b G statistic.

settling in these colonies did not place their nests in the outer parts of colonies or far away from traditional pairs, but selected areas near already-occupied nests. Thus, mean within-colony NND decreased as the number of pairs in the colonies increased though the years (colony A: $F_{4,44} = 2.64$, $P = 0.046$; colony C: $F_{4,20} = 11.29$, $P = 0.000$, Table 2). Mean NND did not vary significantly with time in colony C, where the number of pairs remained stable through the years ($F_{4,34} = 2.07$, $P = 0.106$). Due to this, NNDs are shown separately for each colony in Table 2.

The G-statistic declined progressively for solitary pairs through the years, indicating a regular dispersion of nest sites between 1993–95, but not in 1996 (Table 2). Pooling years, the overall dispersion of solitary nests was not regular ($G = 0.540$), probably because of the progressive increase in the mean NND of solitary nesters over time. Instead, the G-statistic indicated a regular dispersion of nest sites within 22 of 23 colonies with ≥ 3 pairs.

Nest Sites. All territorial pairs built nests ($N = 175$ pairs in 48 nest areas). After settling on territories, most pairs brought nest material to one nest, but 13 pairs in six nest areas brought material to two nests during the beginning of the pre-laying period, before selecting the nest in which they eventually laid eggs. Altitude of the nest sites ranged from 240–870 m, averaging 515 m (± 14 , $N = 175$). The 175 censused territorial nestings took

place in 84 different nest structures, each one occupied for one to five consecutive years ($\bar{x} = 2.1 \pm 0.1$, $N = 84$).

Of these nests, 58% were placed in trees while the remainder were on cliffs ($N = 84$). Of 49 tree nests, 39% were in sweet chestnut, 33% in sessile or downy oak, 18% in locust, 6% in European hop-hornbeam, 2% in common lime (*Tilia europaea*), and 2% in Scotch pine (*Pinus silvestris*) trees. The 35 cliff nests were placed on bare rock ledges (29%) and at the base (54%) or in the canopy (17%) of trees, generally downy oaks, growing on cliff faces. Many pairs used nest structures originally built by other species, to which they added new material: 23% of 84 occupied nest structures were originally built by Common Buzzards (*Buteo buteo*) and 5% were old Raven nests. Some nests were being used by the original occupants when they were taken over by Black Kites. Buzzard nests were taken over during the original owners' pre-laying period and one Raven nest still contained nestlings when it was occupied by kites, which preyed on the chicks before starting to add new material to the nest.

Breeding Season. There were no year-to-year differences in mean laying date ($F_{4,40} = 0.68$, $P = 0.762$, Table 3). Laying dates ranged from 12 April–8 May, averaging 25 April (Table 3). No cases of replacement clutches in the same nest were observed after breeding failures, even when these

Table 3. Mean (\pm SE) laying date and productivity estimates of an Italian pre-Alpine Black Kite population between 1992–96.

VARIABLE	1992	1993	1994	1995	1996	1992–96
Laying date in April	24.6 \pm 1 (7) ^a	23.3 \pm 2 (7) ^a	25.5 \pm 2 (8) ^a	28.7 \pm 3 (9) ^a	25.3 \pm 2 (14) ^a	25.6 \pm 1 (45) ^a
Territorial pairs ^b	17	31	31	33	31	143
% reproductive	100 (17) ^a	76 (21) ^a	86 (22) ^a	86 (21) ^a	74 (19) ^a	84 (100) ^a
Pairs (N)	2.5 \pm 0.2	2.5 \pm 0.2	1.8 \pm 0.3	1.8 \pm 0.4	2.6 \pm 0.2	2.3 \pm 0.1 (42) ^a
Clutch size (N)	(10) ^a	(11) ^a	(8) ^a	(5) ^a	(8) ^a	
% hatching success	68 (25) ^c	89 (27) ^c	79 (14) ^c	89 (9) ^c	100 (21) ^c	84 (96) ^c
% successful pairs	71	58	48	42	61	55
Young fledged per territorial pair	1.06 \pm 0.2	1.16 \pm 0.2	0.71 \pm 0.2	0.67 \pm 0.2	1.32 \pm 0.2	0.97 \pm 0.1
Young fledged per reproductive pair	1.00 \pm 0.2	1.24 \pm 0.2	0.86 \pm 0.2	0.76 \pm 0.2	1.72 \pm 0.3 (18) ^a	1.11 \pm 0.1 (97) ^a
	(16) ^a	(21) ^a	(21) ^a	(21) ^a		
Young fledged per successful pair	1.50 \pm 0.2	2.00 \pm 0.2	1.47 \pm 0.2	1.57 \pm 0.2	2.16 \pm 0.2 (19) ^a	1.78 \pm 0.1 (78) ^a
	(12) ^a	(18) ^a	(15) ^a	(14) ^a		

^a Sample size (when different from that in column "territorial pairs").

^b Those checked for nesting success.

^c Number of eggs. Sample size of nests same as for clutch size.

Table 4. Diet of breeding Black Kites in the Italian pre-Alps (1992–97), as estimated by food remains collected under nests.

PREY CATEGORY	NUMBER OF ITEMS (%)
Fishes	190 (61.9)
Rudd (<i>Scardinius erythrophthalmus</i>)	59 (19)
Chub (<i>Leuciscus cephalus</i>)	56 (18)
Unidentified Ciprinidae	37 (12)
Others ^a	38 (12)
Birds	85 (27.7)
Blackbird (<i>Turdus merula</i>)	20 (7)
Others ^b	65 (21)
Unidentified Passeriformes	20 (7)
Mammals	24 (7.8)
Unidentified Microtidae	15 (5)
Others ^c	9 (3)
Reptiles ^d	5 (1.5)
Amphibians ^e	1 (0.3)
Invertebrates ^f	2 (0.7)
Total	307

^a Includes: perch (*Perca fluviatilis*, $N = 13$), bleak (*Alburnus albidus alborella*, $N = 11$), roach (*Rutilus rutilus*, $N = 8$), pumpkinseed (*Lepomis gibbosus*, $N = 4$), large-mouth black bass (*Micropterus salmoides*, $N = 2$).

^b Includes: Rock Dove (*Columba livia*, $N = 11$), Starling (*Sturnus vulgaris*, $N = 6$), Jay (*Garrulus glandarius*, $N = 5$), Italian Sparrow (*Passer domesticus italiae*, $N = 4$), Black Kite nestling ($N = 2$), Honey Buzzard nestling (*Pernis apivorus*, $N = 2$), Tawny Owl (*Strix aluco*, $N = 2$), Hooded Crow (*Corvus corone cornix*, $N = 2$), Song Thrush (*Turdus philomelos*, $N = 2$), Moorhen (*Gallinula chloropus*, $N = 1$), Collared Dove (*Streptopelia decacto*, $N = 1$), Barn Swallow (*Hirundo rustica*, $N = 1$), House Martin (*Delichon urbica*, $N = 1$), Chaffinch (*Fringilla coelebs*, $N = 1$), Great Tit (*Parus major*, $N = 1$), Reed Bunting (*Emberiza schoeniclus*, $N = 1$).

^c Includes: dormouse (*Myoxus gliis*, $N = 3$), common mole (*Talpa europaea*, $N = 3$), rabbit (*Oryctolagus cuniculus*, $N = 2$), unidentified mammal from slaughterhouse ($N = 1$).

^d Includes: Aesculapian snake (*Elaphe longissima*, $N = 2$), unidentified Colubridae ($N = 3$).

^e Includes: *Rana* spp. ($N = 1$).

^f Includes: *Cetonia* spp. ($N = 2$).

happened early in incubation. All nestlings fledged by 15 July and all Black Kites departed the study area by 10 August each year.

Productivity. Each year, 74–100% of territorial pairs laid eggs (Table 3), with no clear trend over time. Year did not enter a stepwise logistic regression model with laying or nonlaying of eggs as a dependent variable. The overall mean number of laid eggs ($\bar{x} = 2.3$, $N = 42$) varied significantly among years ($F_{4,37} = 2.75$, $P = 0.043$) and was significantly lower in 1994 than in 1992, 1993, and 1995 (Duncan's Multiple Range Test, $P < 0.05$, Ta-

ble 3). On the whole, 84% of 96 eggs checked hatched. Stepwise logistic regression analysis showed a significant effect of year on probability of egg hatching ($B = 0.65$, Wald = 5.88, $df = 1$, $P = 0.015$, reclassification rate = 84%).

The number of young fledged per territorial pair averaged 0.97 ($N = 143$) and differed significantly among years ($F_{4,138} = 2.49$, $P = 0.045$). Productivity was significantly higher in 1996 than in 1994 and 1995 (Duncan's Multiple Range Test, $P < 0.05$, Table 3). Significant among-year differences also were detected for mean number of fledged young per reproductive pair ($F_{4,92} = 2.68$, $P = 0.036$). Again, average values were significantly higher in 1996 than in 1994 and 1995 (Duncan's Multiple Range Test, $P < 0.05$, Table 3). Mean number of fledged young per successful pair was 1.78 ($N = 78$) and also varied among years ($F_{4,73} = 3.69$, $P = 0.009$), with more young fledged on average in 1996 than in 1992, 1994, and 1995 and in 1993 than in 1994 (Duncan's Multiple Range Test, $P < 0.05$, Table 3). Finally, the percentage of successful territorial pairs in the population ranged from 42% in 1995 to 71% in 1992, with no significant among-year differences ($\chi^2 = 4.98$, $df = 4$, $P = 0.301$, Table 3).

Sample size allowed us to test the effect of year and colony on mean number of fledged young in three colonies (A, B, and C) by means of a two-way ANOVA. The effect of the interaction between year and colony on mean number of young fledged per territorial pair was significant (partial $F_{8,83} = 3.01$, $P = 0.005$), but only approached significance when using mean number of fledged young per reproductive pair or per successful pair as the dependent variable (respectively: partial $F_{8,66} = 1.80$, $P = 0.092$; partial $F_{6,42} = 1.96$, $P = 0.093$). In these two cases, colony was the only significant main effect (respectively: partial $F_{2,66} = 3.32$, $P = 0.042$; partial $F_{2,42} = 3.54$, $P = 0.038$). These patterns were mainly caused by the productivity of colony C, where fledging success remained similar to that in other colonies until 1995, when no young were raised in any of the eight nests checked. In 1996, only one young was raised in seven nests checked in colony C. The reason for such a dramatic decline in productivity was not clear.

Overall, causes of breeding failure were seldom identified: 89% of failures occurred during incubation ($N = 19$) and the rest occurred during the early part of the fledging period. Probable causes of failure included: failed hatching of eggs and

Table 5. Nesting density of Black Kite populations in Europe, 1966–96.

AREA (PERIOD)	HABITAT	(N)	DENSITY (pr/100km ²)	NEAREST NEIGHBOR DISTANCE (N)	REFERENCE
Matas Gordas, Spain (1987–89)	Grassland and marshland	21–45	700–1500		Viñuela et al. 1994
Rhône Plain, France (1970)	River plain	140	609		Sermet 1980
Doñana, Spain (1981–84)	Marshland	80	266.6	206 (47) ^a	Hiraldo et al. 1990
Lac Lemán, Switzerland (1975–90)	Farmland and lake	319	100.6		Henrioux and Henrioux 1995
Neuchâtel, Switzerland (1968)	Farmland and lake	337	69.6		Sermet 1980
Lorraine, France (1966)	Woodland and pas- ture	66	44.6		Thiollay 1967
Lake Lugano, Italy (1992– 96)	Woodland and lake	27–41	24–38	441 (175)	This study
Castelporziano, Italy (1991– 92)	Woodland and farmland	16	33.3	103 (16)	De Giacomo et al. 1993
Lake Constance, Germany (1968–69)	Farmland and lake	25–30	18.5–22.2		Heckenroth 1970
Limousin, France (1976– 78)	Bocage ^b	21	9.5		Nore 1979
Drömling, Germany (1993– 94)	Farmland	8	7.02	2330 (8) ^c	Seelig et al. 1996
Monti della Tolfa, Italy (1973–80)	Woodland and pas- ture	42	4.9		Petretti and Petretti 1981
Brandenburg, Germany (1979)	Farmland	215	0.74		Fiuczynski 1981

^a Estimate from Bustamante and Hiraldo (1990), for the period 1985–88.

^b Pasture and woodland enclosed by stone walls or hedges.

^c Calculated from the published map.

consequent desertion (three cases), predation (two cases) and disturbance by rock climbers (one case).

Diet. Fish and birds dominated the diet and accounted for 61.9% and 27.7% of 307 identified prey items, respectively (Table 4). Mean length of 15 fish found uneaten in nests was 18.6 cm (± 1.8 , range = 7–30 cm). Of 54 avian prey items, 26% were juveniles.

DISCUSSION

The number of territorial pairs of Black Kites increased steadily during our study. It is difficult to say whether this was caused by a real population increase or a simple population fluctuation. Spatial and temporal variations in Black Kite population density and productivity have been reported by many authors (Fiuczynski and Wendland 1968, Viñuela et al. 1994, Doumeret 1995, Bijlsma 1997).

Results of the analyses on NND and fledging success in the three large colonies showed that each colony could be considered a separate unit within the population. Each colony was characterized by its own nest spacing distance, which tended to be regular, but which differed from that of other colonies and sometimes varied from one year to the next. Similarly, productivity varied among colonies within and among years within each colony. These results emphasized the importance of monitoring populations composed of more than just one colony for as many years as possible to obtain an unbiased estimate of density, nest dispersion, and productivity. To date, many studies on Black Kites have been conducted in just one colony or in areas of homogeneous high density that are functionally similar to one large colony (e.g., Desai and Malhotra 1979, Koga et al. 1989, Viñuela et al. 1994).

Overall, the population showed remarkable op-

Table 6. Productivity of Black Kite populations in Europa and Asia, 1966–96.

AREA (PERIOD)	HABITAT	N	HATCHING		
			CLUTCH SIZE	SUCCESS ^a (EGGS)	BREEDING SUCCESS
Doñana, Spain (1987–89)	Marshland	166			92%
Germany (1992–95)		599			79%
Nagasaki, Japan (1983–86)	Fishing port	32	2.18 (28) ^b	79% (61) ^b	75%
Limousin, France (1976–78)	Bocage ^d	22			68%
Berlin, Germany (1940–79)	Farmland	215			62%
Lake Lugano, Italy (1992–96)	Woodland and lake	143	2.29 (42) ^b	84% (96) ^b	55%
Slovakia (1975–89)		162	2.98 (44) ^b		
Lac Lemán, Switzerland (1975–90)	Farmland and lake	165	2.25		
Lorraine, France (1966)	Woodland and pasture	66	2.26 (45) ^b		
New Delhi, India (1973–76)	Urban	45	2.3 (60) ^b	55% (102) ^b	

^a Data on hatching success not shown in table: 75% ($N = 36$ eggs from 14 nests, Hakel, Germany, 1957; Stubbe 1961) and 64% ($N = 28$ eggs from 10 nests, Mazio, Italy, date unknown; Petretti 1992).

^b Sample size (when different from that in column "N").

^c Data also from Mammen and Stubbe (1995, 1996).

^d Pasture and woodland enclosed by stone walls or hedges.

portunism and elasticity. First, variability in the extent of coloniality between and within years was paralleled by high flexibility in NNDs, the highest observed NND being 70 times greater than the lowest one. Interestingly, as the population increased over the years, new pairs settling in large colonies positioned their nests near existing pairs, possibly as a result of conspecific attraction (Stamps 1988), as was also reported by Viñuela et al. (1994). Advantages of nesting near traditional older pairs (Viñuela 1993) could include local enhancement (Hagan and Walters 1990), information parasitism (e.g., Green 1987) and greater opportunities for kleptoparasitism (Viñuela et al. 1994). The opposite trend was recorded for solitary pairs whose NNDs increased as new pairs colonized the area, suggesting pronounced overall variations in individual pairs nest dispersion, probably in relation to food distribution (Newton 1979, Viñuela et al. 1994).

Second, Black Kite nests were found in a variety of situations: in mature and young trees, within large forests, in small clumps of two or three trees, in isolated trees and on large (>100 m high) and small (<20 m high) cliffs. Nests originally built by other species, especially Common Buzzards, also were occupied readily and taken over by persistent harassment of the original occupants. Cliff nesting,

which is very common all over the Italian pre-Alps, is very rare elsewhere in the Black Kite's range (Cramp and Simmons 1980) and only locally reported in Sicily (Massa 1985), in an area of central Spain (Blanco 1997) and near some Swiss lakes (Sermet 1980).

Finally, diet was dominated by fish and birds on a numeric basis. However, all vertebrate classes and some occasional invertebrate prey were also represented. This finding agreed with the common definition of Black Kites as opportunistic feeders with local specialization in the most available prey (Delibes 1975, Arroyo 1978, Viñuela and Veiga 1992, Blanco 1997).

Despite the overall opportunism and adaptability, productivity estimates for our study population were remarkably low when compared to other published estimates in Europe, Japan and India (Table 5). Nesting densities across Europe were highest near large wetlands and intermediate or very low in farmed or extensive livestock rearing landscapes. Preference for proximity to large wetlands and higher densities near water bodies have been reported by many authors (Heckenroth 1970, Delibes 1975, Hiraldo et al. 1990, Henrioux and Henrioux 1995). Density in the Italian pre-Alpine area was much lower than that of populations near large wetlands (Sermet 1980, Hiraldo et al. 1990,

Table 6. Extended.

MEAN NUMBER OF FLEDGED YOUNG			
TERRITORIAL PAIR	BREEDING PAIR	SUCCESSFUL PAIR	REFERENCE
1.77		1.92 (153) ^b	Jones and Manez 1990
1.63		2.07 (471) ^b	Gedeon 1994 ^c
1 00	1.14 (28) ^b	1.33 (24) ^b	Koga et al. 1989
	1.32	1.93 (15) ^b	Nore 1979
1 20		1.90 (133) ^b	Fiuczynski 1981
0.97	1.1 (95) ^b	1.78 (78) ^b	This study
	2.31		Danko 1989
	2.02		Henrioux and Henrioux 1995
1.32	1.58 (55) ^b		Thiollay 1967
0 98			Desai and Malhotra 1979

Viñuela et al. 1994, Henrioux and Henrioux 1995). It was similar to that along Lake Constance in the 1960s and in low intensity farmland with scattered wetlands (Heckenroth 1970, Thiollay 1967, Seelig et al. 1996), but higher than that in farmed or pasture habitats with few wetlands (Nore 1979, Fiuczynski 1981, Petretti and Petretti 1981). Thus, the observed density was intermediate, but low, compared with other populations near large lakes or wetlands.

Clutch size was similar to that of other populations (Table 6) and hatching success also was comparable to that of other published estimates, except the one of New Delhi, although all of these data were from studies conducted outside Europe or during the pesticide era (1960–70s; Newton 1979). In contrast, the percentage of successful pairs and mean number of fledged young per territorial, reproductive, or successful pair were the lowest ever recorded in Europe and similar only to those in India and Japan. Reasons for such low natality were unclear. During the 1960s, trapping and persecution were common practice in the county of the study area. For example, Bianchi et al. (1969) reported gamekeepers killing 22 Black Kites in one month in a 1-km² area. However, this practice now is rare and we observed no cases of nest robbing, trapping, or persecution. Clutch and nestling predation was minimal, as important potential predators such as Goshawks (*Accipiter gentilis*) and Eagle Owls (*Bubo bubo*) were very scarce in the study area. Thus, the remaining potential causes

of low natality could be low food availability or water pollution and consequent prey contamination. DDT contamination of water and fish contamination was reported recently in nearby Lake Maggiore (Ceschi et al. 1996). Even though lake eutrophication and pollution could benefit this species by providing dead or moribund fish (Geroudet 1965, Bijeleveld 1974, Doumeret 1995), pesticide contamination clearly can be harmful for Black Kites (e.g., Jenni-Eiermann 1996, Bijlsma 1997) causing low natality and eventual population decline in the long term. The aim of current and future research on Black Kites in northern Italy is to monitor pesticide concentrations in eggs, population density and productivity levels in different lakes and correlate them with levels of pollution in water and fish prey. There is need for studies assessing the level of water contamination above which toxic chemicals concentrations start to be harmful, both for Black Kites and their fish prey. More published estimates of density and productivity, especially hatching success, are also needed from other European countries.

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