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Breeding biology, behaviour, diet and conservation of the red kite (Milvus milvus), with particular emphasis on Mediterranean populations

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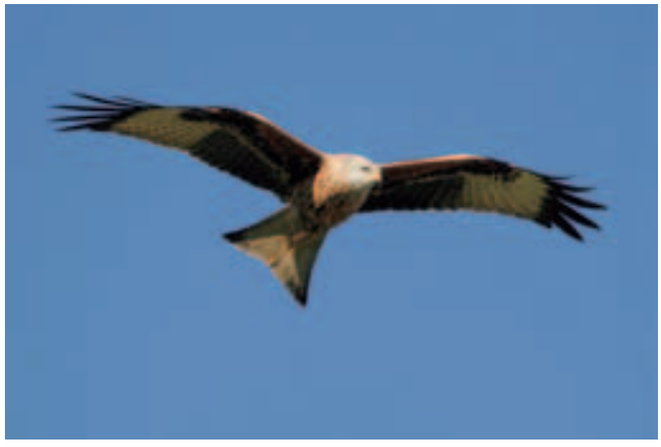
figIntroduction

The genus *Milvus* includes two main species of kites, the black kite *Milvus migrans* and red kite *Milvus milvus*. Both black and red kites are opportunistic raptors of open habitats (although they usually need fragmented forests and trees for breeding; Newton *et al.*, 1996; Carter, 2001), which favour extensive agricultural habitats where they forage and scavenge over a wide variety of food prey items (Cramp & Simmons, 1980; Carter, 2001; Sergio *et al.*, 2003). Conversely to the black kite, which is widely distributed over Africa *and* Eurasia and is probably the most abundant raptor in the world (Fergusson-Lees & Christies, 2001), the red kite is endemic to the western Palaearctic (distributed over only 2 million km^2), with a much smaller and declining world population. Red kite population estimates vary from 10,800-12,500 pairs with probably more than 100,000 individuals (Fergusson-Lees & Christies, 2001), to 19,000-25,000 pairs (BirdLife International, 2004) and most recently, to 20,818-25,409 pairs (Aebischer, 2009) or 19,000-23,000 pairs (42,000-51,000 individuals), in an area of 1,160,000 Km^2 (BirdLife International, 2009). Its main population strongholds are found in Germany, Spain and France, which host about 85% of the world population. Across most of its breeding range, the species has been declining in recent years, and especially so on the three countries that form the bulk of the world population: c. 25% decline in Germany (Mammen, 2000), 21% decline in France (Thiollay & Bretagnolle, 2004), and 30-50% decline in Spain (Viñuela *et al.*, 1999). Declines have been attributed mainly to habitat degradation and intensification, and to illegal killing through persecution and poisoning (Villafuerte *et al.*, 1998; Viñuela *et al.*, 1999; Carter, 2001; Wotton *et al.*, 2002). Because of the recent population declines in its main population strongholds and in the Mediterranean (Viñuela *et al.*, 1999) the red kite is now considered as a declining species (BirdLife International, 2004). However, some breeding populations have been increasing, for instance in Sweden and in Switzerland (Evans & Pienkowski, 1991), and in the UK where the species was re-introduced in England and Scotland (Carter & Newbery, 2004; Wotton *et al.*, 2002). Genetic studies have highlighted that the red kite has one of the lowest mitochondrial DNA diversities reported in birds of prey (Roques & Negro, 2005), probably as a consequence of recent population bottleneck events and range contractions in most European populations, particularly marked in small populations in the south-eastern part of the range and in island populations (Roques & Negro, 2005). Our aim here is to provide an overview of the current knowledge on the breeding biology, communicative behaviour, diet, and conservation status of the red kite, with particular emphasis on the conservation of Mediterranean populations.



Red kite flying prospecting. Sergio González Ahedo.

Breeding biology

Breeding habitat

Red kites breed in open wooded lands (forests or woods, or clumps of trees mixed with farmland, pastures or heath land), normally at low or medium altitudes. In Corsica, the red kite is mainly sedentary and breeds from sea level up to 1400 m, the highest density being usually found at altitudes less than 600 m (Thiollay, 1968; Patrimonio, 1990). Red kites nest in trees, coniferous or broad-leaved, in main fork or fork of a large branch, and

In flight displays of three red kites.

very rarely on cliff ledge (e.g. Cape Verde islands; Sicily). Each pair has several nests (2-5) and usually reuses the same nest site between consecutive seasons, but sometimes changes nest sites after a breeding failure. Red kites build their nest or use old nest of other species (buzzards or corvids). The nest is constructed with dead twigs, is typically 30-50 wide, and lined with dry (not green) vegetation and other materials (wool, paper, plastic, rags). In Corsica (Mougeot & Bretagnolle, 2006), most nests (84.9%) were built in oak trees (*Quercus viridis:* 51.3%; *Q. suber*: 19.3% and *Q. pubescens*: 14.3%), but kites used a wide range of tree species for breeding, including olive tree *Olea europaea* (10.1%), alder *Alnus cordata* (2.5%) and pine trees *Pinus spp.* (2.5%). Most nests were in isolated trees surrounded by Mediterranean bush (42.1%), or in small woods (37.3%), more rarely in forests (14.7%) or alongside streams (5.9%). Nesting tree height averaged 11.8 ± 4.6 m (range 6-20) and nest height 8.7 ± 3.7 m (range 5-18). In Germany (Ortlieb, 1989), nest height is between 4-30 m, typically 18-20 m. In central England (Carter, 2001), nest height is between 8-20 m (average 15 m).

Breeding density and nest dispersion

Breeding dispersion is not regular (the red kite being a loosely colonial raptor). Unlike its close relative, the black kite, which can breed in true colonies (Cramp & Simmons, 1980), the red kite is a facultative colonial breeder and forms loose breeding aggregations, especially when breeding at high density where food is abundant (e.g. Cramp & Simmons, 1980; Ortlieb, 1980). In Corsica (Mougeot & Bretagnolle, 2006), red kites breed at high densities (up to 1.8 pairs per km^2) and typically form loose colonies of 2-5 pairs. Similar densities and aggregations have been reported in optimal areas of Spain, Germany, and Switzerland (Viñuela *et al.*, 1999; Aebischer, 2009). Breeding pairs had their nest c. 450 m apart on average, but many nests were only 200-300 m apart, sometime as close as 50 m. Red kites bred on both large and small trees of various species, including isolated trees, so a limited availability of suitable trees for nesting is unlikely to explain the aggregation in loose colonies. Such aggregations of kite territories usually occur when food supply is abundant (Villafuerte *et al.*, 1998; Mougeot & Bretagnolle, 2006) and is facilitated by con-specific

attraction and potential benefits of nest clumping such as collective nest defence or the sharing of public information (see Sergio & Penteriani, 2005).

Age at first breeding

Red kites first breed at 3-4 years of age (sometimes at 2 years of age, exceptionally at 1 year of age, and sometimes as late as 7 years of age; Evans *et al.*, 1998; Carter, 2001). Adults can leave up to 26 years in the wild and up to 38 years in captivity (Carter, 2001). Young red kites (inexperienced breeders) have a lower breeding success than older birds (Evans *et al.*, 1999). Breeding productivity improves during the first years of life (between age 2 and 4; Carter, 2001).

Pair bond and extra-pair copulations

Once paired, red kites remain faithful to their territory, and stay together until a pair member dies, though divorces occur occasionally (Newton *et al.*, 1994). Polygamous breeding and trios have been rarely reported (Carter, 2001). Extra-pair copulations occur at high breeding densities. In Corsica, extra-pair copulations accounted for 3.5% of all copulations and concerned 15% of study females, all breeding with close neighbours (more than two breeding pairs within a 500-m radius around the nest site). Males use mate guarding to avoid extra-pair copulations and rely on frequent copulations to reduce the risk of extra-pair paternity (Mougeot, 2000).

Breeding performance

Egg-laying usually takes place in March-April (Table 34). In the Mediterranean (Corsica), laying is spread over almost three months, with earliest laying recorded on the 27th of February and the latest on the 22nd of May (Mougeot & Bretagnolle, 2006). Average laying date increases with latitude, but was not significantly related to longitude: red kites in the Mediterranean tend to lay

Table 34. *Average laying date and clutch sizes of red kites in western Europe (from Mougeot & Bretagnolle, 2006).*

Country, Region	Years	Laying date	References
UK, Wales	1946-1996	10 April	Newton *et al.* (1996)
Luxembourg	1991-1997	11 April	Kiefer (1998)
Germany, Hakel	1958-1993	13 April (858)	Mammen & Stubbe (1995)
Germany, Mansfeld-H.	-	10 April	*Traue 1978,* in Ortlieb (1980)
Switzerland, Broye	*1995-2003*	*15 April*	*A. Aebisher & GBRO (pers. com.)*
France, Corsica	1996-1999	27 March (137)	Mougeot & Bretagnolle (2006)
Spain, Menorca	1993-1998	18 March (53)	De Pablo & Madrid (1999)
Spain, Andalucia	1988-1989	7 March	Veiga & Hiraldo (1990)

Country, Region	Years	Clutch size	References
Sweden	-	2.8 (30)	*Rosenius 1974,* in Ortlieb (1980)
UK, Northern Scotland	1991-2000	3.0 (24)	in Evans *et al.* (1999) & Carter (2001)
UK, Northern England	1991-1995	2.9 (8)	in Evans *et al.* (1999)
UK, Wales	1946-1996	2.3 (746)	Cross & Davis (1998); Newton *et al.* (1996)
Germany, Mansfeld-H.	-	3.2 (10)	*Traue 1978,* in Ortlieb (1980)
Germany, Leipzig	-	2.8 (19)	*Meyer 1958,* in Ortlieb (1980)
Germany, Nordharz	-	2.7 (10)	*Haensel & Konig 1974,* in Ortlieb (1980)
Germany, Souabe	1960-1969	2.1 (109)	*Bauer & Bezzel 1971,* in Glutz *et al.* (1971)
Germany, Braunschweiger	-	2.8 (14)	*Warncke 1958,* in Ortlieb (1980)
Germany, Hakel	-	2.5 (37)	*Stubbe 1961,* in Ortlieb (1980)
Germany, Niedersachsen	-	2.8 (9)	*Basecke 1938,* in Ortlieb (1980)
Germany, Schwäbisch Alb	-	2.3 (-)	*Rockenbauch 1967,* in Ortlieb (1980)
France, East	1966	2.2 (20)	Thiollay (1967)
France, Corsica	1996-1999	2.4 (96)	Mougeot & Bretagnolle (2006)
Italy, Monti Tolfa	1981-1987	1.92 (13)	Arca (1989)
Spain, Menorca	1993-1998	2.7 (55)	De Pablo & Madrid (1999)
Spain, Andalucia (Donana)	1989-2000	2.33 (208)	Sergio *et al.* (2005)

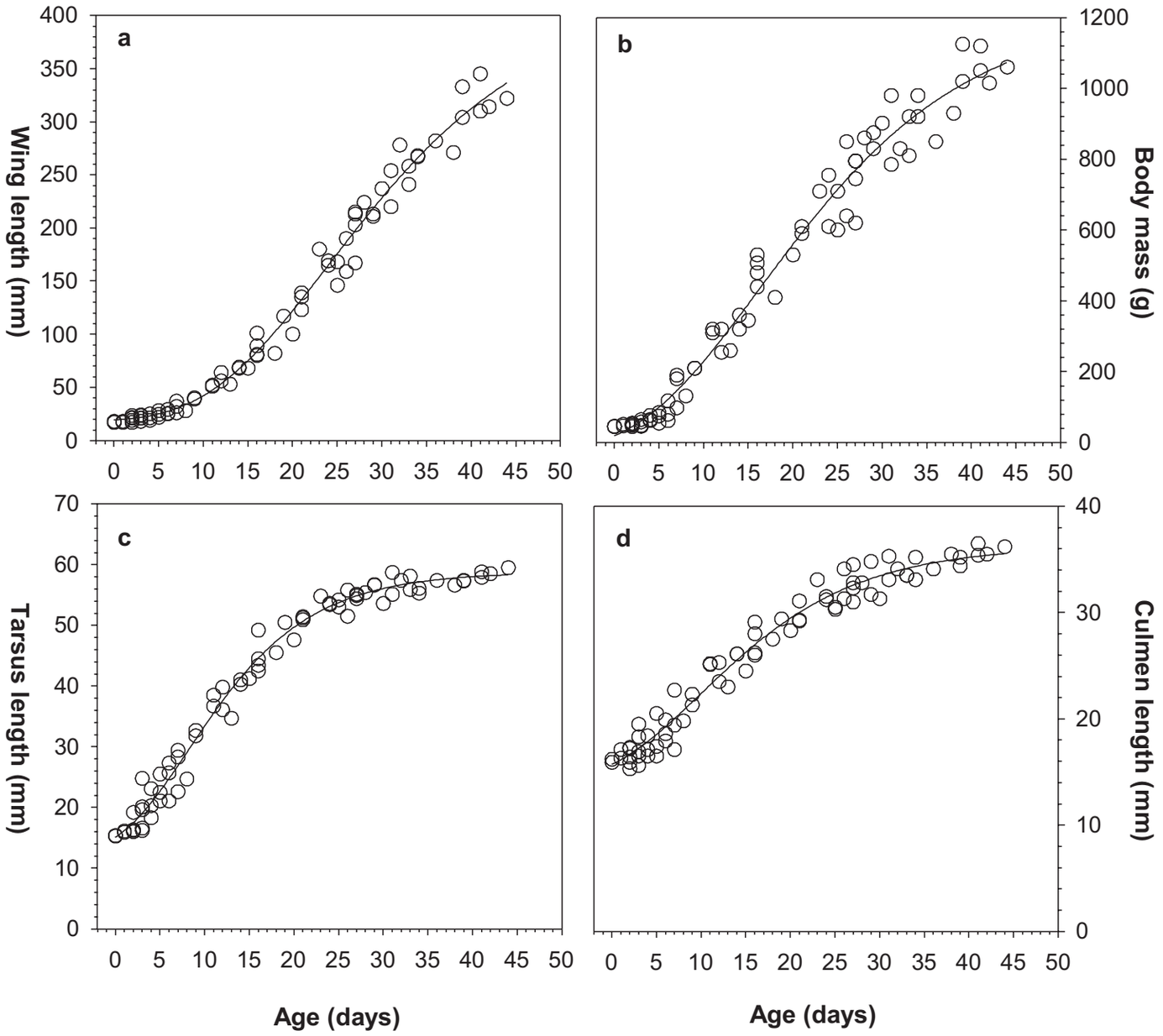


Fig. 46. *Growth curves of nestling (both sexes combined) red kites; a) wing length; b) body mass; c) Tarsus length; d) culmen (beak) length (from Mougeot & Bretagnolle, 2006).*

earlier than those breeding further north (Mougeot & Bretagnolle, 2006). Clutch size is typically 1-3 (up to 5). Mean clutch size data from study populations are summarized in Table 34. Clutch size did not vary significantly with latitude or longitude (Mougeot & Bretagnolle, 2006). Average clutch size in Corsica (2.44) is similar to the overall European clutch size (2.64), as it is in Menorca (2.7), another Mediterranean island, suggesting no evidence of an insular reduction of clutch size.

Each egg is laid every 2-3 days and incubated for 31-32 days. Incubation starts with the first- or second-laid egg, depending on clutch size. Hatching is asynchronous, and brood reductions occur when food supply is limited (Viñuela & Bustamante, 1992). Replacement laying occurs after early failure (Carter, 2001). The fledging period is variable (48-58 days, sometimes up to 60-70 days) depending on brood size and food abundance (Cramp & Simmons, 1980). Chicks are fed by both adults at least 2-3 weeks after fledging. Brood size is usually 1-4, with broods of 2-3 being most frequent. Brood sex-ratio, determined using molecular sexing of offspring, is not different from 1:1 (Carter, 2001). Growth curves (Fig. 46) have been described (see Viñuela & Bustamente, 1992; Viñuela & Ferrer, 1997;

***Table 35**. Productivity (mean number of young per breeding pair and per successful breeding pair) of breeding red kites in western Europe: average laying date and clutch sizes (from Mougeot & Bretagnolle, 2006).*

Country, Region	Years	Productivity		References
		YpBP[1]	*YpSBP*[2]	
Sweden	-	1.7 (1443)	1.98	in Evans *et al.* (1999)
Danemark	-		2.1 (54)	Jorgensen (1989)
UK, Northern Scotland	1991-2000	1.9 (153)		in Evans *et al.* (1999) & Carter (2001)
UK, Northern England	1991-1995	1.9 (59)		in Evans *et al.* (1999)
UK, English Midlands	-	1.6 (31)		in Carter (2001)
UK, Wales	1946-1996	0.7 (1061)		Cross & Davis (1998); Newton *et al.* (1996)
UK, Wales	1991-1998	0.9 (943)		in Carter (2001)
UK, Southern England	-	2.0 (292)		in Carter (2001)
Germany, Eastern	1988	1.8 (491)	2.31 (491)	Stubbe & Stubbe (2006)
Germany, Mansfeld-H.	-		1.7 (48)	*Traue 1978*, in Ortlieb (1980)
Germany, Kyffhauserg.	-		2.5 (13)	*Grimm 1975*, in Ortlieb (1980)
Germany, Nordharz	-		2.2 (18)	*Haensel & Konig 1974*, in Ortlieb (1980)
Germany, Schelswig-Holst.	1974-1975	1.7 (51)		in Gensbol (2005)
Germany, Rhine valley	1974-1975	2.2 (14)		in Gensbol (2005)
Germany, Brandenbourg	1974-1975	2.0 (24)		in Gensbol (2005)
Germany, Hildesheim	-		2.3 (18)	*Trillmich 1969,* in Ortlieb (1980)
Germany, Souabe	1960-1969	1.7 (109)		*Bauer & Bezzel 1971*, in Glutz *et al.* (1971)
Germany, Saaeleaue	-		2.3 (16)	*Koop 1971*, in Ortlieb (1980)
Germany, Hakel	1957-1967		2.2 (427)	*Wuttky 1968*, in Ortlieb (1980)
Germany, Mecklenburg	-		2.1 (27)	*Pflugbeil 1954* in Ortlieb (1980)
Germany, Schwäbisch Alp	-		2.2 (68)	*Rockenbauch 1967*, in Ortlieb (1980)
Switzerland, Broye	1995-2003	1.66 (368)	2.15 (284)	A. Aebisher & GBRO (pers. comm.)
Belgium	1985-1988		2.32 (19)	in Evans & Pienkowski (1991)
France, East	1966	1.3 (20)		Thiollay (1967)
France, East	2002-2008	1.25 (127)		LPO France *
France, North-east	1971-1982	1.4 0 (55)		in Mionnet (2004)
France, Champagne	1971-1982	1.51	1.86	in Evans & Pienkowski (1991)
France, Centre	2002-2008	1.43 (369)		LPO France *
France, Alsace	1997-2001	1.9 (17)		in Thiollay & Bretagnolle (2004)
France, Pyrenees	2002-2008	0.87 (62)		LPO France *
France, Corsica	1996-1999	1.3 (217)	1.7 (173)	Mougeot & Bretagnolle 2006
France, Corsica	2006-2008	1.16 (87)		LPO France *
Italy, North	1980s	0.60	0.77	in Evans & Pienkowski (1991)
Italy, Monti Tolfa	1981-1987	0.77 (13)	1.67 (13)	Arca (1989)
Spain, Menorca	1993-1998	1.6 (68)	1.9 (57)	De Pablo & Madrid (1999)
Spain, Andalucia (Doñana)	1989-2000	0.76 (208)	1.55 (208)	(Sergio *et al.*, 2005)

[1] *YpBP = Mean number of young fledged per breeding pair*
[2] *YpSBP = Mean number of young fledged per successful breeding pair*
** LPO France: see http://milan-royal.lpo.fr/population/population.html*

Mougeot & Bretagnolle, 2006) and are highly reliable for aging young kites during nest visits. Data on productivity (number of young produced per breeding pair or per successful breeding pair) from study populations are summarized in Table 35. Productivity is not related to longitude but increases significantly with latitude: on average, red kites in northern populations produce more fledglings than those in southern populations (Mougeot & Bretagnolle, 2006). This lower productivity is not related to lower breeding investment, as clutch size does not vary with latitude, and therefore it is likely that the lower productivity in southern Europe is due to higher brood reductions. The lower productivity in the southern part of the range might be because the

Red kite carrying carrion. Carlos González.

Mediterranean habitats and climate are not the most suitable for this species (Seoane *et al.,* 2003), which has the bulk of its populations further north, in continental Europe. In Corsica, there is a marked seasonal decline in clutch size, productivity and breeding success of red kite: kites breeding earlier laid larger clutches and had a higher breeding success than those laying later in the season (Mougeot & Bretagnolle, 2006). Such seasonal declines in breeding performance has rarely been documented in red kites (Davies & Newton, 1981).

Communicative behaviour during breeding

Communicative behaviour is a potentially useful tool for sexing birds that cannot be easily sexed from morphology, and for recording and quantifying the effects of various stressors on individuals, such as intra- and inter-specific interactions or human disturbances. A detailed analysis of the red kite communicative behaviour during the breeding season was conducted in Corsica (Mougeot & Bretagnolle, 1997). Like in most raptors, the roles of sexes during reproduction greatly differ, with male red kites providing food for female and young, and females contributing to most of the incubation and brooding (Cramp & Simmons, 1980; Mougeot, 2000; Carter, 2001). Red kite show very little sexual dimorphism in size or plumage, but because of the contrasted roles of sexes during breeding, differences in behaviour between sexes are noticeable (Mougeot & Bretagnolle, 1997).

Visual displays

The behavioural repertoire of breeding red kites includes 10 main ritualized visual displays (Fig. 47). These differ with respect to the position of the body axis and head, and the position of wings and tail (Table 36). In addition to these displays, red kites also exhibit an aggressive "foot showing display", seen during interactions at carrion (illustrated in Cramp & Simmons, 1980), and mutual bill gasping, observed between breeding pair members (pair bonding function).

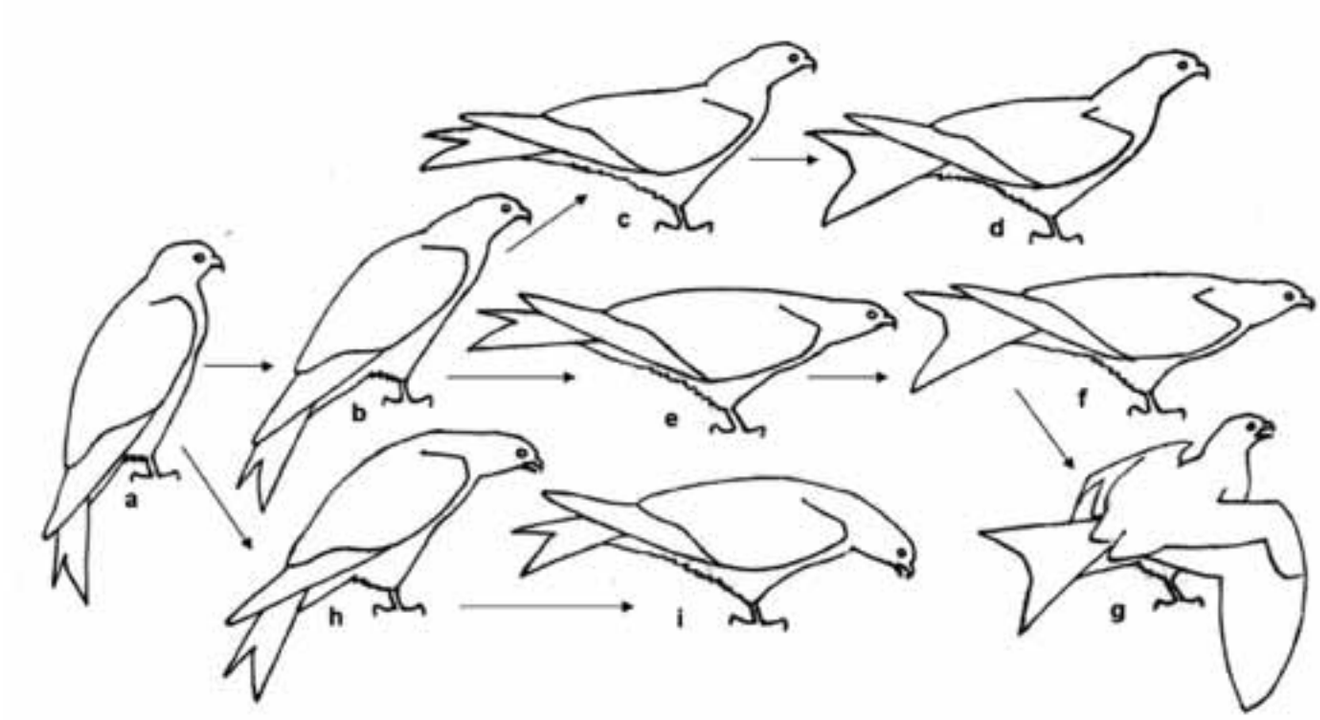


Fig. 47. *Visual displays of red kites. a) Resting = baseline display; b) Alert; c) Alarm low; d) Alarm high; e) Defence low; f) Defence high; h) Solicitation low; i) Solicitation high; g) Mantling (see also Table 36). Arrows indicate the most common progression between displays. Drawings by F. Mougeot.*

Table 36. *Description summary and interpretation of visual displays of perched red kites. All displays are illustrated in Fig. 47.*

Display[1]	Body axis	Head	Wings	Tail	Interpretation
1	Upright	Upright	Closed	Closed	Resting
2	Oblique	Oblique	Closed	Closed	Alert
3	Upright	Horizontal	Closed	Closed	Threatening
4	Oblique	Bowed	Closed	Closed	Solicitation low
5	Horizontal	Bowed	Closed	Closed	Solicitation high
6	Horizontal	Oblique	Closed	Closed	Alarm low
7	Horizontal	Oblique	Carpal exposed	Open	Alarm high
8	Horizontal	Horizontal	Closed	Closed	Defence low
9	Horizontal	Horizontal	Carpal exposed	Open	Defence high
10	Horizontal	Horizontal	Open	Open	Mantling

In flight displays

In addition to the visual displays of perched birds, red kites exhibit a range of displays in flight, which are mainly territorial displays (Mougeot & Bretagnolle, 1997). These included, in a progression from less aggressive to more aggressive: (1) escort flight (a flight parallel to that of an intruder, to follow it and drive it away from breeding territory); (2) exaggerated slow flight (a ritualized flight with slow flapping wings); (3) Chase (pursuit of an intruder with a rapid flight); (4) Dive bomb (dive towards an intruder); (5) talon grasping (short in flight contact with legs extended toward intruder and attempt to lock feet); and (6) mutual cartwheeling (in flight contact in which birds grab each others´ feet and gyrate downward with wings opened, sometimes felling to the ground). In addition, two other in flight displays are used for social play or between paired birds, and most likely have social or courtship functions: (7) Duo flights (pair flying together, wing to wing with synchronized soaring); and (8) "Zig-zag" flight (kites, usually males, flying down in zig zag over breeding territory and to the nest or a nearby perch).

Calls and vocal repertoire

Red kites are highly vocal on breeding sites. Numerous calls and variants have already been described (e.g. Glutz *et al.*, 1971; Cramp *&* Simmons, 1980). The vocal repertoire of breeding red kites consists of 7 main types of calls (Mougeot & Bretagnolle, 1997; Fig. 48). The commonest call is a mewing followed, or not, by a various number of whistling (usually 2 or 3, but sometimes more) and sometimes by another mewing (as illustrated in Cramp *&* Simmons, 1980). Two variants of the mewing call can be distinguished, according to degree of the modulation of the first syllable. In the 'Mewing calls' ('M', Fig. 48a-b), the first mewing is not modulated and short. They are performed by both males and females, and sometimes uttered mutually, in duets (Cramp *&* Simmons, 1980; Mougeot & Bretagnolle, 1997). In the 'Agonistic Mewing calls' ('AM', Fig. 48c-d), the mewing is longer, modulated, with decreasing fundamental frequency. The 'Alarm' or 'Distress call' ('AL', Fig. 48e, also described in Glutz *et al.*, 1971) consist in a higher

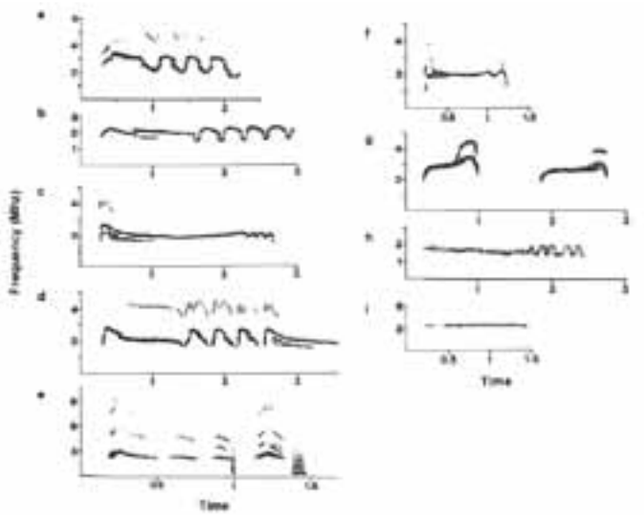


Figure 48. *Main calls of red kites. a) and b) Mewing calls; c) and d) Agonistic mewing calls; e) Alarm call; f) G-call; g) Solicitation call; h) Excited call; i) Copulation call. X-axis: time, in sec.; Y-axis: frequency, in Khz.*

The use of poison to prevent common vole population peaks can cause dramatic effects on red kites. In this case a northern water vole. Iñigo Zuberogoitia.

pitched, trembling mewing followed by shrilled whistlings. The 'G call' ('G', Fig. 48f) sounds like 'Glu-ui' or 'Glu-uu' and is mainly performed by females. The solicitation call ('SOL', Fig. 48g) is a succession of stressed notes sounding like 'UiiI'. It is only given by females to solicit prey delivery by the male or copulation. The 'Excited call' ('EX', Fig. 48h) is a long tremulous and waiving mewing given nearly exclusively by females to obtain food or copulation or when very excited. Other calls include a copulation call ('COP', Fig. 48i) and various calls of the chicks. Chicks perform a version of the individual call when 15 days old and have at least 3 types of begging calls. The vocal repertoire of juveniles is close to that of breeding females and include various mewing calls (the most frequently given calls), the 'G-call', the solicitation call ("food-call" in Cramp *&* Simmons, 1980), and a solicitation call high that resemble an excited mewing with rapid whistling.

Acoustic signals are associated with certain visual displays, in both males and females. For instance, the mewing calls are given mainly in Resting, Alert or Alarm displays, and in flight. The Agonistic mewing calls are given mainly in flight, and in Alert and Alarm displays. The G-call is given in Alert display. The solicitation call

Table 37. *Displays and calls used in an aggressive or territorial context (interactions with other kites) according to the distance between the intruder and the breeding nest. Sample size refer to the number of observations. For mewing calls (M) and agonistic mewing calls (AM), numbers refers to the number of modulations in the call (1, 2 or more than 2 for M1, M2 and M+ calls, respectively).*

Distance	Intra-specific interactions (red kite intruder)									
	<50m		<100m		<150m		<200m		Chi^2	P
Visual displays:										
Resting	13	(11.4)	66	(22.4)	160	(54.6)	70	(79.5)	61.5	***
Upright	41	(35.9)	137	(51.9)	101	(34.5)	16	(18.2)	17.05	**
Low Head	5	(4.4)	0	(0)	0	(0)	0	(0)	27.3	***
Horizontal	17	(14.8)	17	(6.4)	12	(4.1)	0	(0)	20.01	***
Alarm	2	(10.5)	6	(2.3)	1	(0.3)	0	(0)	34.2	***
Protection low	10	(8.8)	14	(5.3)	2	(0.7)	0	(0)	20.7	***
Protection high	2	(1.7)	3	(1.1)	0	(0)	0	(0)	5.45	ns
Take off	14	(12.3)	21	(7.9)	17	(5.8)	2	(2.3)	7.55	0.06
Total:	*114*		*264*		*293*		*88*			
In-flight displays:										
Low flight	69	(40.5)	123	(44.5)	140	(59.8)	10	(76.9)	7.2	0.07
Slow flight	7	(4.1)	21	(7.6)	23	(9.8)	1	(7.7)	4.03	ns
Escort	10	(5.9)	22	(8.0)	22	(9.4)	0	(0)	0.45	ns
Chase	44	(25.9)	73	(26.4)	27	(11.5)	1	(7.7)	2.56	ns
Dive bomb	17	(10.0)	26	(9.4)	19	(8.1)	1	(7.7)	5.15	ns
Talon grasping	15	(8.8)	9	(3.2)	3	(1.3)	0	(0)	14.6	**
Cartwheeling	8	(4.7)	2	(0.7)	0	(0)	0	(0)	16.6	**
Total:	*170*		*276*		*234*		*13*			
Calls:										
No call	23	(14.1)	58	(17.5)	45	(12.4)	13	(13.8)	2.65	ns
M	1	(0.6)	17	(5.1)	20	(5.5)	12	(12.8)	15.6	**
M 1	6	(3.7)	27	(8.1)	61	(16.9)	21	(22.3)	27.7	***
M 2	5	(3.1)	31	(9.4)	72	(19.9)	24	(25.5)	33.1	***
M +	19	(11.6)	40	(12.0)	32	(8.8)	13	(13.8)	2.3	ns
AM	36	(22.1)	80	(26.5)	45	(12.5)	7	(7.4)	17.8	***
AM 1	16	(9.8)	21	(6.3)	35	(9.7)	0	(0)	13.2	**
AM +	22	(13.5)	14	(4.2)	15	(4.1)	0	(0)	24.5	***
EX	7	(4.3)	8	(2.4)	10	(2.7)	1	(1.1)	2.5	ns
G	15	(9.2)	31	(9.3)	19	(5.3)	3	(3.2)	6.6	ns
AL	23	(14.1)	5	(1.5)	7	(1.9)	0	(0)	52.75	***
Total:	*163*		*332*		*361*		*94*			

is given exclusively by females and in Solicitation (low or high) displays. The copulation call is only given during copulations (Mougeot & Bretagnolle, 1997).

Functions of visual displays and calls

Displays and associated calls have two main functions, sexual (communication within breeding pairs) or agonistic (aggressive). For instance, solicitation displays (high and low) are given by females prior to copulation, or when the male is alighting with food and have primarily a sexual function. The G-call, solicitation call, and the exited call are mostly given in a sexual context. Alarm and protection displays are given when intruders (kites, buzzards, corvids) approach the nest site and are aggressive, territorial displays.

When considering how kites respond to an approaching intruder (Table 37), there is a clear progression of agonistic displays and aggressive calls: the closer the intruder, the more threatening and aggressive the displays (from alert, to alarm, to defence low and defence high displays; Table 37). Similarly, the closer the intruder, the more the mewing calls are modulated, and the more syllables they have, and the more frequent are agonistic mewing calls (increased motivation or aggressiveness). Some territorial interactions end up in dive bomb, talon grasping and cartwheeling displays in flight (Table 37). Communicative behaviour is strongly ritualised, making it potentially useful for recording responses to disturbances (including human disturbances). The importance of motivational displays might be related to the habit of red kites to breed in loose colonies, and to aggregate at roost sites in the non-breeding season: red kites use a range of warning signals before fights eventually occur (Mougeot & Bretagnolle, 2007).

When considering displays and calls according to their function (aggressive *versus* sexual), there are some marked differences between sexes (Table 38). Solicitation displays and calls, and the excited call are given only by females in a sexual context, and agonistic mewing calls are given more frequently by males than females in an aggressive context (Table 39).

Diet

The diet of the red kite is one of the best examples, among raptors, of within-species plasticity in foraging behaviour and food consumption. Although the species is usually classified as a scavenger due to a frequent consumption of livestock carrion (Cramp & Simmons, 1980; Lovegrove *et al.*, 1990), it also feeds on small mammals, birds, reptiles, amphibians, insects and fish species (e.g. Veiga & Hiraldo, 1990; García *et al.*, 1998). The observed diversity in food

Table 38. *Sexual dimorphism in displays and calls of red kites used in a sexual or agonistic (aggressive) context. Sample size refer to the number of observations.*

	Sexual context					Agonistic context				
	Male (%)		Female (%)		p	Male (%)		Female (%)		p
Resting	40	(36.4)	139	(31.7)	ns	52	(19.5)	280	(48.8)	***
Upright	27	(24.5)	25	(5.7)	***	123	(46.2)	224	(39.0)	ns
Alert					-	5	(1.9)	15	(2.6)	ns
Alarm	0	(0)	5	(1.1)	ns	6	(2.3)	16	(2.8)	ns
Horizontal	20	(18.2)	46	(10.5)	ns	36	(13.5)	30	(5.2)	***
Solicitation low	10	(11.8)	128	(29.2)	**	0	(0)	0	(0)	-
Solicitation high	13	(9.1)	95	(21.5)	**	0	(0)	0	(0)	-
Protection low						44	(16.5)	9	(1.6)	***
Protection high						5	(1.9)	2	(0.35)	ns
Total:	*110*		*438*			*266*		*574*		
No call	91	(45.7)	185	(32.1)	*	73	(16.6)	119	(16.9)	ns
M	80	(40.2)	146	(25.3)	**	89	(20.2)	329	(46.7)	***
AM	4	(2.0)	19	(3.3)	ns	213	(48.4)	110	(15.6)	***
AL	0	(0.0)	9	(1.6)	ns	25	(5.7)	49	(7)	ns
G	24	(12.1)	32	(5.5)	**	22	(5.0)	70	(9.9)	**
EX	0	(0.0)	139	(24.1)	***	10	(2.3)	27	(3.8)	ns
SOL	0	(0)	47	(8.1)	***	0		0		
Total:	*199*		*577*			*440*		*704*		

Table 39. *Diet of red kites in different populations and seasons (occurrence, in %). B=Breeding period; W= wintering period; MA = mammals; BI = birds; RE = reptiles; AM = amphibians; IN = invertebrates; CA = carrion; FI = fish. Data type: B= percentage of Biomass; P= occurrence in pellets; IT= percentage of prey items.*

Source	Country	Site	Data type	Period	Food category						
					MA	BI	RE	AM	IN	CA	FI
Delibes & García (1984)	Spain	Southern plateau	IT	B	34	32	17	0,3	7	4	3
Veiga & Hiraldo (1990)	Spain	Southern plateau	IT	B	32	37	11	0,9		5	12
Sunyer & Viñuela (1994)	Spain	Northern plateau	B	W	45	14			3	39	
Davis & Davis (1981)	Wales	Central Wales	P	B	58	44		1	14	75	
Davis & Davis (1981)	Wales	Central Wales	P	W	60	25			8	62	
Blanco *et al.* (1987)	Spain	Southern plateau	IT	W	22	51	0,6		26		
Blanco *et al.* (1990)	Spain	Southern plateau	IT	W	17*	30*	1		24	>30*	
Ortega & Casado (1991)	Spain	Southern plateau	IT	W	60	22	0,1			17	
García *et al.* (1998)	Spain	Northern plateau	IT	W	24	10	0,2	0,2	8	55	
García *et al.* (1998)	Spain	Southern plateau	IT	W	34	30	0,6	0,2	2	31	
Blanco *et al.* (2006)	Spain	Northern plateau	P	W	26	9,5			3	30	
Blanco *et al.* (2006)	Spain	Southern plateau	P	W	81	8,5			6	4	
RSPB (2002)	England	Midlands	P	W	68	11			7		
RSPB (2002)	England	Midlands	P	B	61	24					

* Authors did not distinguish between preys consumed as carrion or not (data on carrion were estimated according to type of prey described by the authors: large mammals, > 1000g, and geese).

consumption (Table 39) seems to be related to temporal and geographical differences in the availability of different food sources (García *et al.*, 1998; Villafuerte *et al.*, 1998), but is also related to individual specialization (Davies & Davis, 1973; Viñuela *et al.*, 1999), and varies seasonally (García *et al.*, 1998; Mougeot & Bretagnolle, 2006), leading to a pattern of food consumption somehow unexpected for a raptor species with such a restricted range.

The red kite feeds on a wide variety of carrion, the best known being livestock carcases usually dumped at feeding stations or dumps for dead livestock *("muladares")* or areas adjacent to livestock farms (Valet, 1975; Davis & Davis, 1981; García & Viñuela, 1999), and also game carcasses left by hunters (García *et al.*, 1998). Livestock carcasses included pigs *Sus spp.*, sheep *Ovis aries*, cow *Bos taurus*, goat *Capra spp.*, horse *Equus spp.*, farmed chicken *Gallus spp.*, and farmed rabbits *Oryctolagus cuniculus*. Game carcasses included hares *Lepus spp.*, wild rabbits, deer *Cervus spp.*, wild boar *Sus spp.*, woodpigeons *Columba spp.*, Partridges *Perdix spp.*, *Alectoris spp.*, and pheasants *Phasianus spp.* Birds also form an important part of the diet, especially nestlings of a wide range of bird species, but also adults consumed alive or as carrion; these include different species of *Corvidae*, *Columbidae*, *Sturnidae*, *Turdidae*, *Anatidae*, *Ansaridae*, *Passeridae*, *Rallidae*, *Falconiformes*, *Strigiformes*, and *Laridae* (Cramp & Simmons, 1980; García *et al.*, 1998).

Red kites also prey on a wide range of mammals especially small rodents *(Microtus spp., Clethrionomys spp., Arvicola spp., Apodemus spp., Mus spp.),* brown rats *Rattus norvegicus*, hamsters *Cricetus cricetus*, muskrats *Ondatra zibethicus*), shrews *(Sorex spp., Crocidura spp.),* mole *Talpa europaea*, hares *Lepus spp.*, rabbits *Oryctolagus cuniculus*, and as carrion, hedgehogs *Erinaceus europaeus*, squirrels (*Sciuridae*), dogs *Canis lupus*, red foxes *Vulpes vulpes*, stoats *Mustela erminea*, European polecats *M. putorius*, domestic cats *Felis catus* and deer *Cervus spp.* (Cramp & Simmons, 1980). In Germany, and other countries of central Europe, rodents, particularly voles and hamsters, are often the basic prey (Hille, 1995; Aebischer, 2009).

Reptiles and amphibians occur in low proportion in the diet (Table 39), as well as fishes, which are captured mainly dead, dying or injured (Cramp & Simmons, 1980). Among reptiles, red kite prey on lizards *Lacerta spp.*, snakes *Natrix spp.*, and slow-worms *Anguis fragilis*. Among amphibians, frogs and toads from which *Rana spp.*, *Pelobates spp.* and *Bufo spp.* were the main prey, whereas identified fish species included roach *Rutilus rutilus*, carp *Cyprinus carpio*, crucian carp *Carassius carassius*, tench *Tinca tinca*, perch *Perca fluvialis*, pike *Esox lucius*, brown trout *Salmo trutta*, eel *Anguilla anguilla*. Red kites feed also on invertebrates, including grasshoppers (Orthoptera) and beetles (Coleoptera), but also *Formicidae*, *Acrididae*,

Gryllidae, *Gryllotalpidae*, *Miriapoda*, *Embioptera*, and *Dermaptera* (Cramp & Simmons, 1980; García *et al.*, 1998). Earthworms are an important food item in some populations, such as Wales (Davies & Davis, 1981).

A large body of literature on the diet of this species showed a general pattern of exploiting temporary very abundant food sources. For example, red kites prey upon rabbits whenever they are abundant and accessible in Spain (e.g. Veiga & Hiraldo, 1990). Rabbits represented 67–77% of the prey remains found at nest sites in Corsica (Mougeot & Bretagnolle, 2006), 30% in Doñana (Spain) during breeding (Delibes & García, 1984), 24% in Wales (Davis & Davis, 1981) and 50% of feeding observations during winter in England (RSPB, 2002). In Spain, the consumption of common voles *Microtus arvalis* in periods of population outbreaks of this prey reached 42% of prey items identified in pellets and 47% of total biomass (Sunyer & Viñuela, 1994). Greylag geese *Anser anser* carcasses were dominant (43% of biomass) in the diet of red kites in Doñana (southern Spain) during dry periods (Blanco *et al.*, 1990), when there was a high mortality of waterfowl species. This high dependence on a tem-

Red kites are likely to accumulate toxins and pollutants due to their trophic behaviour. Roberto González.

porally abundant food source leads to large variations in diet composition between distant populations, to marked seasonal variations, and also to differences between years within populations (e.g. Davis & Davis, 1981; García *et al.*, 1998; Blanco *et al.*, 2006). However, some general patterns in food consumption can be extracted from the published literature (Table 39), with rabbits and birds being more common in the spring diet than in the winter diet (Davis & Davis, 1981). Carrions appear more frequent in diet during the winter than during the breeding period (e.g. García *et al.*, 1998).

Dependence on livestock and game carcasses exposes the species to changes in habitat use and human activities, such as agriculture, farming, hunting or sanitary policies. The problem could be especially important in populations and/or years in which the consumption of livestock carrion is predominant in the diet. In Wales, for example, the analysis of pellets collected during April to August between 1975 and 1979 revealed that red kites consumed 75% of sheep remains (Davis & Davis, 1981). In Spain, red kites are also heavily dependent on livestock carrion during winter (reaching more than 50% of biomass in the northern Plateau; Sunyer & Viñuela, 1994; García *et al.,* 1998). More recently, Blanco *et al.*, (2006) found carrion food occurred in 75% of pellets collected in Segovia (northern Spanish plateau). Other problems derived from the consumption of livestock and game carcasses include chemical pollutants ingestion, lead poisoning, ingestion of residues of veterinary drugs and increase risk of transfer of diseases (Blanco *et al.*, 2006; Jiménez *et al.*, 2007; Gómara *et al.*, 2008) that makes the species particularly vulnerable to human impacts due to its feeding habits.

Population trends and conservation

Population estimates and trends

More than 95% of red kites populations are within European borders. The most important natural populations are in Germany, France and Spain, and have declined in the last two decades. Consequently, the species has been recently listed as "Near Threatened" in the IUCN Red list (BirdLife International, 2009). However, the reintroduction program in UK, which started in the 80s, had an impressive success, to the point that the current population in the British Isles is approaching the number of birds in Spain, one of the countries that provided fledglings to be released on that program. Other marginal populations in northern and central Europe have notably recovered in the same period, so it is possible that if these trends hold in the near future, the species may be down listed (BirdLife International, 2009).

The Mediterranean basin can be considered the current southern limit of the red kites´ distribution. The species became extinct from the Canary Islands in the 70s (Viñuela *et al.*, 1999). The taxonomic status of the Cape Verde Islands subspecies *fascicauda* has been recently reviewed, and the true existence of this particular taxon has been challenged (Johnson *et al.*, 2005). Whatever the true taxonomic status of that island variety, its population has probably vanished in recent years (Hille & Thiollay, 2000; Aebischer, 2009). Most red kite populations in the Mediterranean suffered declines since at least 50 years ago (Viñuela, 1996). According to Aebischer (2009), the only Mediterranean countries currently holding significant populations are Portugal, Spain, France and Italy (Table 40). The species has disappeared from Albania, Egypt, Greece, Lybia, the Middle East, Romania, Tunisia, Turkey and the Balkan countries (Table 40). Some isolated pairs may still remain in Algeria, Bulgaria, Morocco, and Serbia (Table 40).

In France, the population was estimated at 2300-2900 pairs in the 80s, and the species showed a clear range expansion up to the early 90s (Viñuela, 1996). In the national raptor census of 2000-2002, the French population was estimated at 3000-3900 pairs, by this higher figure was probably due to an improvement of census coverage and methodology, rather than a real increase. The species recovered its populations between 1975 and 1990 (Mionnet, 2004; Millon & Bretagnolle, 2004), but since the early 90s, large population declines, particularly in the North East of France, were detected (Fombonnat, 2004; Malenfert, 2004). In 2008, a specific national red kite census indicated a population decline of 21% with respect to 2000-2002 numbers (Bretagnolle & Pinaud, 2009).

In Germany, after a period of population recovery during the 70s and 80s, a dramatic population decline occurred between 1990 and 1997. Afterwards, the population stabilized at lower numbers (Nicolai, 2006; Stubbe & Stubbe, 2006; Nicolai *et al.*, 2009). The last available information for the whole country dates back to 2000, and more recent information (later than 2006) is lacking.

Finally, in Spain two national censuses have been conducted in 1994 and 2005, indicating a dramatic

Table 40. *Population trends of red kites in the Mediterranean basin. Population estimates in the early 90s (reviewed by Viñuela, 1996) are compared with the most recent estimates (Aebischer, 2009).*

Country	Number of pairs in the early 90s	Current number of pairs (2009)	Recent trend
Algeria	0?	0-1	Extinct?
Bulgaria	1-4	0-1	Recently extinct?
Croatia	4-5	0	Recently extinct
Egypt	0	0	Extinct
France (continental)	2300-2900	3000-3900	Large recent decline*
France (Corsica)	100-180	208-277	Large increase
Greece	0	0	Extinct
Italy (continental)	110-140	312-426	Large increase
Italy (Sardinia)	<20	15-20	Large decline, recently stable
Italy (Sicily)	10-12	5-10	Going to extinct
Lybia	0	0	Extinct
Middle East	0	0	Extinct
Morocco	Maximum 20	0-10	Almost extinct
Other Balkanian countries	0	0	Extinct
Portugal	100-200	36-67	Large decline
Romania	15-20	0	Recently extinct
Serbia	0?	0-5	Extinct?
Spain (continental)	3328-4044	1994-2167	Large decline
Spain (Balearic I.)	41-48	38	Decline
Turkey	??	0	Extinct

* See text for the case of continental France.

decline of c. 50% in 11 years (Viñuela *et al.*, 1999; Cardiel, 2006). Spain also holds significant proportions of wintering red kites that migrate from northern and central Europe. Thus, the conservation problems affecting resident birds could also be affecting the wintering population (Hiraldo *et al.*, 1995; Viñuela & Villafuerte, 2003).

Conservation problems

It is already widely accepted that the main conservation problem of the species is poisoning, due to its feeding habits (Viñuela *et al.*, 1999; Newbery *et al.*, 2009). The red kite is considered a generalist searcher, catching mainly easy prey, and a facultative carrion-eater. This life style implies that red kites easily detect poisoned baits (direct poisoning) or readily take animals affected by poison (indirect poisoning) (Viñuela *et al.*, 1999; Carter, 2001; Berny & Gaillet, 2008). The illegal use of poison for predator control is a serious problem in Spain (Villafuerte *et al.*, 1998), where 435 red kites were found poisoned between 1990 and 2005, with an estimated number of kites that could have died from poising in that period of more than 14.000 (WWF/ADENA, 2006). For similar reasons, red kites are particularly exposed to secondary poisoning during rodent control campaigns in rural areas that are usually developed using large amounts of anticoagulant rodenticides (Viñuela *et al.*, 1999; Carter, 2001; Newbery *et al.*, 2003; Ntampakis & Carter, 2005; Berny & Gaillet, 2008). Between 1994-1995, large numbers of dead red kites were found during poisoning campaigns in Castilla y León (northern Spain) aimed at controlling outbreaks of common voles *Microtus arvalis* (Viñuela *et al.*, 1999). Castilla y León is one of the main wintering areas of red kites in Spain, and the vole control campaign was mainly conducted in winter, so it likely affected kites from northern populations that winter there (Hiraldo *et al.*, 1995). Mortality in the Spanish winter quarters could partially explain recent population declines in Germany and France. In countries where red kites are mainly sedentary, the breeding populations are recovering (Sweden and Denmark, where red kites have less marked migratory habits, mainly due to food provisioning during winter; UK, where the populations seems to stay within the island; Italy, where the red kite is also sedentary or migrates to northern Africa, or Corsica, where red kites are sedentary). Between 1997 and 2007, no vole outbreak was reported in Spain. However, between 2006 and 2007, a significant vole outbreak occurred in Spain, and hundreds of tons of rodenticide were released to the

field, affecting several non-target species (Olea *et al.*, 2009). Red kite breeding populations were surveyed by road transects in Castilla y León in 2004 and 2008 (Cardiel, 2006; IBERIS, 2008), two years before and the year after the large-scale rodenticide treatments were implemented. The comparison of breeding numbers between areas with different vole densities (different intensities of rodenticide treatments) indicate that these large-scale rodent control campaigns negatively impacted on red kite populations (Table 41).

Other important conservation problems, at least in Spain, are related to feeding habits and the consumption of livestock carrions. Recent studies have highlighted the problems caused by veterinarian drugs (antibiotics or fluoroquinolones) or pathogens consumed in carrions (Blanco *et al.*, 2006; Lemus *et al.*, 2009). Given that this is a food source of prime importance for the species, these can be conservation problems of overlooked importance up to now.

Besides those two key conservation problems, red kites are also affected by diffuse contamination, lead poisoning, illegal shooting, agrarian habitat transformation, wind turbines, traffic collisions (in roads and railways), electrocution in powerlines, and competition with black kites (*Milvus migrans*) (Viñuela *et al.*, 1999; Gómara *et al.*, 2002, 2008; *Bright et al.*, 2008; Carter, 2001; Hegemann & Knuewer, 2005; Sergio *et al.*, 2005; Stubbe & Stubbe, 2007; Jana & Pogacnik, 2008). For instance, casualties on railways in Germany were estimated at 20,000 raptors per year following a conservative estimation (Mammen *et al.*, 2006).

Action plan

An Action Plan for the red kite has been recently delivered to the European Commission by the Royal Society for the Protection of Birds (UK) and BirdLife International (Newbery *et al.*, 2009). The highest priority is given to actions aimed at reducing mortality through the illegal use of poison and by rodent control campaigns. Countries where red kite populations are recovering use to have national programs to increase food availability by means of disposal of livestock remains coming from farms or slaughterhouses. This strategy may also help to reduce poisoning or sanitary risks by providing safe food, and must be urgently considered by other countries, such as Spain, where this type of feeding places have been recently greatly reduced in numbers, or do not have good sanitary conditions (Blanco *et al.*, 2006; Lemus *et al.*, 2009).

Table 41. *Changes (%) in the number of breeding red kites in Castilla y León according to vole density between 2004 and 2008 in 43 natural regions (from Cardiel, 2006 and IBERIS, 2008). Vole density classes were as follows: 1) High vole density regions: where vole plague reached a maximum, and three vole control (rodenticide) campaigns were implemented (spring 2007, summer 2007, and February-April 2008; see details in Olea et al., 1999); 2) Low-medium density: only one or two vole control campaigns implemented; 3) No vole plague: no vole plague detected, no poison extensively used. Data on vole density are from IBERIS (2008), ITACYL, and own unpublished field data. The change in estimated red kite population between 2004 to 2008 was significantly explained by vole density (ANOVA, $F_{2,40}=3.29$, $P = 0.048$).*

Vole density	No of regions	Population 2004 (pairs)	Population 2008 (pairs)	Average % change
High	7	205	59	-42.4 %
Low-medium	17	401	194	-27.1 %
No vole plague	19	563	607	+28.5 %