

DENSITY AND BREEDING HABITAT CHARACTERISTICS
OF AN INSULAR POPULATION OF BARBARY FALCON
FALCO PEREGRINUS PELEGRINOIDES
(EL HIERRO, CANARY ISLANDS)

DENSIDAD Y CARACTERÍSTICAS DEL HÁBITAT DE REPRODUCCIÓN
DE UNA POBLACIÓN INSULAR DE HALCÓN DE BERBERÍA
FALCO PEREGRINUS PELEGRINOIDES (EL HIERRO, ISLAS CANARIAS)

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The Barbary falcon *Falco peregrinus pelegrinoides* ranges from the Canary Islands eastwards across some areas of North Africa, the Middle East and some parts of central Asia (Fergusson-Lees and Christie, 2002). It has characteristic plumage patterns and morphometric differences with respect to the rest of peregrine subspecies, but genetic variation is quite low in the *peregrinus/pelegrinoides* group, and it could be treated as a subspecies of peregrine or even as a well differentiated species (Wink *et al.*, 2000). Furthermore, the Canarian breeding falcon present a Barbary phenotype, but haplotypes of *F. peregrinus brookei* and *F. p. pelegrinoides* are present according to a preliminary study carried out in Fuerteventura (Amengual *et al.*, 1996). Its typical habitat is noted to be inland deserts and other mainly barren arid areas, but locally in other environments. Limited information has been published on its biology worldwide (Fergusson-Lees and Christie, 2002).

Although this falcon is considered as “endangered” (Siverio and Concepción, 2003), its population size has increased and expanded in

the Canaries; in 1988 only seven pairs were known in the eastern islands (Hernández *et al.*, 1991) while nowadays around 75 breeding pairs are occupying all the islets and islands (Siverio and Concepción, 2003). Overall in this archipelago, only preliminary aspects of its breeding biology have been studied (Delgado *et al.*, 1999), and what knowledge there is of this species in El Hierro Island is summarized by Martín and Lorenzo (2001). In the present study, the reproduction of Barbary falcons in El Hierro is reported and furthermore, density, distribution pattern of breeding pairs and characteristics of nesting habitat are analyzed and compared with other peregrine population studies.

The Canary Islands are a volcanic archipelago which is located 100 km off the north-west African coast (27°37'-29°25' N and 13°20'-18°19' W) and is comprised of seven major islands. El Hierro is situated in the south-west of the archipelago presenting an area of 269 km² and a maximum altitude of 1,501 m. Its coastline is predominantly rocky with boulder shores and cliffs up to 300 m. The vegetation

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and landscape are greatly influenced by the northeastern trade winds, altitude and orientation. Around 7,700 persons live on the island (Morales and Pérez, 2000), most of them employed in agriculture and fishing.

Fieldwork was conducted during the breeding seasons of 2003 and 2004 (March, June and July), in which a total of 17 intensive field days were carried out. Observation points and transects on foot, using binoculars and a telescope, were carried out by two observers to inspect all suitable cliffs on the island in search of established pairs. The presence of an established pair was assumed when adults were present and furthermore a nest site, or recent used perching sites in adequate cliffs, or territorial defense behavior, or fledgings were observed.

To determine the influence of cliff availability, percentage of forested land and dispersion of human population centres on density and distribution pattern of falcons in El Hierro, 5-km UTM (Universal Transverse Mercator) squares, occupied and unoccupied by falcon pairs, were compared. Depending on the data characteristics (normality and homocedasticity of the variances), a student *t*-test or a Mann-Whitney *U*-test was employed. These variables were calculated by dividing the 5-km squares into 25 cells of 1 x 1 km, and recording the proportion of these with presence of cliffs (> 50 m height), forests and human settlements, only in terrestrial squares. The size of selected squares (5 x 5 km) allowed us to obtain a minimum sample size (dictated by the small surface area of the island) to perform these statistical analysis.

Habitat data were collected in each territory using the following parameters that were estimated from 1:25000 scale maps: cliff height, orientation, distance to the coast (DC), distance to the nearest falcon pair (DNFP), distance to the nearest paved road (DNPR), distance to the nearest inhabited village (DNIV), % land territory covered by forest (% Forest), % land covered by shrubs (% Shrubs), % land with other characteristics (% Others) and % sea surface (% Sea). The last three variables were measured

in a 9 km² circle in the central of which the nesting cliff was located (Gainzarain *et al.*, 2000; Zuberogoitia *et al.*, 2002; Del Arco *et al.*, 2003).

A principal component analysis (PCA) was performed to order and to identify the contributions of the nine habitat variables so as to describe the Barbary falcon breeding sites in El Hierro. An orientation index (with higher scores for the sunniest and most sheltered orientations according to dominant northeastern trade winds: 1, NE; 2, N and E; 3, NW and SE; 4, W and S; 5, SW) was used to describe potential preferences, but due to the small sample size no statistical analysis was conducted. Statistical calculations were carried out using SPSS and PRIMER packages (Clarke and Gorley, 2001).

A total of nine territorial pairs were found, and successful reproduction was confirmed in eight of them during the present study. The global density resulting for the entire island was 1 pair/30 km². The average DNFP was 5.23 km, ranged between 3.25 and 8.58. Pairs were distributed all around the island and only some forested areas and areas without cliffs were unoccupied. Although there were no significant differences, cliff availability was higher in 5-km squares with pairs than in the unoccupied ones, as opposed to the proportion of forested land and removal to human population centres (Table 1).

General features of habitat of Barbary falcon in El Hierro are summarized in Table 2. All eyries were placed in natural coastal cliff, except one situated 1.9 km inland. The mean score for the orientation index was 1.8, and the percentage of cliffs with sheltered and sunniest orientations was 55.5 % (*n* = 5).

According to the PCA plot all territories were grouped, except territories 3, 5 and 9 (Fig. 1), with the first two principal components explaining 64 % of the variation (PC1 = 34.6 %; PC2 = 29.4 %; Table 3). The first axis separated breeding site 9 from the rest with two variables having high positive loadings (DNIV and % Sea) and the other two having high negative loadings (DC and % Others; Table 3). The second axis

TABLE 1

Means (\pm SD) of three habitat variables in occupied and unoccupied squares UTM (5 x 5 km) by Barbary falcon *Falco peregrinus pelegrinoides* in El Hierro Island, and results of performed statistical tests. [Medias (\pm DT) de tres variables del hábitat en las cuadrículas UTM (5 x 5 km) ocupadas y desocupadas por el halcón de Berbería *Falco peregrinus pelegrinoides* en la isla de El Hierro, y resultados de las pruebas estadísticas realizadas.]

Variable [Variable]	Occupied squares [Cuadrículas ocupadas] (n = 9)	Unoccupied squares [Cuadrículas desocupadas] (n = 11)	t-test	U-test	P
Cliff availability [Disponibilidad de acantilados]	0.37 \pm 0.18	0.21 \pm 0.18	1.95	–	0.066
Proportion of land covered by forest [Proporción de territorio cubierto por bosque]	0.14 \pm 0.21	0.25 \pm 0.29	–	41.0	0.490
Dispersion of human population centres [Dispersión de poblaciones humanas]	0.17 \pm 0.14	0.26 \pm 0.23	-1.08	–	0.295

TABLE 2

Habitat characteristics of nesting Barbary falcon *Falco peregrinus pelegrinoides* in El Hierro Island; see explanation in the text (all in km except cliff height and distance to coast in m).

[Características del hábitat de reproducción del halcón de Berbería *Falco peregrinus pelegrinoides* en la isla de El Hierro; ver explicación en el texto (todos los valores en km exceptuando la altura del acantilado y la distancia a la costa que son en m).]

	Minimum distance to [Distancia mínima a]					% of territory covered by [% de territorio cubierto por]			
	Cliff height [Altura acantilado]	Coast [Costa]	Neighbour pair [Pareja vecina]	Paved road [Carretera asfaltada]	Inhabited village [Poblado habitado]	Forest [Bosque]	Shrubs [Matorral]	Other [Otros]	Sea [Mar]
Minimum [Mínimo]	50	50	3.25	0.08	0.53	0.0	34.6	0.0	0.0
Maximum [Máximo]	510	1900	8.58	2.25	6.08	18.4	66.0	44.8	50.6
Mean [Media]	225	361	5.23	0.74	2.65	3.3	49.6	12.2	31.9
SD [DT]	153.8	591.8	1.82	0.65	2.14	6.0	9.7	12.9	14.6

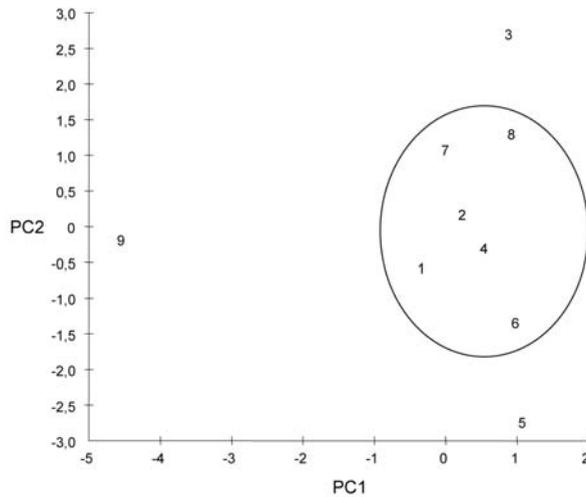


FIG. 1.—Plot of the location of nest sites of Barbary falcon *Falco peregrinus pelegrinoides* in El Hierro Island on the principal component axes.

[Gráfico de localización de los sitios de nidificación del halcón de Berbería *Falco peregrinus pelegrinoides* en la isla de El Hierro en los ejes de componentes principales.]

separated breeding site 3 and 5 from the rest being the variation along this axis the result of high positive loadings for % Forest and high negative loadings for DNPR, % Shrubs and DNIV (Table 3). The breeding sites separated in the PCA, numbered 3, 5 and 9, had high values of % Forest, % Shrubs and DC, respectively. General features of territories are their coastal proximity and situation in low forested areas.

Although it was suspected, no published data existed on the secure reproduction of Barbary falcon in El Hierro. The only information on this subject is the estimation of at least 2 - 3 pairs by Delgado *et al.* (1999), and the observation of an adult female with a juvenile just after the reproduction period (Martín and Lorenzo, 2001). It is important to note that may be many sectors of the island have only recently been well prospected (Martín and Lorenzo, 2001), but it is certain that many pairs have been established in recent years. Probably, the reason why some suitable breeding areas are unoccupied is that their population still continues increasing and those areas could be occupied in the future. It is

known that Barbary falcon population has increased its numbers in the Canaries during the last decade (Delgado *et al.*, 1999; Martín and Lorenzo, 2001; Siverio and Concepción, 2003). The current value of density in El Hierro is similar to the healthiest populations of peregrine worldwide (Ratcliffe, 1962; Olsen and Olsen, 1988; Pepler *et al.*, 1991; Carlier, 1993; Ratcliffe, 1993; Norris, 1995; Gainzarain *et al.*, 2000; Zuberogoitia *et al.*, 2002).

Overall peregrine falcons prefer areas with large cliff availability, no forested and far away from human population centres, being density and distribution closely related with cliff availability (Donazar *et al.*, 1989; Jenkins, 1994; Gainzarain *et al.*, 2002), and it is also said that Barbary falcon use basically semi-desert environments (Fergusson-Lees and Christie, 2002). This could be related with its hunting tactics or because villages are usually on flat terrain, where no suitable rock faces are present (Ratcliffe, 1993; Zuberogoitia *et al.*, 2002). Accordingly, on average, almost 50 % of Barbary falcon territories in El Hierro

TABLE 3

Principal components analysis of the correlation matrix among habitat variables of Barbary falcon *Falco peregrinus pelegrinoides* in El Hierro Island (in bold variables that were significant to each PC, * = $P < 0.05$ and ** = $P < 0.01$).

[Análisis de componentes principales de la matriz de correlación entre las variables del hábitat del halcón de Berbería *Falco peregrinus pelegrinoides* en la isla de El Hierro (en negrita las variables significativas para cada componente principal, * = $P < 0,05$ y ** $P < 0,01$).]

Habitat variables [Variables del hábitat]	Factor loadings [Factores de carga]	
	PC1	PC2
Cliff height [Altura del acantilado]	0.040	0.187
Distance to coast [Distancia a la costa]	-0.558**	0.022
Distance to neighbor pair [Distancia a la pareja vecina]	0.127	-0.149
Distance to paved road [Distancia a la carretera asfaltada]	0.078	-0.518**
Distance to inhabited village [Distancia a poblado habitado]	0.289	-0.370
% of land covered by forest [% de territorio cubierto por bosque]	0.144	0.462*
% of land covered by shrubs [% de territorio cubierto por matorrales]	-0.077	-0.539**
% of land covered by others [% de territorio cubierto por otros]	-0.550**	0.047
% of sea [% de mar]	0.503**	0.177
Eigenvalue [Autovalor]	3.11	2.65
Total explained variation [Variación total explicada]	34.6	29.4

were covered by shrubs, while forest covered only around 3 % (Table 2).

Heights of cliffs used by peregrines varied according to its availability, and sometimes they can breed on the ground, but clearly select the higher and more dominant cliffs respect to the surrounding area (Mearns and Newton, 1988; Pepler *et al.*, 1991; Ratcliffe, 1993; Gainzarain *et al.*, 2000). In the Canaries, Barbary falcons usually nest in high cliffs, but in the eastern islands, where large cliff availability is less than western islands, some pairs also breed on small and accessible hills in wide lava fields (*pers. obs.*), probably because of the growing density of the species.

Although cliff orientation of occupied sites in El Hierro have an average score of 1.8 on the orientation index, geological characteristics of these (high nest site availability and different face orientations) could allow falcons to select more sheltered location for nesting. Peregrines actively select sheltered and insulated

cliff-nest orientations in cold-wet climates and the opposite in warm climates (Olsen and Olsen, 1989b; Norris, 1995; Gainzarain *et al.*, 2000; Jenkins, 2000) and it could be positively related with breeding success (Mearns and Newton, 1988; Olsen and Olsen, 1989a).

In the Canaries, and particularly in El Hierro, the majority of breeding territories are situated at coastal areas and falcons usually hunt over sea (Martín and Lorenzo, 2001; *pers. obs.*), but is probably related with the high availability of suitable coastal cliffs. It is said that peregrines usually breed and hunt near or over water (e.g., Beebe, 1960; Bijlsma, 1990; Pepler *et al.*, 1991; Carlier, 1993; Monteagudo and García, 1995). However, in continental regions, the typical of Barbary falcon habitat is that of inland deserts and other mainly arid barren areas where no water is present, and they hunt in semi-desert environments (Fergusson-Lees and Christie, 2002).

Some territories in El Hierro were less than one km from a human population centre or just

overlooking a paved road. Only small villages and a little road traffic are present on this island. In studied populations in Spain, peregrines could select areas with low density of paved roads (Gil-Sánchez, 1999; Gainzarain *et al.*, 2000). However, it is well known that elsewhere, urban areas are also used by peregrines as breeding, hunting or wintering sites, and a lot of man made structures, like bridges, buildings, electric pylons and quarries are utilized as hunting perches or nesting sites (Ratcliffe, 1993). Some wintering and breeding Barbary falcons use buildings or electric pylons to breed or hunt (Brouwer and Mullié, 2000; Fergusson-Lees and Christie, 2002). In Tenerife, Barbary falcon usually hunts over towns and villages, occasionally using electric pylons as perches (*pers. obs.*).

In summary, breeding density and habitat attributes of Barbary falcons in El Hierro are agreed with the exposed in many peregrine populations. Population size is the higher never estimated to this island and maybe it continues increasing the next years. Since all territories, except one, are located in natural protected zones and any significant negative factor has been detected, no special conservation measures need to be taken shortly for its conservation.

RESUMEN.—*En el presente trabajo se confirma la nidificación de nueve parejas de halcón de Berbería Falco peregrinus pelegrioides en la isla de El Hierro, y se evalúa la densidad y las características del hábitat de nidificación. La densidad total fue de 1 pareja/30 km² y la distancia media entre territorios de 5,23 km, variando entre 8,58 y 3,25. En la mayoría de los territorios (n = 6), las variables del hábitat presentaron valores similares entre sí, y a los de otras poblaciones estudiadas de halcón peregrino. No se detectó ninguna amenaza directa sobre la especie, por lo que no es necesario tomar medidas inmediatas para su conservación.*

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