J. Raptor Res. 41(4):331–336

STATUS, DISTRIBUTION, AND DIET OF ELEONORA'S FALCON (*FALCO ELEONORAE*) IN THE CANARY ISLANDS

LEANDRO DE LEÓN,[1] BENEHARO RODRÍGUEZ, AND AURELIO MARTÍN
Departamento de Biología Animal (Zoología), Universidad de La Laguna, E-38206 La Laguna, Tenerife, Canary Islands, Spain

MANUEL NOGALES
Grupo de Ecología y Evolución en Islas (IPNA, CSIC), E-38206 La Laguna, Tenerife, Canary Islands, Spain

JESÚS ALONSO AND CARLOS IZQUIERDO
Departamento de Biología Animal (Zoología), Universidad de La Laguna, E-38206 La Laguna, Tenerife, Canary Islands, Spain

KEY WORDS: *Eleonora's Falcon*; Falco eleonorae; *Canary Islands*; *diet*; *distribution*; *status*.

The Eleonora's Falcon (*Falco eleonorae*) ranges from Cyprus to the Canary Islands (Snow and Perrins 1998). The Atlantic colonies are located on the Moroccan coast of Essauira and north of Salé (Thévenot et al. 2003), and the Canaries harbor the only breeding site of the species in the Macaronesian Archipelagos (Martín and Lorenzo 2001). This population represents the westernmost and southernmost limit of its breeding range (Vaughan 1961, Snow and Perrins 1998). The Canary Islands, a volcanic archipelago located 100 km from the Atlantic coast of northwestern Africa (27°37′–29°25′N, 13°20′–18°19′W), comprises seven major islands and some small islets and rocks. The only known breeding sites of Eleonora's Falcon in the Canaries are located in the northern islets of Lanzarote (Martín and Lorenzo 2001). Known as ''Archipiélago Chinijo,'' they make up a small archipelago of three islets and two small rocks: La Graciosa (with an area of 27 km² and elevation of 266 m above sea level), Alegranza (10.20 km² and 289 m), Montaña Clara (1.33 km² and 256 m), Roque del Este (0.06 km² and 84 m), and Roque del Oeste (0.01 km² and 41 m).

The breeding season of Eleonora's Falcon coincides with the postnuptial migration of small passerines (Walter 1979, Ristow et al. 1986). Consequently, the study of the falcons' diet during this period may also provide some valuable information on the general composition and temporal distribution of the migratory flow (Walter 1979, Ristow et al. 1986, Dolç-García and Dies 1987, Spina et al. 1987, Wink et al. 1993). The objectives of our study were: (1) to update data on the status and distribution of the breeding Eleonora's Falcons in the Canary Islands, and (2) to provide detailed information on the temporal variation of falcon diet during the breeding season.

METHODS

During the breeding seasons of 2000, we determined the status and distribution of the species in the Archipiélago Chinijo. Fieldwork was conducted during two visits, by a minimum of six observers: 9–24 August (incubation) and 11–27 September (early chick-rearing period). We counted the number of nests containing eggs or chicks in most locations, as they were generally accessible; however, at a few inaccessible sites, we estimated the number of nests using binoculars from adjacent sites. During both the breeding seasons of 2000 and 2001, we studied the diet of Eleonora's Falcons. We used only bird prey remains with complete body, wings, legs, or distinctive feathers, which remained in the proximities of the falcon's nests ($N = 95$; Hernández et al. 1985, Ristow 2004) for prey identification (following Jonsson 1994, Svensson 1998). Minimum number of individuals was estimated. In cases in which prey remains did not allow identification in the field, they were collected for a laboratory comparison with a reference collection. Biomass was calculated using the mean weight of each prey taxa taken from Snow and Perrins (1998), except for Plain Swifts (*Apus unicolor*; data were obtained from birds trapped for ringing in Gran Canaria; F. Rodríguez pers. comm.). For unidentified species (Table 2), fresh masses were estimated from the mean mass of species in the same genus which were identified as prey in this study or of species frequently observed in the study area. In Alegranza, Montaña Clara, and Roque del Oeste, nest inspections were made opportunistically (a maximum of 6 visits per eyrie). At Roque del Este, nests were systematically surveyed in August, September and October 2000: two visits of ca. 2 hr were conducted each month by four or five observers. We calculated Morisita's Index to study similarities in diet composition through the breeding season. Niche breadth for each month was evaluated using the standardized Levin's niche-breadth Index (Krebs 1989), where values close to 0 indicate dietary specialization, and values close to 1 indicate a broad diet. Furthermore, likelihood ratio tests were conducted to analyse monthly differences in the occurrence of the most abundant prey birds.

RESULTS AND DISCUSSION

Population. A total of 37 pairs of Eleonora's Falcons were counted at El Roque del Este, resulting in the highest

[1] Email address: ldeleon@icia.es

Table 1. Estimation of the Eleonora's Falcon population in the Canary Islands, according to different authors and years (value in parentheses = number of nests or pairs located).

LOCATIONS	AUGUST (1970) LOVEGROVE (1971)	AUGUST (1983) HERNÁNDEZ ET AL. (1985)	AUGUST (1987) TRUJILLO ET AL. (1994)	AUGUST–SEPTEMBER (2000) PRESENT STUDY
Roque del Este	25 (13)	21 (0)	12 (8)	(37)
Alegranza	25 (9)	22 (3)	24 (12)	(59)
Roque del Oeste	—	—	—	(2)
Montaña Clara	10 (2)	21 (5)	30 (7)	(85)
La Graciosa	1 (0)	—	—	—
TOTALS	**61 (24)**	**64 (8)**	**66 (27)**	**200 (183)**

density (6.2 pairs/ha) of the species in the Canary Islands (Table 1). The largest colony was located in Montaña Clara, where 85 nests were counted (Table 1). No evidence of nesting was found at La Graciosa and Famara massif although historic breeding at these sites was documented or suggested by some investigators (Etchécopar and Hüe 1957, Lovegrove 1971, Álamo Tavío 1975, Trujillo et al. 1994).

Current population in the Canary Islands is three times higher than previously estimated, and represents 18.5% of the entire Spanish population (along with Columbretes [45 pairs] and the Balearic Islands [836 pairs]), and 1.5% of the world population (Viada 2006). It is possible that the higher numbers that we recorded are due to a recent population increase in the Canary Islands (Viada 2006). However, methodological improvements applied during this census (participation of many observers, more time invested, and a detailed check of the breeding colonies) may have simply allowed us to detect more nests than were noted in previous censuses (Table 1).

Prey. Breeding-season diet in our study area was composed primarily of small birds, with only a few additional prey items such as moths (*Acherontia atropos*) and beetles (*Hegeter* sp.). At other sites, lizards (*Gallotia atlantica*) and rabbits (*Oryctolagus cuniculus*) are also consumed occasionally (Martín and Lorenzo 2001, F. Rodríguez pers. comm.). A total of 2371 bird prey items, belonging to a minimum of 41 species, were counted (Table 2). The majority of them were migratory European passerines (83.1%, $N = 1970$), mostly of the Sylviidae family (49.6%, $N = 1175$). In fact, the falcon's diet was composed primarily of Melodious Warblers (*Hippolais polyglotta*; 24.5%, $N = 582$), Greater Whitethroats (*Sylvia communis*; 20.5%, $N = 487$) and European Pied Flycatchers (*Ficedula hypoleuca*; 25.6%, $N = 607$). These three species are considered regular visitors to the Canary Islands (Martín and Lorenzo 2001). Prey biomass consisted of these three previous mentioned passerine species (42.9%) and other non-passerine prey such as the Common Quail (*Coturnix coturnix*) and the Common Cuckoo (*Cuculus canorus*), which represented 24.8%.

Prey selection at Roque del Este varied among the months of August, September, and October according to the Morisita Index, C_λ, (August–September, $C_\lambda = 0.41$; September–October, $C_\lambda = 0.75$ and August–October, $C_\lambda = 0.12$). Levin's niche breadth, B, was very narrow in the three months studied, but was increasing as the breeding season advanced during the period studied (August: $B = 0.01$, September: $B = 0.10$, and October: $B = 0.18$). The three species *H. polyglotta*, *S. communis* and *F. hypoleuca* were more frequently caught than the rest of the prey species ($G_1 = 291.2$, $P < 0.001$; $G_1 = 98.8$, $P < 0.001$ and $G_1 = 131.8$, $P < 0.001$, respectively; Table 4). The falcons captured significantly more *H. polyglotta* in August and September than in October ($G_2 = 186.05$, $P < 0.001$); *S. communis* was consumed more during September ($G_2 = 219.62$, $P < 0.001$), and the great majority of *F. hypoleuca* were captured in September ($G_2 = 303.57$, $P < 0.001$). When the number of species of migratory birds was low (August), Eleonora's Falcons showed a predisposition toward dietary specialization. Their diet shifted toward a broader prey selection when the migratory flow became richer in species (September and October; Martín and Lorenzo 2001).

A different pattern of diet composition was observed in Mediterranean populations, probably reflecting some differences in prey species' migration routes (Ristow et al. 1986, Dolç-García and Dies 1987, Spina et al. 1987, Wink et al. 1993). Although several factors may influence the composition of Eleonora's Falcons' diet (e.g., variation in the falcon energetic requirements during the different phases of their reproductive cycle, more efficient escape strategies of some prey species; Walter 1979, Hedenström and Rosén 2001), some authors have suggested that Eleonora's Falcons are not specialized in their diet (Walter 1979, Spina et al. 1987). Therefore, the study of the Eleonora's Falcon diet may provide some useful information on the composition of migratory flows.

Falcons in the Canary Islands preyed on resident species in small number (Table 2), as they did in other regions (Walter 1979). However, European Storm-Petrel (*Hydrobates pelagicus*) made up 35.7% of the total prey items on Alegranza, but most of them were captured by one pair that nested very near the main colony of this petrel on Alegranza (Rodríguez et al. 2003). The presence of breed-

Table 2. Species and number of individuals tallied as prey of Eleonora's Falcon during the summers of 2000 and 2002 in the entire study area (+ = values lower than 0.1%; * = species with a resident population in the study area).

SPECIES	NUMBER OF INDIVIDUALS	% FREQUENCY OF OCCURRENCE	% BIOMASS
*Bulweria bulwerii**	11	0.5	1.6
*Hydrobates pelagicus**	118	5.0	5.0
*Falco tinnunculus**	1	+	0.3
F. eleonorae	2	0.1	1.2
Coturnix coturnix	74	3.1	12.4
Porzana porzana	2	0.1	0.3
Crex crex	2	0.1	0.5
Charadrius hiaticula	1	+	0.1
Calidris ferruginea	1	+	0.1
Calidris sp.	1	+	0.1
Tringa sp.	1	+	0.3
Actitis hypoleucos	65	2.7	5.8
*Columba livia**	1	+	0.5
Columba sp.	1	+	0.5
Streptopelia turtur	11	0.5	2.5
Streptopelia sp.	3	0.1	0.7
Cuculus canorus	67	2.8	12.4
Otus scops	3	0.1	0.4
Apus unicolor	2	0.1	0.1
A. apus	6	0.3	0.4
A. pallidus	2	0.1	0.1
Apus sp.	8	0.3	0.5
*Upupa epops**	10	0.4	1.1
Jynx torquilla	8	0.3	0.5
Hirundo rustica	1	+	+
Anthus trivialis	3	0.1	0.1
Motacilla flava	1	+	+
Erithacus rubecula	11	0.5	0.3
Luscinia megarhynchos	76	3.2	2.5
Luscinia sp.	1	+	+
Phoenicurus ochruros	9	0.4	0.2
P. phoenicurus	7	0.3	0.2
Phoenicurus sp.	3	0.1	0.1
Saxicola rubetra	3	0.1	0.1
Oenanthe sp.	4	0.2	0.2
Locustella naevia	13	0.5	0.3
Locustella sp.	1	+	+
Acrocephalus schoenobaenus	7	0.3	0.2
Hippolais polyglotta	582	24.5	13.1
Hippolais sp.	15	0.6	0.3
Sylvia cantillans	4	0.2	0.1
S. melanocephala	1	+	+
S. communis	487	20.5	14.9
S. atricapilla	7	0.3	0.3
Sylvia sp.	2	0.1	0.1
Phylloscopus bonelli	6	0.3	0.1
P. trochilus	30	1.3	0.5
Phylloscopus sp.	20	0.8	0.3
Muscicapa striata	19	0.8	0.5
Ficedula hypoleuca	607	25.6	14.9
Lanius senator	50	2.1	3.2
Total prey	2371	—	—

Table 3. Monthly variation in the diet composition of Eleonora's Falcon on Roque del Este (August–October 2000).

	AUGUST-2000			SEPTEMBER-2000			OCTOBER-2000		
SPECIES	NUMBER OF PREY	% FREQUENCY OF OCCURRENCE	% BIOMASS	NUMBER OF PREY	% FREQUENCY OF OCCURRENCE	% BIOMASS	NUMBER OF PREY	% FREQUENCY OF OCCURRENCE	% BIOMASS
Bulweria bulwerii	—	—	—	2	0.2	1.1	—	—	—
Hydrobates pelagicus	1	0.5	0.6	9	1.1	1.5	—	—	—
Falco tinnunculus	1	0.5	4.8	—	—	—	—	—	—
Coturnix coturnix	—	—	—	14	1.7	8.9	6	7.2	30.6
Actitis hypoleucos	1	0.5	1.3	8	1.0	2.7	3	3.6	8.1
Columba livia	—	—	—	1	0.1	1.8	—	—	—
Streptopelia sp.	—	—	—	2	0.2	1.7	—	—	—
Cuculus canorus	7	3.3	19.2	4	0.5	2.8	—	—	—
Apus apus	4	1.9	4.1	—	—	—	—	—	—
Apus sp.	1	0.5	0.9	—	—	—	—	—	—
Upupa epops	—	—	—	1	0.1	0.4	—	—	—
Jynx torquilla	—	—	—	2	0.2	0.5	—	—	—
Hirundo rustica	—	—	—	1	0.1	0.1	—	—	—
Anthus trivialis	—	—	—	2	0.2	0.3	—	—	—
Erithacus rubecula	—	—	—	—	—	—	9	10.8	7.6
Luscinia megarhynchos	5	2.3	2.4	20	2.5	2.5	—	—	—
Phoenicurus ochruros	—	—	—	—	—	—	4	4.8	3.1
P. phoenicurus	—	—	—	1	0.1	0.1	6	7.2	4.4
Saxicola rubetra	—	—	—	—	—	—	2	2.4	2.0
Locustella naevia	—	—	—	5	0.6	0.5	1	1.2	0.8
Hippolais polyglotta	184	86.4	61.3	231	28.7	19.9	5	6.0	3.4
Sylvia cantillans	2	0.9	0.6	1	0.1	0.1	1	1.2	0.7
S. melanocephala	—	—	—	—	—	—	1	1.2	0.6
S. communis	4	1.9	1.8	227	28.2	26.6	10	12.0	9.3
S. atricapilla	—	—	—	—	—	—	5	6.0	5.8
Phylloscopus bonelli	—	—	—	1	0.1	0.1	—	—	—
P. trochilus	—	—	—	14	1.7	1.0	1	1.2	0.6
Muscicapa striata	—	—	—	4	0.5	0.4	—	—	—
Ficedula hypoleuca	—	—	—	234	29.1	22.0	28	33.7	21.0
Lanius senator	3	1.4	2.9	20	2.5	4.9	1	1.2	2.0

ing Eleonora's Falcons in some small Mediterranean archipelagos has been suggested as the reason European Storm-Petrels do not breed at these sites (Martínez-Abraín et al. 2005). Nevertheless, the number of breeding pairs of this petrel species on Alegranza seems to have remained stable during the last decades (Rodríguez et al. 2003). It is also important to note that fledging chicks of Eleonora's Falcon were consumed, according to the remains (wing feath-

Table 4. Results of the likelihood ratio tests of the main Eleonora's Falcon prey (*Hippolais polyglotta*, *Sylvia communis*, and *Ficedula hypoleuca*) with respect to the rest of the prey species.

		AUGUST–SEPTEMBER		AUGUST–OCTOBER		SEPTEMBER–OCTOBER	
SPECIES	df	*G*	*P*	*G*	*P*	*G*	*P*
Hippolais polyglotta	1	241.4	<0.001*	180.0	<0.001*	25.5	<0.001*
Sylvia communis	1	93.0	<0.001*	11.9	0.001*	11.6	0.001*
Ficedula hypoleuca	1	127.3	<0.001*	79.2	<0.001*	0.75	0.384

* Significant at Bonferroni-corrected *P* level (0.05/9 = 0.005).

ers and partially eaten legs of two individuals) found in two different nests where complete broods were also present.

Finally, if we consider that each falcon pair catches six small passerines a day, as observed for Elenora's Falcons nesting in some Mediterranean colonies (Spina et al. 1988), during the three months of the breeding season, the total number of birds caught by the Canary Island population would be ca. 100 000 individuals. This large value underscores the importance of this area for the migration of these species.

ESTATUS, DISTRIBUCIÓN Y DIETA DE *FALCO ELEONORAE* EN LAS ISLAS CANARIAS.

RESUMEN.—En este trabajo investigamos el estatus, la distribución y la dieta del halcón *Falco eleonorae* en los islotes al norte de Lanzarote (Islas Canarias), en los meses comprendidos entre julio y octubre de 2000 y 2001. La población canaria actual (≈200 parejas nidificantes) es tres veces superior a la estimada previamente. Sin embargo, su distribución permanece similar a la reportada en estudios anteriores, limitándose a roqueríos e islotes deshabitados. Exceptuando algunos invertebrados (escarabajos y mariposas nocturnas), la dieta de este halcón está compuesta básicamente por paseriformes europeos migratorios. En total se contabilizaron unas 2371 presas pertenecientes a al menos 41 especies. Las especies más consumidas fueron *Ficedula hypoleuca* (25,6%, $N = 607$), *Hippolais polyglotta* (24,5%, $N = 582$) y *Sylvia communis* (20,5%, $N = 487$). Estos halcones también consumieron algunas especies nidificantes, como *Bulweria bulwerii* e *Hydrobates pelagicus*, que alcanzó el 5% ($N = 118$).

[Traducción de los autores editada]

ACKNOWLEDGMENTS

The results of this paper are part of the project ''Restoration of the islets and the cliffs of Famara (Lanzarote Island)'' (LIFE NAT/E/006392, 2000–2002) financed by the European Union and the Cabildo Insular de Lanzarote (Canary Islands, Spain). We thank María Candelaria Martín, Patricia Marrero, Néstor Puerta, Juan Cazorla, Bernardo Rodríguez, Marta López, Juan Manuel Martínez, David Pérez, Jaime Ginovés, and Eduardo González for helping us with fieldwork. The personnel of the Cabildo Insular de Lanzarote (especially Luis Pascual and Elena Mateo) and the crew of the ''César Manrique'' made possible our visits to the islets. Felipe Rodríguez and Rubén Barone provided us with interesting information. Josh Donlan and two anonymous referees provided very valuable advice on a previous version of the manuscript.

LITERATURE CITED

ÁLAMO TAVÍO, M. 1975. Avifauna Canaria. Inventario de las aves de Canarias orientales. Pages 71–96 *in* G. Kunkel [ED.], Inventario de los recursos naturales renovables de la Provincia de Las Palmas (Islas Canarias, España). I.U.C.N./W.W.F., Las Palmas de Gran Canaria, Spain.

DOLÇ-GARCÍA, J.C. AND N. DIES. 1987. El Halcón de Eleonor (*Falco eleonorae*, Gené) en las islas Columbretes. Pages 241–262 *in* L.A. Alonso, J.L. Carretero, and A.M. García [EDS.], Islas Columbretes, contribución al estudio de su medio natural. Generalitat Valenciana, Valencia, Spain.

ETCHÉCOPAR, R.-D. AND F. HÜE. 1957. Nouvelles donées sur l'Avifaune des Iles Canaries recueillies au printemps 1956. *L'Oiseau et R.F.O.* 27:309–334.

HEDENTRÖM, A. AND M. ROSÉN. 2001. Predator versus prey: on aerial hunting and escape strategies in birds. *Behav. Ecol.* 12:150–156.

HERNÁNDEZ, E., A. MARTÍN, G. DÍAZ, O. TRUJILLO, AND M. ASCANIO. 1985. Censo y datos sobre la biología del Halcón de Eleonor (*Falco eleonorae* Gené, 1839) en las Islas Canarias, Agosto–Septiembre 1983. *Doñana Acta Vert.* 12:63–73.

JONSSON, L. 1994. Aves de Europa con el Norte de África y el Próximo Oriente. Omega, Barcelona, Spain.

KREBS, C.J. 1989. Ecological methodology. Harper Collins, New York, NY U.S.A.

LOVEGROVE, R. 1971. B.O.U. supported expedition to northeast Canary Islands. July–August 1970. *Ibis* 113: 269–272.

MARTÍN, A. AND J.A. LORENZO. 2001. Aves del Archipiélago Canario. Lemus Editor, La Laguna, Spain.

MARTÍNEZ-ABRAÍN, A., D. ORO, R. BELENGUER, V. FERRIS, AND R. VELASCO. 2005. Long-term change of species richness in a small Mediterranean archipelago. *Anim. Biodivers. Conserv.* 28:131–136.

RISTOW, D. 2004. On the insect diet of Eleonora's Falcon *Falco eleonorae* and its importance for coloniality. Pages 705–712 *in* R.D. Chancellor and B.-U. Meyburg [EDS.], Raptors worldwide; proceedings of the VI world conference on birds of prey and owls. World Working Group on Birds of Prey and Owls, Berlin, Germany and MME/BirdLife Hungary, Budapest, Hungary.

———, C. WINK, AND M. WINK. 1986. Assessment of Mediterranean autumn migration by prey analysis of Eleonora's Falcon. *Suppl. Ric. Biol. Selvaggina* 10:285–296.

RODRÍGUEZ, B., L. DE LEÓN, A. MARTÍN, J. ALONSO, AND M. NOGALES. 2003. Status and distribution of breeding seabirds in the northern islets of Lanzarote (Canary Islands). *Atl. Seabirds* 5:41–56.

SNOW, D.W. AND C.M. PERRINS. 1998. The birds of the western palearctic. Vol. 1 and 2. Oxford Univ. Press, Oxford, U.K.

SPINA, F., S. FOCARDI, P. MAGAGNOLI, AND A. SCAPPI. 1988. Autumn migration through the Mediterranean and the activity of Eleonora's Falcon *Falco eleonorae* (Gené) (Aves Falconidae): a comparison between two methods of data collection. *Monit. Zool. Ital.* 22:307–313.

———, A. SCAPPI, B. BERTHEMY, AND G. PINNA. 1987. The diet of Eleonora's Falcon *Falco eleonorae* in a colony of the western coast of Sardinia with some remarks on the migration of small passerines through the Mediterranean. *Suppl. Ric. Biol. Selvaggina* 12:235–254.

SVENSSON, L. 1998. Guía para la identificación de los Passeriformes Europeos. Sociedad Española de Ornitología, Madrid, Spain.

THÉVENOT, M., R. VERNON, AND P. BERGIER. 2003. The birds of Morocco. BOU Checklist Series: 20. British Ornithological Union and British Ornithological Club, Tring, U.K.

TRUJILLO, O., J. CARRILLO, M. NOGALES, AND V. QUILIS. 1994. Distribución y status del Halcón de Eleonor (*Falco eleonorae*) en las Islas Canarias. *Vieraea* 23:149–153.

VAUGHAN, R. 1961. *Falco eleonorae. Ibis* 103:114–129.

VIADA, C. 2006. Barbaki, el halcón del Egeo. *La Garcilla* 126:34–35.

WALTER, H. 1979. Eleonora's Falcon: adaptations to prey and habitat in a social raptor. The Univ. of Chicago Press, Chicago, IL U.S.A.

WINK, M., H. BIEBACH, F. FELDMANN, W. SCHARLAU, I. SWATSCHEK, C. WINK, AND D. RISTOW. 1993. Contribution to the breeding biology of Eleonora's Falcon (*Falco eleonorae*). Pages 59–72 *in* M.K. Nicholls and R. Clarke [EDS.], Biology of small falcons. The Hawk and Owl Trust, London, U.K.

Received 22 November 2006; accepted 24 July 2007
Associate Editor: Vincenzo Penteriani