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Section: Biodiversity and Ecosystem Analysis

XXV Cycle

Ecological overlap between two sympatric birds of prey (*Milvus milvus* and *Milvus migrans*) during the breeding season

Sovrapposizione ecologica tra due specie simpatriche di uccelli rapaci (*Milvus milvus* e *Milvus migrans*) durante la stagione riproduttiva

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INTRODUCTION

The Red Kite, *Milvus milvus* (Linnaeus, 1758) (RK), and the slightly smaller Black Kite, *Milvus migrans* (Boddaert, 1783) (BK) are two medium sized raptors, characterized by slender wings and a long forked tail, more deeply in RK. RK appears multi-coloured, with red rust body, wide white spots under the wings and light grey head, while BK is quite uniformly dark brown. The slight sexual dimorphism is difficult to note in the field.

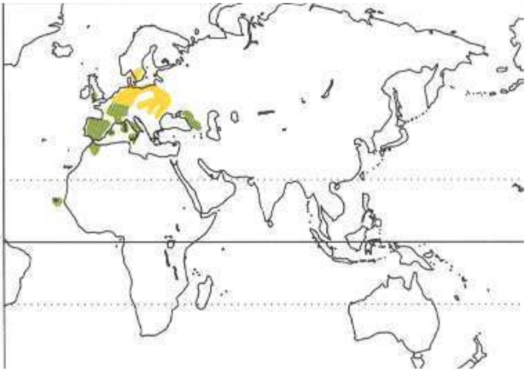
The geographic range of RK is restricted in the Western Palearctic region (Europe and North Africa), including the Cape Verde Islands where an almost extinct subspecies occurs. On the contrary, BK, with six subspecies, is widely spread throughout the Old World and Australasia, and has been defined as one of the most numerous and successful birds of prey in the world (Brown and Amadon 1968). Both RK and BK were included in Annex I of the Bird Directive (2009/147/EC), but the former has a more unfavorable status (SPEC 2) than BK (SPEC 3), due to its recent decline in Central Europe (Birdlife International 2004, 2012).

Several factors negatively affect these species, either directly (shooting, poisoning, windfarms) or indirectly (landscape modifications, changes in land use). In the Tyrrhenian side of the Italian Peninsula the RK was widespread until middle 20^{th} century (Cortone et al. 1994) but currently is both wintering and resident only in the Tolfa Mountains (Latium), a hilly area located 200 km from the nearest natural breeding populations (Abruzzo and Molise), apart from individuals recently re-introduced in Tuscany (Ceccolini & Cenerini 2007). The BK, summer visitor, also breeds in the Tolfa Mountains and in other parts of the Latium Region, often in loose colonies, close to waste dumps, lakes and along the Tiber valley (Guerrieri & De Giacomo 2012).

The two species share the following eco-ethological features: 1) an opportunistic feeding behavior, from scavenger to predator, on a large variety of food resources; 2) a variable breeding dispersion, with nests either clustered in loose colonies (sometimes including pairs of both species) or dispersed throughout suitable habitats, according to the distribution of food resources (Ortlieb 1989,1998, Sergio & Boto 1999, Mougeot & Bretagnolle 2006); 3) a tendency to aggregate, particularly outside the breeding season, in wheeling flocks and in communal night roosts.

Figure 1. Red Kite (above) and Black Kite (below).

Figure 2. On left: flying Red Kite (above) and Black Kite (below). On right, immature and adult Red Kite (above), immature and adult Black Kite (below).



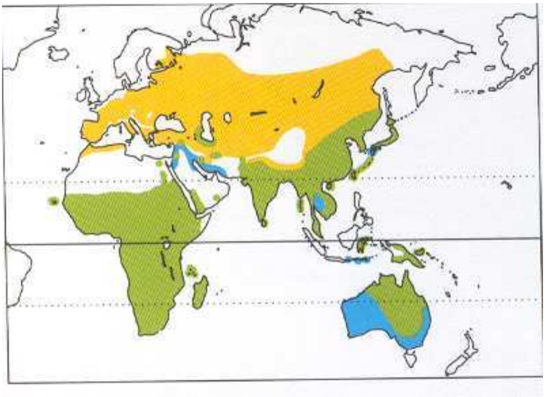


Figure 2. World distribution of Red Kite (above) and Black Kite (below)
Yellow: summer only Green: all year Blue: winter only

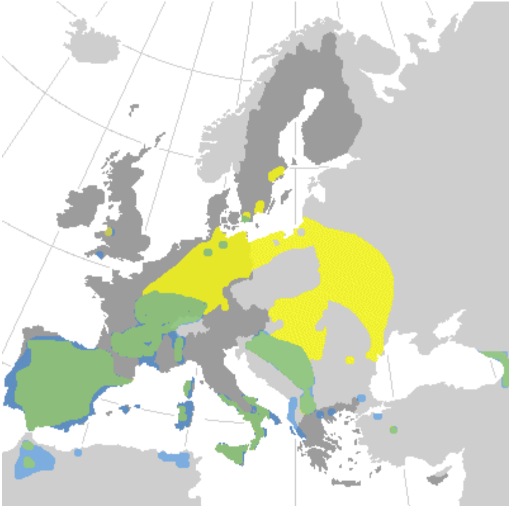


Figure 3. Distribution in Europe of Red Kite (left) and Black Kite (right).
Yellow: summer only Green: all year Blue: winter only

Research carried out in the past pointed out an overlap in food and spatial niches of the two species (Minganti & Panella 1991) and competition between the two species was suggested by some authors as a possible cause concurring in RK's decline in some regions of Central Europe (Birdlife International 2012).

The main purpose of the PhD project was to provide quantitative data on phenology, breeding calendar, nest dispersion, breeding performance, diets and nest habitat features of both species in order to explore the existence of overlaps between their ecological niches.
Taking into account the breeding success and the productivity of the pairs, we focused to the following research subjects:
1. time overlap: phenology and breeding calendar;
2. space overlap: intra and interspecific nest dispersion patterns;
3. dietary overlap;
4. nesting habitat overlap.

The following papers were written in order to analyse the above mentioned subjects:

"Breeding biology of sympatric populations of Red Kite *Milvus milvus* and Black Kite *Milvus migrans* in Central Italy." (1, 2)
"Dietary overlap of sympatric Red Kite (*Milvus milvus*) and Black Kite (*Milvus migrans)* during breeding season in Central Italy". (3)
"Nest habitat selection by sympatric populations of Red Kite and Black Kite (*Milvus milvus* and *Milvus migrans*) in Central Italy" (4)

The ecology of the two kite species was studied to detect differences or similarities among them, with the long term goal of predicting the land management effects on their conservation.

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ARTICLE 1
(submitted to Acta Ornithologica)

BREEDING BIOLOGY OF SYMPATRIC POPULATIONS OF RED KITE *Milvus milvus* AND BLACK KITE *Milvus migrans* IN CENTRAL ITALY

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Key words: Red Kite, Black Kite, phenology, breeding biology, nest dispersion, Central Italy.

ABSTRACT

In 2010-2012 we surveyed 37 Red Kite *Milvus milvus* (RK) and 55 Black Kite *Milvus migrans* (BK) territorial pairs during the breeding season, and the communal roosts of RK in winter, in the Tolfa Mountains (Central Italy), within an area of 510 km^2. The breeding density of both species (mean values: 2.32 and 3.59 territorial pairs per 100 km^2 respectively for RK and BK) was almost constant during the study period. Laying dates of BK (9 April-5 May) were shifted of about a month later with respect to RK (20 March-3 April), while a marginal overlap occurred in fledging periods between the species. Most of nests were clumped in mixed loose colonies, while solitary nests were less than 20%. Mean nearest neighbor distances between conspecific pairs were higher in RK than in BK. The lowest value of mean nearest neighbor distance was found between heterospecific pairs. Nest dispersion patterns showed a progressive increase in clustering, from RK to BK, and up to reciprocal interspecific nest distribution. Mean productivity and breeding success were slightly higher for RK. From the observed nest dispersion we suggested that BK pairs were attracted by the presence of RK as indirect cue of habitat quality. No influence of BK neighbors on RK productivity and breeding success was observed.

1. INTRODUCTION

Red Kite (*Milvus milvus*) (RK) and Black Kite (*Milvus migrans*) (BK) are species in Annex I of the Bird Directive (2009/147/EC). Several factors negatively affect directly (shooting, poisoning, windfarms) and indirectly (landscape modifications, changes in land use) both species. However the RK, due to recent decline in Central Europe, has a more unfavorable status (SPEC 2) than BK (SPEC 3) (Birdlife International 2004, 2012). The geographic range of RK is restricted in the Western Palearctic region (Europe and North Africa), including the Cape Verde Islands where an almost extinct subspecies occurs. On the contrary, the BK, with six subspecies, is widely spread throughout the Old World and Australasia, and has been defined as one of the most numerous and successful birds of prey in the world (Brown and Amadon 1968).

In the Tyrrhenian side of the Italian Peninsula the RK was widespread until middle 20th century (Cortone et al. 1994) but currently is both wintering and resident only in Tolfa Mountains (Latium), a hilly area located 200 km from the nearest natural breeding populations (Abruzzo and Molise), apart from individuals recently re-introduced in Tuscany (Ceccolini & Cenerini 2007). The BK, summer visitor, also breeds in Tolfa Mountains and in other parts of the Latium Region, often in loose colonies, close to waste dumps, lakes and along the Tiber valley (Guerrieri & De Giacomo 2012).

The two species share the following eco-ethological features:

1) an opportunistic feeding behavior, from scavenger to predator, on a large variety of food resources;

2) a variable breeding dispersion, with nests either clustered in loose colonies (sometimes including pairs of both species) or dispersed throughout suitable habitats, according to the distribution of food resources (Ortlieb 1989,1998, Sergio & Boto 1999, Mougeot & Bretagnolle 2006);

3) a tendency to aggregate, particularly outside the breeding season, in wheeling flocks and in communal night roosts.

Research carried out in the past pointed out overlaps in food and spatial niches of the two species (Minganti & Panella 1991) and competition between the two species was suggested by some authors as a possible cause concurring in RK's decline in some regions of Central Europe (Birdlife International 2012).

In this paper, we report the results of a three years study carried out on sympatric RK and BK populations in the Tolfa Mountains with the aim to provide quantitative data on phenology, breeding calendar, nest dispersion and breeding performance of both species in order to explore the existence of temporal and spatial niche overlaps between them.

2. STUDY AREA

The study area (510 km^2) is located in "Monti della Tolfa" (Tolfa Mountains), within the north-western part of Latium Region (Central Italy). It ranges from the Tyrrhenian coast to about 25 km inland (N42° 08' 03.1'', E11° 56' 56.5'') and is characterized by a central relief of volcanic origin (up to 633 m a.s.l.) surrounded by lower sedimentary formations. The hilly landscape is engraved by a dense hydro-graphic network of intermittent or ephemeral streams ("fossi"), with marked seasonal regime, directly flowing into the sea or into the Mignone river, that runs throughout the eastern and northern sectors of the study area. The climate ranges from Mediterranean to Temperate, according to elevation and distance from the sea-coast, with hot dry summers and cool rainy autumns and winters; the average temperature during the year is 15.8°C, while annual rainfall fluctuates between 700 and 1000 mm, with a maximum in autumn and a minimum in July (Tommaselli et al. 1973). The total rainfall in 2009, 2010, 2011 and 2012 were respectively of 1029, 1220, 796 and 766 showing an evident deficit in March, June and July 2012, with respect to the normal values for these months in the previous years. Mean temperatures didn't differ substantially from long term mean values, but two weeks with temperatures under 0° C and exceptional snowfalls occurred in February 2012 (referred to Canale Monterano, SIARL).

The study area is included within the SPA (Special Protection Area) "Comprensorio Tolfetano-Cerite- Manziate (IT6030005) designated in 1995 by the Italian National Authority (Ministry of Environment) thanks to the presence of several species of Community interest (Annex I of the Birds Directive), including the two kites.

Data from Land Use Map (ARP 2010), indicate 2% (10 km^2) of urban areas, 35.5% (181 km^2) of farmland, 38.5% (197 km^2) of woodland, 7.5% (38 km^2) of grassland and 16.5% (84 km^2) of scrubland. Probably the extension of urban areas is underestimated, due to the rapid increasing in building activities both around villages and scattered over the territory, leading to changes land use from agricultural to residential. Extensive cultivations (wheat, corn) cover 87% of farmland, while vineyards, fruit trees and gardens cover most of the remaining agricultural territory. Most of woodlands are dominated by *Quercus cerris* sometimes in association with

Quercus ilicis or *Quercus pubescens* (82% of wooded areas), the remaining by *Quercus ilicis* or *Pinus* in warmer and by *Fagus sylvatica* or *Castanea sativa* in cooler and moister areas. Except for small portions of ancient forest and neglected coppice (woodlots left unmanaged), forested areas are managed for firewood production by stool shoot regeneration (coppice system) on a 20-30 yr rotation basis, where single mature trees are kept into the next rotation as seed bearers. Wooded areas form a mosaic with shrub- and grassland (24% of the study area) where extensive livestock rearing (especially cattle, horses and donkeys, marginally sheep too, but only in open areas) is the main productive activity. After some small rubbish dumps inside the study area were closed in 80's, at present two active dumps are located out of the study area: Civitavecchia and Bracciano, 12 km west and 20 km east from its center, respectively. A large number of Black Kite pairs, at least 20 in 2011 (inf. G. Prola), bred in proximity of the rubbish dump of Bracciano.

3. METHODS

Data collecting

In 2010-2012 field work was carried out in about 260 days during the breeding season and 70 days out of breeding season, respectively. Since February, the woodlands and the open areas of the study area were surveyed to locate the pairs of both species (RK and BK) by means of observations of territorial and courtship behavior. Nest site locations were recorded by means of Garmin GPSMAP60CSx. From about two weeks after hatching up to fledging, the nest sites were visited at least three times to assess the breeding success of the pairs by observations from vantage points on the ground.

We defined "territorial pair" every association between two adults showing courtship and territorial behavior in possible nest sites. Since the non-invasive method adopted did not allow to see the eggs inside the nests, we defined "breeding pairs" those who showed an incubation behavior at least until hatching time and were assumed to have laid. Finally, we defined "successful pairs" those who raised at least one chick to fledge (Steenhof 1987).

Age of nestlings (older chicks) was estimated with a $\pm$3 days approximation by observation of their feathering and behaviour. We used such estimation to backdate the date of laying and hatching by assuming a mean incubation periods of 33 and 29 days and a mean raising periods of 52 and 47 days respectively for RK and BK (Traue & Wuttky 1966, Ortlieb 1989,1998).

According with Sergio & Boto (1999), the pairs of BK were defined solitary when they nested >700m from their nearest neighbor; pairs <700m from their nearest neighbor, with observed interactions between them, were defined as colonial. In our study area, where two kite species occurred together, considering the 700 m threshold as above, we defined the following cases: 1) Solitary pair of BK; 2) Solitary pair of RK; 3) Loose colonial pair of BK; 4) Loose colonial pair of RK; 5) Loose mixed colony (RK and BK). We defined "mixed colonies" all the groups composed, in one or more of the study years, by at least three nests of whatever species included within a 700 m ray circle with at least two nests that were less than 700 m apart and where interactions between neighbors were often observed. Finally, an association of two nests, either intraspecific or interspecific, with reciprocal NND<700 m is defined "couple of pairs".

Statistical analyses

Geographic analyses were performed by means of GIS software ArcGis 9.3. Statistical analyses were performed by means of SPSS statistic 17.0. Mean values are given $\pm$ standard error. Non parametric tests (Mann-Whitney's U test, χ^2 test for differences, Spearman's correlation) were performed to detect differences and correlations between the two species.

Intra and inter-specific spatial relationships were analyzed by means of "Average Nearest Neighbor Distance" (ANN) test (Clark & Evans 1954) with correction for edge effect (Donnelly 1978), applied on the area of the boundary polygon having no edge closer to any peripheral nest than half the distance these are from their nearest neighbor (Campbell 1996). Significance of resulting values (>1 for homogeneous and <1 for aggregated distributions) were tested according to mathematical procedures indicated in Krebs (1998). Moreover, dispersion patterns were analyzed by means of the G-statistic (Brown 1975), calculated as the ratio between the geometric and arithmetic mean of the squared nearest neighbor distances (NNDs) and varying between 0 and 1, with values >0.65 indicating a regular dispersion and <0.65 a clustering of nest sites. As in 2011 two black kite breeding pairs occupied the same nests of territorial red kite pairs after their abandon, nearest distances equal to zero are modified in 0.1 to calculate the geometric mean.

4. RESULTS

Phenology

The number of RK individuals increased gradually in autumn reaching the top in December-January owing to the arrival of wintering migrants. In 2012, between 21 and 24 December, two distinct communal roosts consisting of 22 and 31 individuals respectively were observed at 16 km of distance from each other. In several cases, night roost locations changed in few days, often according to weather conditions or human presence (hunting or forestry activities), within a 2.5 km ray circle. Both before and after December-January, about 20% of RKs of the largest aggregation gathered 5 km far from main roosting area. Wintering RKs were observed during the day to spread over the study area and in part to visit the two rubbish dumps outside it, moving in late afternoon towards roosts. At the end of winter, the number of RK aggregated individuals decreased, while resident breeding pairs settled into nest sites. After April, small groups of non-reproductive individuals were occasionally observed, often nearby food sources, as carrions or insect swarms. Aggregation trend was again observed in Autumn. From late February, when breeding RK pairs were already busy in courtship and territorial defense, the earliest BKs arrived at nest sites (27 February-7 March). The number of BK individuals continued to increase until May, also after that breeding pairs had laid their eggs. Sometimes, small groups (6-12) of non-territorial individuals (floaters) were observed near breeding colonies. Most of BKs

departed from nest sites in late Summer, but at least one BK individual was often seen during winter (e.g. 11 January 2012).
RK laid eggs almost one month before BK; RK fledging occurred around three weeks before BK (Fig. 1). These data showed a clear shift between the two species (20 March-3 April, median = 25 March, N=22, for RK; 9 April-5 May, median 21 April, N=29, for BK; Mann-Whitney U-test: = 0.000, N= 51, df = 1, p = 0.000). On the contrary, a marginal overlap was observed in fledging period, due to BK's shorter incubation and growth periods (13-27 June, median = 18 June, N=22, for RK; 24 June-20 July, Median = 6 July, N=29 for BK; Mann-Whitney U-test: = 13.5, N= 51, df = 1, p = 0.000). One exception was recorded in 2012 for one BK pair that laid on 25 May and produced only one young which fledged on 8 August.

Productivity, density and nest dispersion

In 2010-2012, the number of territorial pairs and the reproductive parameters didn't show relevant variations, while a clear drop in breeding success for RK was recorded in 2012 (Table 1). RK mean productivity and breeding success were a little higher than those of BK.
In 2010-2012, RK and BK territorial pairs occupied respectively 18 and 39 different nests, each one utilized for one to three consecutive years. Mean occupation time of the same nest was higher for RK (mean= 1.94, SE=0.21, median=2, N=18) than for BK (mean=1.39, SE=0.09, median=1, N=39), with significant difference between the medians (Mann-Whitney U test=225.5, N= 92, df= 1 p=0.015). In 2011, two BK pairs bred in the same nests at first defended and then abandoned by two RK territorial pairs. The same nests were occupied in 2012 by two RK breeding pairs, while two BK pairs were observed in nests at 60 and 120 m respectively.
Most of nests were distributed in four loose mixed colonies or in associations of two nests, while solitary nests were occupied by 18.6 % of RK and 14.4 % of BK pairs (Table 2). Intraspecific NNDs were different between the species (Mann-Withney U test=500, N=92, df=1, p=0.000), higher for RK (with only 2 pairs with NND < 700 m in 2010) than for BK. ANN test and G-statistic indicated two distinct

dispersion patterns for the two species: a clustered pattern for BK and a random one for RK (Table 3). Interspecific median values of NND were always lower than intraspecific ones, without significant differences between the species (Mann-Withney U test=846, N=92, df=1, p=0.173). Aggregation index values for both RK to BK and viceversa showed a clustered pattern between species. (Table 3).
Around 50% of nests (49% of RK and 54% of BK nests) were located within the wooded areas used in winter by RK as communal night roosts. Pooling data, 89% of BK nests were detected in one or more of the following conditions: 1) in mixed colonies, 2) in association with a RK nest or 3) solitary or in association with a BK nest and within a RK's winter communal roost area.
Non parametric tests performed on NNDs and productivity showed a negative correlation between intraspecific BK NNDs and number of fledglings (N=55, $r_s = -0.311$, p=0.021). No significant correlation was found between productivity and interspecific NNDs or number of neighbors (both conspecific and heterospecific pairs) within the 700 buffers surrounding the nest.
Location of nests didn't seem to be related either with distance from active rubbish dumps (min=5700 m, median=12394 m, N=92) or from streams (min=135 m, median=7903 m, N=92), with no significant differences between species, although 27% of BK (N=55) and 8% of RK (N=37) pairs, including two colonies, occupied nests within 2 km from Mignone river (χ^2=5.162, N=92, df=1, p=0.023).

5. DISCUSSION

In the study area, notwithstanding the clear shift in laying and hatching, there was a wide overlap during nestling periods (approximately since 20 May to 20 June) that occurred when the availability of preys was probably the highest in the year (mainly large insects, nestlings of other birds and snakes). A short period of overlap in fledging was also observed (since 24 to 27 June). According to literature data, RK egg-laying , as in other populations in south Europe, occurred about 20-30 days early with respect to northern populations, while BK laying dates were similar to those of other European populations (Ortlieb 1998, Mougeot & Bretagnolle 2006).

In the study area, the breeding density of both species was stable in 2010-2012. In the whole district of Tolfa Mountains, during the last thirty years, the number of RK pairs showed a positive trend, from 4 in 1980 to 13 in 2011 (Petretti & Petretti 1981, Arcà 1989, Minganti 2004, Minganti et al. 2007, present study). A steeper increase, from 50 in 1994 up to 150 in 2011, was recorded in the number of wintering RK individuals (sedentary plus migrants from North Europe) counted at communal roosts (Minganti 2004, Minganti et.al. 2007, unpublished data, present study) (Fig. 2). The large number of wintering RKs, confirms the importance of Tolfa Mountains for resident pairs and European migrants. On the contrary, data on breeding density of BK gathered in the last thirty years (Petretti & Petretti 1981, Guerrieri & De Giacomo 2012), even if fragmentary and not standardized, showed a decrease that could be related with the closure of three rubbish dumps in 1980s, located within the study area. Nevertheless, in the last years, a new increase of BK pairs (about 20 in 2011, Guido Prola pers. comm.) was recorded in a breeding colony nearby the rubbish dump of Bracciano, outside of study area.

The closure of rubbish dumps within the study area seems to affect the commoner species at global level (BK), but not the most threatened species (RK), although rubbish dumps represent possibly an important food source also for wintering RK.

Mean reproductive parameters of both species aligned with those of other populations in South Europe but the values were slightly lower than those from Central Europe (Ortlieb 1989, 1998, Sergio & Boto 1999, Sergio et al. 2005, Mougeot & Bretagnolle 2006). Productivity values of RK were about 7% higher than those observed in BK, either in the study area or in Coto Doñana national park (Sergio et al. 2005).

The steep fall of RK breeding success in 2012 could be due to unusual weather conditions (lack of rainfall in autumn 2011 and two weeks of snowfall with very low temperatures in February 2012).
RK pairs spacing appeared to be related to a scattered distribution of food sources. On the contrary, most of the BK pairs showed a clear trend to nest nearby conspecific and/or heterospecific breeding pairs. Although an accurate habitat analysis is needed to exclude an influence of favorable habitats on nest clustering, the extension and distribution of woodlands over the study area didn't seem to represent a limiting factor.
Besides the trend to conspecific attraction (Stamps 1988), usually observed in BK (Sergio & Penteriani 2005) and connected with colonial breeding, a trend to heterospecific attraction (Mönkkönen and Forsman 2002) could be also suggested for the species, that seemed to use the presence of RK pairs and communal roosts as indirect cues of habitat quality.
The presence of BK neighbors didn't seem to influence productivity of RK pairs, although we cannot exclude that, in case of food shortage or excessive wood logging, the overlap in spatial and temporal niche could trigger competitive interactions.

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Table 1 . Reproductive parameters of sympatric *Milvus milvus* and *Milvus migrans* pairs in the Tolfa Mountains (Central Italy)

	Year	Number of: Territorial pairs	Breeding pairs	Successful pairs	Fledged birds	Breeding success[a]	Mean (±SE) number of fledged birds per: Territorial pair	Breeding pair	Successful pair
Milvus milvus	2010	12	10	10	16	83.33	1.33 ± 0.26	1.60 ± 0.22	1.60 ± 0.22
	2011	12	10	8	13	66.67	1.08 ± 0.29	1.30 ± 0.30	1.63 ± 0.26
	2012	13	12	5	8	38.46	0.62 ± 0.24	0.67 ± 0.26	1.60 ± 0.24
	2010-2012	37	32	23	37	62.82	1.00 ± 0.15	1.16 ± 0.16	1.61 ± 0.14
Milvus migrans	2010	18	15	9	14	50.00	0.78 ± 0.22	0.93 ± 0.25	1.56 ± 0.24
	2011	19	16	12	16	63.16	0.84 ± 0.19	1.00 ± 0.20	1.33 ± 0.19
	2012	18	16	11	18	61.11	1.00 ± 0.21	1.13 ± 0.22	1.64 ± 0.15
	2010-2012	55	47	32	48	58.09	0.87 ± 0.12	1.04 ± 0.13	1.50 ± 0.11

[a] Percentage of territorial pairs raising at least one chick until fledging.

Table 2. Density and distribution of *Milvus milvus* (RK) and *Milvus migrans* (BK) pairs in four mixed colonies (A-D), in two nests associations or in solitary territories, during 2010-2012 in Tolfa Mountains (Central Italy) .

Year	Species	Density[a]	Number of pairs in mixed colonies[b]						Couples of pairs with NND<700 m[c]				Solitary pairs[d]		Total
			A	B	C	D	tot	*(%)*	RK+BK	*(%)*	BK+BK	*(%)*	N	*(%)*	N
2010	RK	2.35	3	1	1	1	**6**	*(50.0)*	**6**	*(50.0)*	**0**	*(0.0)*	**0**	*(0.0)*	12
	BK	3.53	4	2	1	2	**9**	*(50.0)*	**6**	*(33.3)*	**2**	*(11.1)*	**1**	*(5.6)*	18
2011	RK	2.35	2	1	1	1	**5**	*(41.7)*	**4**	*(33.3)*	**0**	*(0.0)*	**3**	*(25.0)*	12
	BK	3.73	3	3	3	2	**11**	*(57.9)*	**4**	*(21.1)*	**0**	*(0.0)*	**4**	*(21.1)*	19
2012	RK	2.55	2	1	1	1	**5**	*(38.5)*	**4**	*(30.8)*	**0**	*(0.0)*	**4**	*(30.8)*	13
	BK	3.53	3	3	3	2	**11**	*(61.1)*	**4**	*(22.2)*	**0**	*(0.0)*	**3**	*(16.7)*	18
Mean 2010-2012	RK	2.42	2.3	1.0	1.0	1.0	**5.3**	*(43.4)*	**4.7**	*(38.0)*	**0.0**	*(0.0)*	**2.3**	*(18.6)*	12.3
	BK	3.59	3.3	2.7	2.3	2.0	**10.3**	*(56.3)*	**4.7**	*(25.5)*	**0.7**	*(3.7)*	**2.7**	*(14.4)*	18.3

[a] Number of terrritorial pairs/100 km^2 .

[b] Loose colonies composed, in one or more of the study years, by at least three nests of whatever kite species included within a 700 m ray circle, where at least two nests were less than 700 m apart.

[c] Associations of two kite nests with reciprocal NND<700 m.

[d] Pairs nesting >700m from their nearest neighbor kite nest.

Table 3. Spacing and dispersion patterns of *Milvus milvus* and *Milvus migrans* territorial pairs in Tolfa Mountains (Latium, Central Italy) in 2010-2012.

	year	N	Nearest Neighbor Distance[a] (m)			ANN[b]			G-statistic
			range[c]	median	mean ± SE	ratio	z	P[d]	
Milvus milvus intra-specific distances	2010	12	549-10620	2873	3669 ± 846	1.011	0.068	>0.05	0.312
	2011	12	7159-10620	3660	3782 ± 809	1.043	0.253	>0.05	0.381
	2012	13	759-10724	4236	4159 ± 797	1.200	1.236	>0.05	0.401
	2010-2012	37	549-10620	3085	3878 ± 460	1.084	0.506	>0.05	0.362
Milvus migrans intra-specific distances	2010	18	143-6569	1165	1728 ± 454	0.599	-2.939	<0.01	0.111
	2011	19	174-6627	968	1761 ± 420	0.629	-2.797	<0.01	0.186
	2012	18	359-7120	867	2003 ± 525	0.694	-2.241	<0.05	0.163
	2010-2012	55	143-7120	944	1829 ± 265	0.640	-2.663	<0.01	0.149
Milvus milvus inter-specific distances to nearest *Milvus migrans*	2010	12	55-594	110	190 ± 49	0.052	-5.617	<0.01	0.306
	2011	12	0-2810	166	651 ± 269	0.179	-4.864	<0.01	0.007
	2012	13	61-4202	238	847 ± 346	0.244	-4.669	<0.01	0.056
	2010-2012	37	0-4202	220	570 ± 153	0.159	-5.047	<0.01	0.031
Milvus migrans inter-specific distances to nearest *Milvus milvus*	2010	18	55-1678	202	482 ± 135	0.167	-6.101	<0.01	0.111
	2011	19	0-2870	316	749 ± 201	0.267	-5.520	<0.01	0.028
	2012	18	61-2294	365	594 ± 140	0.206	-5.817	<0.01	0.190
	2010-2012	55	0-2870	296.5	611 ± 94	0.214	-5.809	<0.01	0.091

[a] Distance to nearest neighbour nest (NND)

[b] "Average Nearest Neighbor Distance" test (Clark and Evans 1954) with correction for edge effect (Donnelly 1978), applied on the area of the boundary polygon having no edge closer to any peripheral nest than half the distance these are from their nearest neighbor (Campbell 1996).

[c] As in 2011 two BK breeding pairs occupied the same nests of territorial RK pairs after their abandon, nearest distances equal to zero were modified in 0.1 to calculate the geometric mean.

[d] Statistical significance of the deviation of nest spacing pattern from randomness toward regularity.

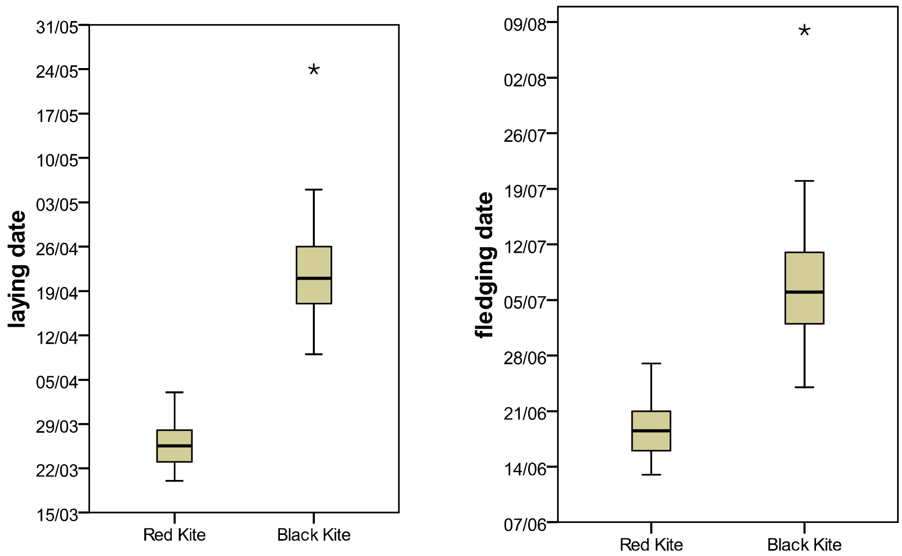

Fig. 1. Dates of egg-laying and fledging in sympatric *Milvus milvus* and *Milvus migrans*, during three years (2010-2012) in the Tolfa Mountains.

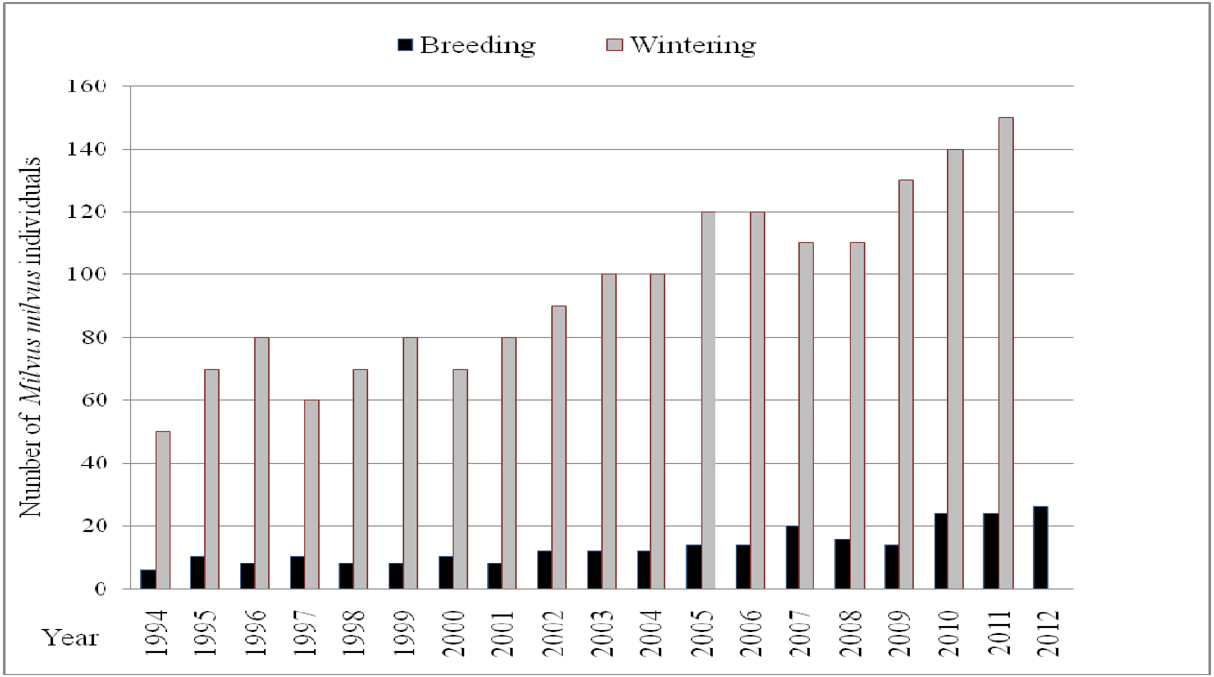

Fig. 2. Number of wintering and breeding individuals of *Milvus milvus* in the Tolfa Mountains (1994-2012).

ARTICLE 2
(submitted to Vie et Milieu- Life and Environment)

Dietary overlap of sympatric Red Kite (*Milvus milvus*) and Black Kite (*Milvus migrans)* during breeding season in Central Italy.

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Key words: Kites, diet, niche overlap, interspecific competition, Italy.

ABSTRACT
Prey remains and pellets were collected in 2009-2011 under nests occupied by breeding pairs of : Red Kite, *Milvus milvus* (Linnaeus, 1758) (RK), and Black Kite, *Milvus migrans* (Boddaert, 1783) (BK) to compare the food habits of these two sympatric species in the Tolfa Mountains, throughout a mosaic of open habitats and woodlands. Birds (50%) and other small terrestrial vertebrates represented the largest part of biomass consumed by both the species. The proportion of food items coming from waste dumps (mainly slaughterhouse refuses) in the diet of BK (23%) was higher than in RK (15%). Analyses, performed both on number and biomass of food items, grouped into 11 taxonomic and weight classes, showed similar niche breadth and wide niche overlap between the two species.

INTRODUCTION

Both Red Kite (*Milvus milvus*) (RK) and Black Kite (*Milvus migrans*) (BK) show opportunistic food habits, exploiting resources that range from many small and medium sized live prey to carrions and slaughterhouse refuses (Ortlieb 1989, 1998, Carter 2001). Both the species figure in Annex I of the Bird Directive (2009/147/EC). Several factors negatively affect them directly (shooting, poisoning, windfarms) and indirectly (landscape modifications, changes in land use). However the RK, due to recent decline in Central Europe, has a more unfavorable status (SPEC 2) than BK (SPEC 3) (Birdlife International 2004, 2012). The geographic range of RK is restricted in the Western Palearctic region (Europe and North Africa), including the Cape Verde Islands where an almost extinct subspecies occurs. On the contrary, the BK, with six subspecies, is widely spread throughout the Old World and Australasia, and has been defined as one of the most numerous and successful birds of prey in the world (Brown & Amadon 1968).

In Italy, RK was widespread along the Tyrrhenian side of the Italian Peninsula until middle 20th century (Cortone *et al* 1994) but currently is either wintering or resident only in the Tolfa Mountains (Latium), a hilly area located 200 km from the nearest natural breeding populations (Abruzzo and Molise), apart from individuals recently re-introduced in Tuscany (Ceccolini & Cenerini 2007). The BK, summer visitor, also breeds in the Tolfa Mountains and in other parts of the Latium Region, often in loose colonies, close to waste dumps, lakes and along the Tiber valley (Guerrieri & De Giacomo 2012).

RK and BK are sympatric breeders, sometimes in loose mixed colonies, in large part of their European range, and they defend only a small territory around the nest, while the home ranges of neighbour pairs can be widely overlapped. Comparative studies on food habits, carried out on sympatric pairs breeding in areas characterized by the presence of waterbodies or marshlands, showed that terrestrial preys were more abundant in RK diet, while water-related preys were preferred by BK (Thiollay 1967, Fiuczynski 1981, Veiga & Hiraldo 1990, Zawadzka 1999). Research carried out in the past pointed out overlaps in food and spatial niches of the two species (Minganti & Panella 1991) and competition between the two species was suggested by some authors as a possible cause concurring in RK's decline in some regions of Central Europe (Birdlife International 2012).

In this paper we report the results of a three years research (2009-2011) carried out to compare the diet of sympatric breeding populations of RK and BK in the Tolfa Mountains (Latium, Italy), in order to provide information useful for their conservation and management.

STUDY AREA

The study area (510 km^2) is located in "Monti della Tolfa" (Tolfa Mountains), within the north-western part of Latium Region (Central Italy). It ranges from the Tyrrhenian coast to about 25 km inland (N42° 08' 03.1'', E11° 56' 56.5'') and is characterized by a central relief of volcanic origin (up to 633 m a.s.l.), surrounded by degrading lower formations. The hilly landscape is engraved by a dense hydrographic network of intermittent or ephemeral streams ("fossi"), with a marked seasonal regime, directly flowing into the sea or into the Mignone River, that runs throughout the eastern and northern sectors of the study area.

The climate varies from Mediterranean to Tempered according to elevation and distance from the sea-coast, with hot arid summers and cool rainy autumns and winters; the average temperature during the year is 15.8°C, while annual rainfall fluctuates between 700 and 1000 mm, with a maximum in autumn and a minimum in July (Tommaselli *et al* 1973).

The study area is included within the SPA (Special Protection Area) "Comprensorio Tolfetano-Cerite- Manziate (IT6030005) designated in 1995 by the Italian National Authority (Ministry of Environment) thanks to the presence of several species of Community interest (Annex I of the Birds Directive), including the two kites. Data from Land Use Map (ARP 2010) indicate 2% (10 km^2) of urban areas, 35.5% (181 km^2) of farmland, 38.5% (197 km^2) of woodland, 7.5% (38 km^2) of grassland and 16.5% (84 km^2) of shrubland. Probably the extension of urban areas is underestimated, due to the rapid increasing in building activities both around villages and scattered over the territory, leading to changes in land use from agricultural to residential. Extensive cultivations (wheat, corn) cover 87% of farmland, while vineyards, fruit trees and gardens cover most of the remaining agricultural territory. Most of woodlands are dominated by *Quercus cerris* sometimes in association with *Quercus ilicis* or *Quercus pubescens* (82% of wooded areas), the remaining by *Quercus ilicis* or *Pinus* in warmer and by *Fagus sylvatica* or *Castanea sativa* in cooler and moister areas.

Large part of the study area, utilized for traditional free-ranging livestock (cows, horses and donkeys), is a mosaic of open habitats and woodlands. The patchiness of the landscape is correlated with the high diversity in insect communities and small and medium sized vertebrate assemblages. Sheep rearing, connected with crop rotation in agriculture, is mainly spread in the northern part of study area. Free-range livestock provides placentas abandoned by females after delivery (especially in February-April), and carcasses of dead animals often not removed by the owners. Slaughterhouse refuses can be found near hen-houses and rabbit-warrens and at the edge of secondary roads, because of the widespread practice of illegal dumping waste. Moreover, small animals run over by cars are common on main roads.

Since three waste dumps within the study area were closed in the Eighties, two active dumps were located outside the study area in 2009-2011, at Civitavecchia and Bracciano, more than 7 km and 9 km respectively from the nearest breeding kite pair here considered.

METHODS

Data collection

In 2009-2011, during the period from two weeks after egg hatching to one month after young fledging, food remains were searched on the ground under the nests and surrounding perches of 21 RK an 24 BK breeding pairs. For analyses, only the 11 RK and 9 BK sites were selected, where at least 10 preys and 5 pellets were collected on the whole.

Several unpredictable factors (rainfalls, ground cover, scavengers, passage of ungulates) and the different persistence of some food remains with respect to others could bias the assessment of the actual composition of the diet. Nevertheless, we assumed the results sufficiently reliable for comparative purposes, since food processing habits are very similar between the two species.

Double counting of prey was avoided by assuming the lowest number of individuals. Mean weights reported in specialized literature were assigned to each species (Toschi & Lanza 1959, Toschi 1965, Chaline *et al* 1974, Cramp *et al* 1977-1994, Di Palma & Massa 1981, Moreno 1985,1986, Brown et al. 1987, Amori et al. 2008, Boitani *et al* 2003) to estimate biomass and to arrange preys in 11 taxonomic and weight classes (Tab.I). Biomass of a refuse (bone remains of livestock, poultry, rabbit and heads of fish) was estimated between 50 and 100 g, taking into account the size of the fragment.

Statistical analyses

Non parametric tests were performed to compare medians or differences in frequency of prey categories between the species. The food niche breadth was calculated using the index of Levin (B) and its standardized form (B_a) (Levin 1968; Hurlbert 1978) with values ranging from zero (lower diversity in the assemblage) to one (higher diversity).

Dietary overlap between the species was estimated through Pianka's index (Pianka 1973), ranging from zero (no overlap) to one (complete overlap). Because the evaluation and comparison of niche overlap indexes are affected by the limitation of arbitrary cut-offs (Feinsinger *et al* 1981), we compared the observed overlap values to an appropriate null model. The distribution of the null model was created using EcoSim software (version 7.0; Gotelli & Entsminger 2001, 2003) running two simulations, each with 1000 randomized replication of the data set. The simulations were generated using two randomization algorithms: RA2 (Niche breadth relaxed/ Zero States retained) whereby every cell in the matrix is replaced with a randomly chosen, uniforming number between zero and one but maintaining the zero structure in the matrix; and RA3 (the

“scrambled zero” randomization algorithm proposed by Winemiller and Pianka 1990) whereby the entries in each row of the utilization matrix were randomly reshuffled for each iteration retaining the niche breadth of each species but randomizing which particular resources states are utilized (Vignoli et al. 2009).
Both niche breadth and niche overlap indexes were calculated taking into account the 11 taxonomic and weight classes described above. Insects, for their large number, were excluded from numeric analyses.

RESULTS

Regarding to biomass, birds were the prevalent class eaten by both RK (55%) and BK (49%). In descending order, RK diet was composed by mammals (20%), refuses (15%), amphibians (6%) and reptiles (5%), whiloe BK diet included refuses (23%), mammals (19%), reptiles (6%) and amphibians (3%). A small amount of freshwater fish (*Leuciscus* sp.) was found only under one BK nest near the Mignone River. Insects (Orthoptera and Coleoptera), almost exclusively from pellets, formed only a small portion (about 0.5%) of the eaten biomass in both the species (Fig. 1).
At a lower taxonomic level, pooling data of the two kite species, Corvidae (*Garrulus glandarius, Pica pica, Corvus corone*), for the half part young birds with feathers not fully developed, amounted to about 24% of total biomass. In descending order we found *Phasianus colchicus* (17%), *Rattus* sp. (10%), *Erinaceus europaeus* (8%) and Columbidae (6%).
Refuses, more abundant in number in the BK’s diet ($\chi^2 = 7.126$, N=555, df=1, p=0.01,), included remains of poultry (mostly heads of *Gallus* sp., *Oryctolagus* sp., together representing 9% of total biomass), bone fragments of large mammals (Bovidae, Suidae, Equidae, 7%), heads of sea-fish (<2%). The illegal hunting of *Hystrix cristata* could have provided fragments of this species found under three different nests. In the rest of refuse category, we included only remains of dog. As for small mammals and other wild

vertebrates it was impossible to ascertain if these preys were got from active predation or found dead by the kites.
No significant difference between RK and BK was found grouping the vertebrate prey items in two broader categories according to their individual weight (lower or higher of 100 g): small (classes 3, 5 and 8) and medium-large sized (classes 1, 2, 4, 6, 7 and 9).
Distance of the pairs to the nearest waste dumps (RK mean=11.03 km $\pm$SE= 0.78, N=11; BK mean=12.90 $\pm$SE=1.07 km, N=9) showed for BK a significant negative correlation with the number of refuses in the diet (N=9, r_s = -.812, p=.008)
The values of niche breadth index, similar for the two species, show an inhomogeneous exploitation of resources, but also the absence of specialization on a particular class of prey. Pianka's index shows a wide overlap in the diet spectra of the two species in both numeric (0.975) and weight (0.974) data. The observed degree of overlap was significantly higher (p=0.000) than the two simulations generated using randomization algorithms RA2 (Niche breadth relaxed/ Zero states retained) and RA3 (Niche breadth retained/Zero states reshuffled) (Tab. II).

DISCUSSION

Results show that most of preys were small wild animals occurring in the environmental mosaic of the study area, either in open habitats or woodlands and their edge, in relation with livestock raising and low human density. Moreover, human activities indirectly provided refuses, representing an important part of the diets. Diversity index values agree with the well known generalist food habits of the two kite species.
Apart from the prevalence of refuses in BK, the two species are very similar in the exploitation of food sources. The statistically significant large overlap observed between the species indicate a high level of shared resource utilization that can be due to the lack of competition (Gotelli and Graves 1996) as well as a certain degree of competition that has not yet led to divergence in resource use.

Additional data on resource availability and species interactions are needed for a reliable discussion (Sale 1974, Connell 1980). However, as the identified prey species seem to be very common during chick rearing period in the study area, it is possible that both kite species benefit of relatively abundant food sources that are selected according to their availability. This doesn't exclude that occasional food scarcity could trigger competition between the two species.

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Table I. Diet composition of sympatric Milvus milvus and Milvus migrans during breeding season in Tolfa Mountains (Central Italy) in 2009-2011.

	Milvus milvus		*Milvus migrans*	
Number of broods	11		9	
Number of pellets	110		114	
Prey categories (weight range)	N (%)*	mass (g) (%)	N (%)*	mass (g) (%)
1 Pisces (100-200 g)	0 (0.0)	0 (0.0)	3 (1.0)	500 (1.0)
2 Amphibia (200 g)	15 (5.6)	3000 (6.0)	7 (2.4)	1400 (2.9)
3 Reptilia I (7-20 g)	12 (4.5)	111 (0.2)	11 (3.8)	147 (0.3)
4 Reptilia II (100 g)	15 (5.6)	2250 (4.5)	17 (5.9)	2550 (5.3)
5 Aves I (30-100 g)	17 (6.4)	1150 (2.3)	11 (3.8)	655 (1.4)
6 Aves II (140-300 g)	67 (25.2)	12280 (24.6)	71 (24.6)	12240 (25.2)
7 Aves III (400-1000 g)	17 (6.4)	14000 (28.0)	16 (5.5)	10700 (22.1)
8 Mammalia I (6-100 g)	12 (4.5)	396 (0.8)	8 (2.8)	330 (0.7)
9 Mammalia II (200-700 g)	33 (12.4)	9100 (18.2)	29 (10.0)	8800 (18.1)
10 Refuses (50-100 g)	78 (29.3)	7500 (15.0)	116 (40.1)	10900 (22.5)
11 Insecta (0.5-2 g)	223	230 (0.5)	269	280 (0.6)
Total	489	50017	558	48502
Total invertebrate excluded	266		289	
B_a [#]	0.495	0.399	0.347	0.401

Composition of prey categories (% in number)

1 *Leuciscus sp.*

2 *Bufo sp.*

3 Unidentified small reptiles (43%), *Chalcides chalcides* (22%), *Podarcis sp.* (17%), *Lacerta bilineata* (13%) , *Anguis fragilis.*

4 Unidentified snakes (94%), *Elaphe quatuorlineata., Hierophis viridiflavus,*

5 *Turdus merula* (43%), unidentified small Passeriformes (46%), *Dendrocopos mayor, Upupa epops.*

6 *Garrulus glandarius* (59%), *Pica pica* (25%), *Columba livia* (7%), *Streptopelia sp.* (2%), *Falco sp., Athene noctua, Tyto alba, Coracias Garrulus, Picus viridis, Corvus monedula* .

7 *Phasianus colchicus (52%), Corvus corone (30%), Columba palumbus (18%)* .

8 Unidentified small Mammalia (95%), *Crocidura sp.*

9 *Rattus sp.* (82%) *Erinaceus europaeus (18%).*

10 Bone fragments of Bovidae (36%), Galliformes (24%), Lagomorpha (23%), Seafishes (13%), *Canis sp., Hystrix cristata,*

11 Orthoptera (72%), Coleoptera (19%), Dermaptera (7%), *Lyristes plebejus* , nest of *Polistes sp.*

Notes

* Invertebrates excluded from numeric analyses.

[#] Levin's niche breadth index (1968) standardized (Hurlbert 1978).

Table II. Values of observed and expected (mean of simulated indices) niche overlap between *Milvus milvus* and *Milvus migrans,* and associated probability that observed overlap is major or equal to the expected between real and pseudo-communities applying both RA2 and RA3 algorithms. The indexes were calculated taking into account the 11 classes described in Tab. 1.

	Observed overlap	Mean of simulated indices		p (obs≥exp)	
		RA2	RA3	RA2	RA3
	Table				
Number	0.9752595	0.71539	0.46233	0.0000	0.0000
Weight	0.9740621	0.73229	0.44617	0.0000	0.0000

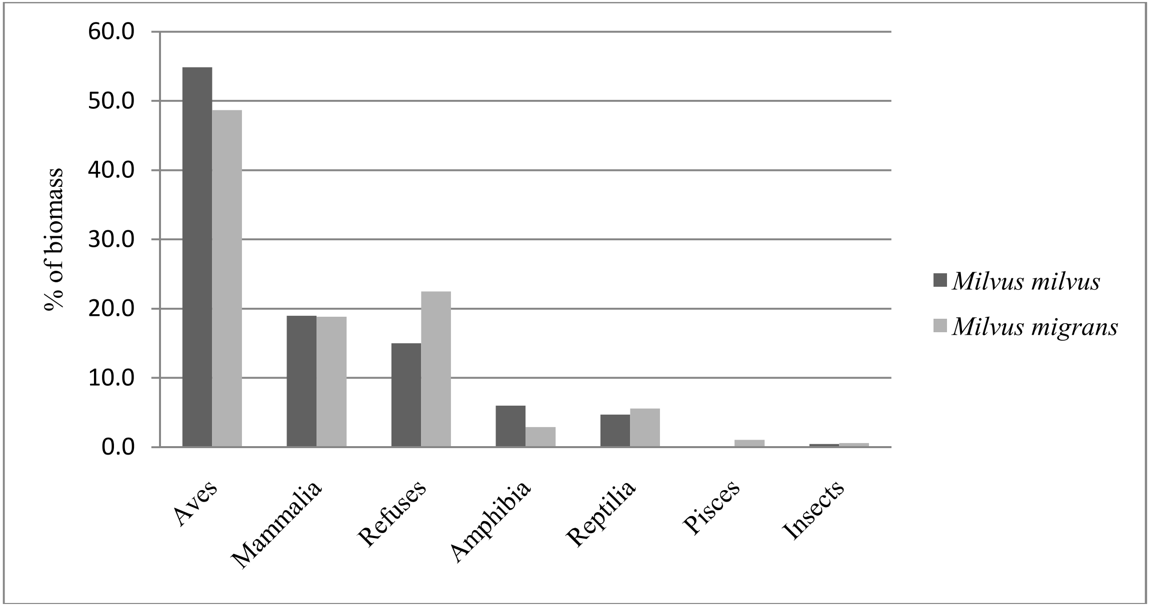

Figure 1. Biomass proportion of preys resulting from analyses in *Milvus milvus* and *Milvus migrans* diets in the Tolfa Mountains, 2009-2011.

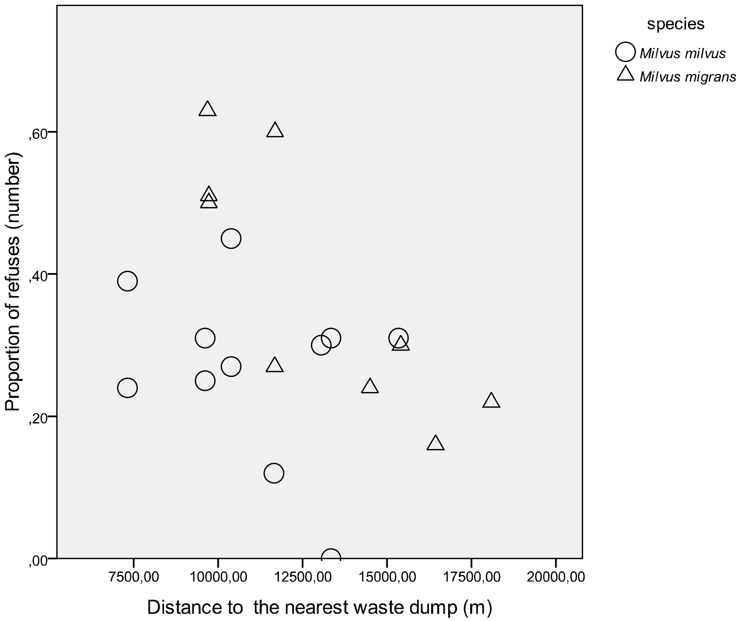

Figure 2. Relation between proportion in number of refuses consumed and distance from the nests to the nearest waste dump.

ARTICLE 3

Nest habitat selection by sympatric populations of Red Kite and Black Kite (*Milvus milvus* and *Milvus migrans*) in Central Italy

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Key words: Red Kite, Black Kite, phenology, breeding biology, nest dispersion, Central Italy.

ABSTRACT
We compared data on nest habitat of Red Kite (*Milvus milvus*) (RK) and Black Kite (*Milvus migrans*) (BK) breeding pair, collected during 2010-2012 in Tolfa Mountains (Central Italy) . Habitat features were measured within a circular plot of 0.04 ha (radius 11.29 m) surrounding the nest. Moreover GIS analyses were performed on habitat features within circular buffers of 200 m and 500 m ray around each nest by means of Land Use Map. Due to nest clustering usually observed in the study area, the variables measured at nest tree and within the plot showed only marginal differences, while the wide overlap of buffers around the nests didn't permit to detect significant differences.

INTRODUCTION

Two species of kite occur in Europe: Red Kite (*Milvus milvus*) (RK) and Black Kite (*Milvus migrans*) (BK). The geographic range of RK is restricted in the Western Palearctic region (Europe and North Africa), including the Cape Verde Islands where an almost extinct subspecies occurs. On the contrary, the BK, with six subspecies, is widely spread throughout the Old World and Australasia, and has been defined as one of the most numerous and successful birds of prey in the world (Brown and Amadon 1968). Both RK and BK were included in Annex I of the Bird Directive (2009/147/EC), but the former has a more unfavorable status (SPEC 2) than BK (SPEC 3), due to its recent decline in Central Europe (Birdlife International 2004, 2012).

Several factors negatively affect these species, either directly (shooting, poisoning, windfarms) or indirectly (landscape modifications, changes in land use). In the Tyrrhenian side of the Italian Peninsula the RK was widespread until middle 20th century (Cortone et al. 1994) but currently is both wintering and resident only in the Tolfa Mountains (Latium), a hilly area located 200 km from the nearest natural breeding populations (Abruzzo and Molise), apart from individuals recently re-introduced in Tuscany (Ceccolini & Cenerini 2007). The BK, summer visitor, also breeds in the Tolfa Mountains and in other parts of the Latium Region, often in loose colonies, close to waste dumps, lakes and along the Tiber valley (Guerrieri & De Giacomo 2012).

The two species share the following eco-ethological features: 1) an opportunistic feeding behavior, from scavenger to predator, on a large variety of food resources; 2) a variable breeding dispersion, with nests either clustered in loose colonies (sometimes including pairs of both species) or dispersed throughout suitable habitats, according to the distribution of food resources (Ortlieb 1989,1998, Sergio & Boto 1999, Mougeot & Bretagnolle 2006); 3) a tendency to

aggregate, particularly outside the breeding season, in wheeling flocks and in communal night roosts.
Research carried out in the past pointed out an overlap in food and spatial niches of the two species (Minganti & Panella 1991) and competition between the two species was suggested by some authors as a possible cause concurring in RK's decline in some regions of Central Europe (Birdlife International 2012).
The aim of this study was to compare the habitat characteristics of the nesting sites selected by the two kite species occurring in the same area, to detect differences or similarities among them, with the long term goal of predicting the land management effects on their conservation.

STUDY AREA

The study area (510 km^2) is located in "Monti della Tolfa" (Tolfa Mountains), within the north-western part of Latium Region (Central Italy). It ranges from the Tyrrhenian coast to about 25 km inland (N42° 08' 03.1'', E11° 56' 56.5'') and is characterized by a central relief of volcanic origin (up to 633 m a.s.l.) surrounded by lower sedimentary formations. The hilly landscape is engraved by a dense hydro-graphic network of intermittent or ephemeral streams ("fossi"), with marked seasonal regime, directly flowing into the sea or into the Mignone river, that runs throughout the eastern and northern sectors of the study area. The climate ranges from Mediterranean to Temperate, according to elevation and distance from the sea-coast, with hot dry summers and cool rainy autumns and winters; the average temperature during the year is 15.8°C, while annual rainfall fluctuates between 700

and 1000 mm, with a maximum in autumn and a minimum in July (Tommaselli et al. 1973).
The study area is included within the SPA (Special Protection Area) "Comprensorio Tolfetano-Cerite- Manziate (IT6030005) designated in 1995 by the Italian National Authority (Ministry of Environment) thanks to the presence of several species of Community interest (Annex I of the Birds Directive), including the two kites.
Data from Land Use Map (ARP 2010), indicate 2% (10 km^2) of urban areas, 35.5% (181 km^2) of farmland, 38.5% (197 km^2) of woodland, 7.5% (38 km^2) of grassland and 16.5% (84 km^2) of scrubland. Probably the extension of urban areas is underestimated, due to the rapid increasing in building activities both around villages and scattered over the territory, leading to changes land use from agricultural to residential. Extensive cultivations (wheat, corn) cover 87% of farmland, while vineyards, fruit trees and gardens cover most of the remaining agricultural territory. Most of woodlands are dominated by *Quercus cerris* sometimes in association with *Quercus ilicis* or *Quercus pubescens* (82% of wooded areas), the remaining by *Quercus ilicis* or *Pinus* in warmer and by *Fagus sylvatica* or *Castanea sativa* in cooler and moister areas. Except for small portions of ancient forest and neglected coppice (woodlots left unmanaged), forested areas are managed for firewood production by stool shoot regeneration (coppice system) on a 20-30 yr rotation basis, where single mature trees are kept into the next rotation as seed bearers. Wooded areas form a mosaic with shrub- and grassland (24% of the study area) where extensive livestock rearing (especially cattle, horses and donkeys, marginally sheep too, but only in open areas) is the main productive activity. After some small rubbish dumps inside the study area were closed in 80's, at present two active dumps are located out of the study area: Civitavecchia

and Bracciano, 12 km west and 20 km east from its center, respectively. A large number of Black Kite pairs, at least 20 in 2011 (inf. G. Prola), bred in proximity of the rubbish dump of Bracciano.

METHODS

Data collection

Surveys were carried out in 2010-2012 during the breeding season in order to locate the occupied breeding territories and active nests. Nest site locations were recorded by means of Garmin GPSMAP60CSx, and visited at least three times after hatching up to fledging to assess breeding success. Of 37 RK and 55 BK nests occupied in 2010-2012, only 16 RK and 21 BK nests were taken in the analysis, excluding, to avoid pseudo-replication, those located in the same territory in different years and possibly occupied by the same pair.
The habitat features were measured, out of the breeding season, at nest tree level and within a circular plot of 0.04 ha (radius 11.29 m) surrounding the nest (Mosher et al. 1987, Poirazidis et al. 2007, Sergio et al. 2003, Sergio et al. 2005). Within each plot the height of all trees was measured by means of TruPulse^{tm} 360R, Laser Technology, Inc telemeter and clinometers provided by ISPRA (Istituto Superiore per la Protezione e la Ricerca Ambientale).
Moreover, nest tree locations were entered in ArcGIS to analyse habitat features within two larger plots (buffers) of respectively 200 m and 500 m of ray around each nest, by means of digital cartography, including a Land Use Map (ARP Lazio 2010).

Statistical analysis

Variables were tested using Shapiro-Wilk test for normality, and normalized, when necessary, by transformation in natural logarithm or square root. A Pearson product-moment correlation coefficient (r) was computed between all pairs of variables in order to reduce the colinearity among them, and one variable was eliminated from pairs with *r* greater than 0.6 (Green 1979). The decision as to which variable was to be retained was based on the results of a one-way ANOVA, and was that with the greatest between-groups variance. Univariate one-way ANOVA models were performed to check for significant differences ($p<0.05$) between the two species in each of the remaining variables. Groups were compared by means of χ^2 test.

RESULTS AND DISCUSSION

Due to nest clustering usually observed in the study area, the variables measured at nest tree and within the plot showed only marginal differences, while the buffers around the nests revealed an excessive overlap, too large for detecting significant differences.

The major significant difference concerned the variable "mean diameter of trees in the plot" suggesting a preference of RK pairs for mature woods, while a larger proportion of BK pairs nested in more recently cut coppice stands.

Another significant difference is that all RK pairs used to nest in trees covered by ivy (*Hedera helix*). It may be explained by the fact that RK lays eggs before oaks and other deciduous trees burst into leaf, while ivy cover represents a good protection for incubating females.

An evaluation of habitat suitability in the Tolfa Mountains is needed to assess if nest clusters of kite pairs were determined by scarce availability of suitable sites or by other factors, even intrinsic factors, like the heterospecific attraction.

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Tab. 1. Comparison of nest tree and nest plot variables measured at Red Kite (N=15) and Black Kite (N=21) nests in the Tolfa Mountains, 2010-2012.

	mean	(SE)	median	mean	(SE)	median	test	p
Characteristics of nest tree								
Nest tree diameter at breast height (cm)	56.3	(3.53)	57.0	46.0	(3.64)	45	anova	0.057
Nest tree height (m)	19.9	(0.84)	20.0	19.0	(0.74)	19	anova	0.415
Nest height above the ground (m)	13.1	(0.65)	13.0	13.7	(0.59)	14	anova	0.517
	"0"	"1"		"0"	"1"			
Nest tree covered (1) or not (0) by ivy.	0	15		11	10		χ^2	0.003
Nest position nest on main trunk (0) or on lateral branch (1)	6	9		15	6		χ^2	0.123
Characteristics of the plot of 0.04 ha surrounding the nest tree	mean	(SE)	median	mean	(SE)	median		
Elevation of nest site above sea level (m)	269.9	(18.75)	278.0	242.3	(20.01)	260.0	anova	0.341
Orientation of the nest site, expressed as deviation from the east (sine)	0.29	(0.17)	0.45	-0.05	(0.15)	-0.04	anova	0.137
Orientation of the nest site, expressed as deviation from the north (cosine)	0.60	(0.11)	0.71	0.64	(0.09)	0.77	anova	0.804
Slope (degrees)	21.9	(1.82)	24.0	23.5	(1.95)	23.0	anova	0.554
Total number of live single trees and shoots with diameter >10 cm. (log n)	12.6	(1.95)	12.0	14.6	(1.96)	12.0	anova	0.370
Mean diameter at breast height (cm) of live trees, including both single trees and shoots with diameter >10 cm.	32.1	(2.51)	30.0	26.2	(1.49)	23.0	anova	0.041
Mean tree height (cm), including both single trees and shoots with diameter>10 cm.	14.9	(0.91)	14.0	13.4	(0.55)	13.0	anova	0.131
% of ground covered by shrubs. (log n)	32.0	(9.66)	10.0	44.1	(8.10)	30.0	anova	0.173
% of trees covered by ivy (1) or not (0).	36.0	(7.30)	25.0	30.3	(6.03)	25.0	anova	0.550
	"0"	"1"		"0"	"1"			
Number of stools <3 (0) or >3 (1)	8	7		11	10		χ^2	0.955
Mean number of shoots per stool <1 (0) or >1 (1)	5	10		5	16		χ^2	0.529

CONCLUSIONS

The following conclusions can be drown after three years of field research on the ecology of Red Kite (RK) and Black Kite (BK) in the Tolfa Mountains

1. Time overlap: phenology and breeding calendar

The Tolfa Mountains resulted to be a focal breeding area for populations of both RK and BK, but also an important wintering area for migrant RK.
Notwithstanding the clear shift in laying and hatching, a wide overlap was detected in the nestling period (approximately since 20 May to 20 June).

2. Space overlap: intra and interspecific nest dispersion patterns

RK nests were well spaced from each other; on the contrary, most of the BK pairs showed a clear trend to settle near conspecific and/or heterospecific breeding pairs.

3. Dietary overlap

Apart from the prevalence of refuses in BK, the two species are very similar in the exploitation of food sources, as shown by the statistically significant large trophic niche overlap.

4. Nesting habitat overlap

Due to nest clustering usually observed in the study area, the variables measured at nest tree and within the surrounding plot showed only marginal differences, while the buffers around the nests revealed an excessive overlap, too large for detecting significant differences.

Since no significant relation resulted between productivity of the two species and the interspecific nest dispersion, the detected wide overlap cannot be interpreted as an evidence of ecological competition, but rather as a high level of shared resources utilization.

More reliable analyses would be needed to estimate food resources availability, but the relevant niche overlap observed during the breeding season (spring-early summer) coincides with the period of the year characterized by the highest amount of preys (nestlings of other birds, snakes and large insects,). Moreover, although an evaluation of habitat suitability in the Tolfa Mountains is needed, the extension and distribution of the woodlands over the study area didn’t seem to represent a limiting factor, and the clustered interspecific nest dispersion could be due to other factors, even intrinsic, like the heterospecific attraction.

The complexity of the interspecific relations observed between the two species should be taken into account in planning raptor management and conservation actions.

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