Short Communication

Effects of land use, nesting-site availability, and the presence of larger raptors on the abundance of Vulnerable lesser kestrels *Falco naumanni* in Kazakhstan

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Abstract The lesser kestrel *Falco naumanni* is a cavity-nesting falcon that breeds colonially in steppe-like habitats. Circum-Mediterranean populations declined sharply during the 20th century and the species is categorized as Vulnerable on the IUCN Red List. We investigated the numbers of breeding pairs in Kazakhstan, previously considered to be an important area for the species, where it still inhabits natural steppe and semi-natural grasslands and breeds on cliffs. The availability of cliffs for nesting does not seem to be limiting as most cliffs are unoccupied. However, lesser kestrels tended to breed on small cliffs, where larger predatory raptors are scarcer. Abundance of lesser kestrels was also related to land use. Cliffs in semi-natural grasslands were apparently preferred over those in natural steppe, while those in agricultural landscapes were avoided despite the lower presence there of larger raptors. Large-scale transformation of steppe and grasslands into intensive agriculture might have reduced lesser kestrel numbers, and with the development of new agricultural projects, monitoring and conservation programmes for lesser kestrel populations are urgently required in Kazakhstan.

Keywords *Falco naumanni*, Kazakhstan, land use, lesser kestrel, nest sites, predation.

The lesser kestrel *Falco naumanni* is a cavity-nesting falcon that breeds colonially in steppe-like habitats. Circum-Mediterranean populations declined sharply during the 20th century and the species is categorized as Vulnerable on the IUCN Red List (BirdLife International, 2000; IUCN, 2003). Most research on the lesser kestrel has been conducted in Spain, a country in which the species has undergone one of its largest population declines but that still holds the largest European population (Atienza & Tella, in press). These studies have indicated that the loss of traditional agropastoral systems, causing a reduction of foraging habitats and prey availability, was the main cause for the species' decline (Tella *et al.*, 1998). This may not be the case, however, for the lesser kestrel in other parts of its breeding range. European landscapes have been extensively modified by centuries of agricultural development, with most populations surviving in former steppe habitats transformed into large areas of cereal crops, and the original cliff-nesting habit of the species has been abandoned, with most colonies now sited in buildings. Breeding in buildings reduces nest predation, but urban spread reduces breeding success because of a reduction in foraging habitats surrounding the colonies (Tella *et al.*, 1998).

Little is known of the breeding ecology of the lesser kestrel in Asian countries such as Kazakhstan, where the species still breeds in relatively intact steppe habitats and uses cliffs for nesting (Korelov, 1962; Zollinger & Hagermeijer, 1994; Parr *et al.*, 2000). In order to provide an insight into the conservation problems facing this species in areas other than the heavily developed landscapes of Europe, we investigated the relationships between land use, nest site availability, presence of larger raptors and the abundance of breeding lesser kestrels in Kazakhstan.

The study was conducted in a large area of south-east Kazakhstan (Fig. 1) that has been identified as one of the main breeding areas for lesser kestrels in the country (Zollinger & Hagermeijer, 1994; Parr *et al.*, 2000). The area has a continental, arid climate, and a landscape dominated by steppe habitats, transformed in many

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Fig. 1 The study area in south-east Kazakhstan; the solid lines indicate the routes used for the surveys.

areas by agriculture (for further details of the study area, see Sánchez-Zapata *et al.*, 2003). Surveys were carried out during 12–28 June 1999 and 1–16 June 2003 by driving along *c.* 1,300 km of mostly unpaved roads and tracks (Fig. 1). Most of the cliffs observed within 500 m of the route were carefully inspected to locate breeding raptors; 1–4 hours were spent at each cliff, depending on its size and complexity, with 3–6 experienced researchers walking along the cliff, and observations were also made with telescopes. Breeding was determined by reproductive behaviour and/or the presence of nests with eggs or chicks. We recorded the number of breeding pairs of lesser kestrels as well as of larger raptors that could affect the distribution of the lesser kestrel: saker falcon *Falco cherrug*, peregrine falcon *Falco peregrinus*, golden eagle *Aquila chrysaetos*, steppe eagle *Aquila nipalensis*, long-legged buzzard *Buteo rufinus* and eagle owl *Bubo bubo*. The height of each cliff was placed into one of four categories: (1) up to 5 m, (2) 5–10 m, (3) 10–20 m, and (4) >20 m. The habitat around each cliff was classified into agricultural landscapes (dominated by cereals and irrigated crops, managed pasturelands and human settlements), semi-natural grasslands (with extensive livestock, some abandoned fields and degraded steppe), and natural steppe.

We first explored the relationships between number of breeding raptors, cliff size, and habitats using non-parametric tests. Then, we employed Generalized Linear Models (GLM) to assess the relationships between the number of breeding lesser kestrels and cliff size, habitat, and number of larger raptors associated with each cliff, using a Poisson error and a log link function (McCullagh & Nelder, 1989). The effects of each variable on lesser kestrel abundance were first tested using univariate statistical models. We then used a forward stepwise procedure, resulting in a multivariate statistical model in which only significant effects were retained.

Only 14 out of 95 potential nesting sites (14.7%) were used by lesser kestrel pairs, with 1–16 pairs (mean = 6.6 ± SD 5.3) at occupied sites. The percentage of cliffs unoccupied by lesser kestrels did not vary between habitat types ($\chi^2 = 4.06$, d.f. = 2, P = 0.13). Forty-nine (51%) of the cliffs were used by 60 breeding pairs of six larger raptor species: peregrine falcon (1 pair), saker falcon (13), golden eagle (3), steppe eagle (10), long-legged buzzard (27), and eagle owl (6). The number of larger raptors increased with cliff height (Kruskal-Wallis test, $\chi^2 = 24.39$, d.f. = 3, $P < 0.001$; Fig. 2a), and cliff size varied between habitat types (Kruskal-Wallis test, $\chi^2 = 9.55$, d.f. = 2, P = 0.008; Fig. 2b). Numbers of larger raptors per cliff were lower in agricultural landscapes (Kruskal-Wallis test, $\chi^2 = 22.55$, d.f. = 2, $P < 0.001$; Fig. 2c).

Univariate GLMs showed that the abundance of breeding lesser kestrels was negatively related to the presence of larger raptors ($\chi^2 = 30.5$, d.f. = 93, $P < 0.0001$, explained deviance 11.3%) and cliff height ($\chi^2 = 16.7$, d.f. = 93, $P < 0.0001$, explained deviance 4.1%), and abundance varied among habitats ($\chi^2 = 32.94$, d.f. = 93,

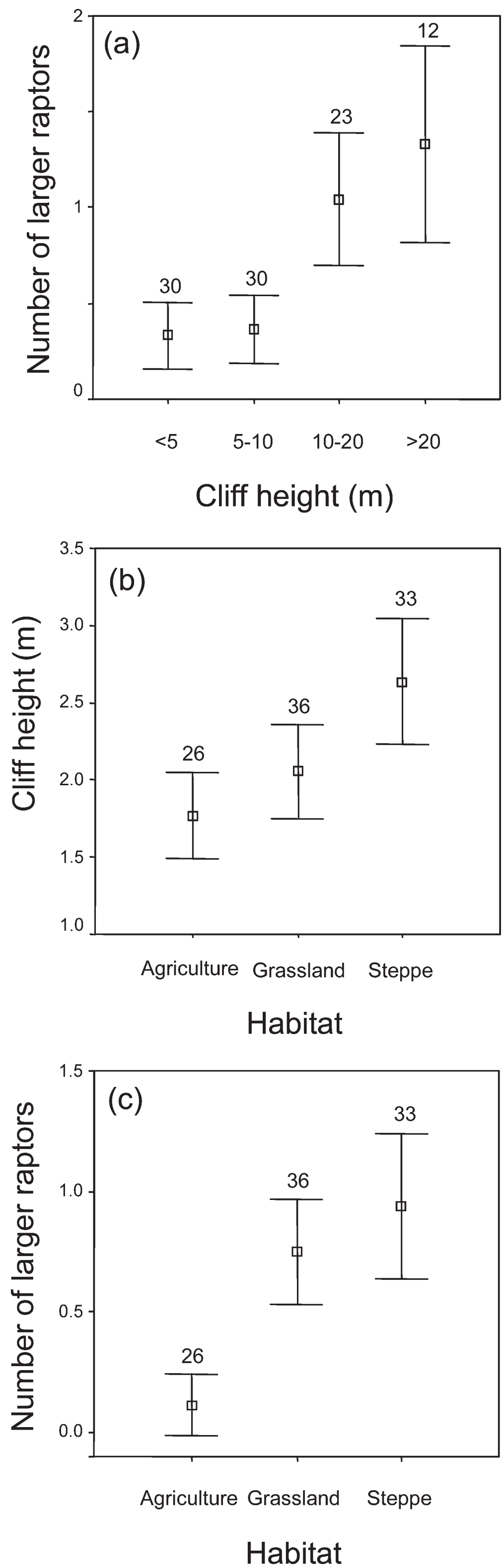

Fig. 2 Relationships between (a) number of breeding pairs of larger raptors and cliff height, (b) cliff height (scored in four categories; see text for details) and habitat type, and (c) number of breeding pairs of larger raptors and habitat type. Numbers above bars are the sample sizes.

Table 1 Multivariable model of the abundance of breeding lesser kestrels in south-east Kazakhstan.

	Coefficient	SE	χ^2	P
Intercept	0.28	0.24	1.41	0.23
Number of larger raptors	–1.84	0.26	49.85	< 0.0001
Habitat: agriculture	–0.96	0.37	6.50	<0.05
Habitat: grasslands	1.10	0.27	16.81	< 0.0001

$P < 0.0001$, explained deviance 8.1%). However, the multivariate GLM (which explained 25.8% of deviance, Table 1) only included the number of larger raptors and habitat as significant predictive variables. Compared to natural steppe the abundance of lesser kestrels was lower in agricultural habitats and higher in grasslands.

Sánchez-Zapata *et al.* (2003) showed that foraging lesser kestrels were positively associated with semi-natural grasslands in eastern Kazakhstan. However, it was unknown whether lesser kestrels preferred grasslands as foraging habitats *per se*, or whether this apparent preference resulted from ecological constraints such as availability of nest sites and presence of competitors. Our results suggest that breeding lesser kestrels are not limited by nesting sites, as most cliffs were unoccupied by the species and breeding numbers were negatively related to cliff height. This latter point could be explained by the increase in the number of large raptors with cliff size (Fig. 2a). Predation has been shown to be the main factor influencing the occupancy and growth of lesser kestrel colonies (Tella, 1996). Sharing a cliff with a larger raptor may result in continuous risk of both harassment and predation. Large species of eagles, falcons and buzzards, as well as eagle owls, prey upon fledgling and adult lesser kestrels (Tella, 1996). We found three adult lesser kestrels recently eaten by larger raptors, and the remains of another four lesser kestrels in pellets of eagle owls (Navarro *et al*., 2003). Therefore, our results suggest that the abundance of larger raptors (Sánchez-Zapata *et al.*, 2003) may be limiting the distribution and possibly the breeding population of lesser kestrels.

The abundance of breeding lesser kestrels was also related to land use around the cliffs. Grasslands seem to be preferred over natural steppe, while the presence of larger raptors is similar in both habitats (Fig. 2c). Moreover, agricultural landscapes are less used despite larger raptors being scarcer there than in grasslands and steppes (Fig. 2c). The transformation of steppe into grasslands for livestock pasture may have increased prey availability for lesser kestrels, whereas transformation into intensive agricultural areas may have reduced both adequate foraging areas and prey, as has happened in Spain (Tella *et al.*, 1998). This is a point of concern for the global conservation of the species. The population of lesser kestrels in Kazakhstan was considered to be

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important for the species (Zollinger & Hagermeijer, 1994), but a survey in 1997 suggested that there was only 5,000–8,000 breeding pairs in the whole country (Parr *et al.*, 2000). This contrasts with the present population of the species in Spain, a country five times smaller than Kazakhstan but still with 12,000 pairs (Atienza & Tella, in press). The transformation of large steppe and grassland areas of Kazakhstan into intensively managed agriculture might have dramatically reduced its lesser kestrel population, as has been argued as an explanation for the decline of other steppe birds such as great bustards *Otis tarda*, little bustards *Tetrax tetrax*, and black-bellied sandgrouse *Pterocles orientalis* (National Academy of Sciences, 1996). Although the expansion of farming activities halted after the collapse of the Soviet Union in 1991, new agricultural projects are being now developed as a result of recent economic growth (pers. obs.). Monitoring and conservation programmes for lesser kestrel populations are thus urgently required in Kazakhstan.

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Biographical sketches

All the authors are interested in the biology and conservation of threatened bird species. The collaboration between the Kazakh and Spanish research teams is aimed at comparing the ecology and conservation problems of avian species and communities in the relatively more pristine Asian steppes and the fragmented landscapes of Europe.

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