

Breeding Biology and Conservation of Eleonora's Falcon *Falco* *eleonorae* in South-West Sardinia, Italy

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INTRODUCTION

Eleonora's Falcon *Falco eleonorae* is a rare social raptor that breeds in colonies of up to 300 pairs on rocky sea cliffs and islets (Cramp & Simmons, 1980). The entire breeding population, amounting to about 4500 pairs (Tucker & Heath, 1994), is concentrated in the Mediterranean (two-thirds in the Aegean Sea), although the breeding range extends to the Atlantic coast of Morocco and the Canary Islands (Walter, 1979). The species shares with the Sooty Falcon *Falco concolor* the peculiarity of breeding in late summer. This delayed breeding season allows the parents to feed their chicks on the Palearctic migrant birds crossing the Mediterranean Sea from August to October (Walter, 1979). From mid October Eleonora's Falcons leave the breeding colonies and migrate to East Africa and Madagascar. In April they return from their winter quarters and from May onwards they can be seen already occupying their breeding territories. Some aspects of the breeding biology of this species have been well studied in various countries of the Mediterranean (Mayol, 1977; Ristow *et al.*, 1979, 1991; Spina *et al.*, 1987; Wink *et al.*, 1982, 1985) and in Morocco (Clark, 1974; Vaughan, 1961; Walter, 1979). The present paper, part of an extensive study carried out over 8 years, aims to present new data concerning the species' breeding biology and conservation in Sardinia. New reports regarding the general biology of the Eleonora's Falcon are also given.

STUDY AREA AND METHODS

Field researches were carried out on a large rocky island (51 km²) 6 km off the south-west coast of Sardinia. The falcon colony is situated along 6.6 km of the west uninhabited coast (39°9'N-8°13'E). The study area is characterized by vertical cliffs,

exposed to W-NW and ranging in height from 40 to 110 m above the sea level. The vegetation consists mainly of Mediterranean scrub, even with low bushes not higher than 20 cm; many areas are almost free of shrubs owing to the rocky substrate. The typical vegetation recognizable is a halophile garigue referring to the *Crithmo-limonietum* association. The climate is subtropical, characterized by hot, dry, sunny summers and wet, rainy winters. The aridity period occurs from April to September. The annual mean temperature is 18°C while the mean of annual precipitation is 450 mm.

The research has been carried out every year from 1987 to 1994 for periods of between 2 and 8 weeks each year. During this period a total of 545 nests have been located and monitored from August to October at intervals of 2-5 days. Sites have been found in different ways as a consequence of the various stages of the breeding cycle (see Badami, 1993). Observations have been made between sunrise and sunset from the top of the cliffs and from places chosen in order to avoid any disturbance to the clutches. Unfortunately it has been impossible to see clearly into all the nests, since many pairs breed in invisible and inaccessible sites. However about 85-90% of the nests in the breeding colony have been checked regularly.

DATE OF ARRIVAL, NEST SITE AND NESTING DENSITY

Most of the birds arrive in April from their wintering quarters in southeast Africa and Madagascar. However the earliest observation of Eleonora's Falcons at the colony was the 18th March 1990 (7 individuals). The departure from the area occurs from the beginning of November and by the 10th of November only a few birds remain.

The nests are located in high vertical cliffs made of trachytic rocks. Most pairs (68%) prefer to nest in holes, cavities and crevices 30-50 cm deep, which provide shade for the incubating bird and protection from bad weather. However 24% of the pairs bred on completely open ledges, while 8% used sheltered ledges. The main exposure was NW and W. The height of the nests varied from 5 to 110 m above the sea level. Several sites have been found occupied annually for 2 to 6 years. About 40-60% of the nests located during one breeding season were re-used the subsequent year. In one case Eleonora's Falcon nested on a site previously utilized by Peregrine *Falco peregrinus brookei* (M.Dore, pers. com.).

Nesting density varied in different years. The mean distance between nests ranged from 22.6 m to 48.5 m with maximum and minimum distances of 250 m and 1 m respectively. The lower value was observed for two nests located on the same rock, overlapped and with different orientation. This is the lowest datum recorded for the inter-nests distances in Eleonora's Falcon and refers to 1990 which has been regarded as a good breeding year (see below).

LAYING DATE, HATCHING DATE AND FLEDGING PERIOD

Data refer to 1989-1991 and to 1993-1994 periods. In 1989-91 egg laying started on 16th July; 73% of the clutches were initiated between 16th and 31st July and 27% were laid between 1st and 7th August. The incubation period in the study area is 30-35 days, so hatching occurred from 18th August to 10th September with a peak hatching on 27th August. The chicks fledge after a nestling period lasting 36 days, so they have left the nest between 22nd September and 12th October.

In 1993-94 the laying period was slightly delayed. Thus 61% of the clutches were laid between 22nd and 31st July, while 39% were laid between 1st and 8th August. Hatching occurred from 21st August to 10th September with the peak on 29th August. Fledging has been recorded between 25th September and 15th October.

Generally, by the beginning of August almost 95% of all eggs are laid. Incubation starts from the first egg. There is no replacement clutch upon egg loss. In 1993 the hatching interval between the first and the second egg of a clutch was 4 days.

CLUTCH SIZE AND BREEDING SUCCESS

The clutch size over the 8 years ranged between one and five eggs per nest ($n = 156$, mean 2.56, D.S. = 0.65). The only five-egg clutch recorded in the colony refers to 1993 (Table 1). This is the first occurrence reported for Eleonora's Falcon over the whole breeding range. The mean number of eggs per clutch was not significantly different between years (Mann-Whitney test). Substantial proportions of the eggs laid failed to hatch (either infertile or with dead embryo) or were abandoned: 13-67% depending on the year. Only three clutches were found preyed upon, probably by birds.

The population size in the colony was floating (Table 2). The lower sample size in 1987 is due to a limited census. Breeding performance of the species varied significantly between all years (Mann-Whitney test) and was

Table 1. Clutch size of Eleonora's Falcon for the study area.

	Year							
	1987	1988	1989	1990	1991	1992	1993	1994
<i>Total</i>	7	14	48	14	14	22	12	25
1-egg clutches	-	-	2	-	1	3	-	3
2-eggs clutches	2	3	22	2	1	7	6	12
3-eggs clutches	5	11	22	12	12	12	5	10
4-eggs clutches	-	-	2	-	-	-	-	-
5-eggs clutches	-	-	-	-	-	-	1	-
Mean	2.71	2.78	2.5	2.86	2.78	2.41	2.67	2.28

significantly lower in 1994 than in the other years (Table 2). In 1991 a nest with four young that fledged successfully was recorded. This is the first known case for Eleonora's Falcon. The overall productivity in the population (young fledged/pair) was 1.45 ($n = 545$, D.S. = 0.91), while the number of young fledged per laying pair was 1.49 ($n = 532$, D.S = 0.89). Breeding failures concerned 74 chicks (8%), of which 4 were found dead and 70 disappeared.

Table 2: Breeding success of Eleonora's Falcon in the study area.

	Year							
	1987	1988	1989	1990	1991	1992	1993	1994
Nests found	30	87	79	62	69	76	69	73
Laying pairs	30	87	78	62	68	73	69	65
Successful pairs	29	87	53	60	63	66	61	35
Young fledged	58	137	99	118	114	108	105	52
Productivity	1.93	1.57	1.25	1.9	1.65	1.42	1.52	0.71
Young fledged per laying pair	1.93	1.57	1.27	1.9	1.68	1.48	1.52	0.8
Young fledged per successful pair	2.0	1.57	1.87	1.96	1.81	1.64	1.72	1.48
% of successful pairs	96.6	100	68	96.8	92.6	87	88	48

RATIO OF COLOUR PHASE

In the colony the percentage of dark phased falcons was always lower (8-17%) than the percentage of light phased (83-92%) (Table 3). Thus the ratio of colour phases among breeding birds ranged from 6:1 to 11:1 in favour of the light phase. Most of the pairs (73-84%) consisted of light males and females; pairs with mixed phased falcons were 13-25% while those in which both partners belonged to the dark phase were only 2-7% or absent.

Table 3: Percentage of light- and dark-phased falcons in the colony.

	Year							
	1987	1988	1989	1990	1991	1992	1993	1994
Breeding falcons [%]								
Light female	40	40	42	40	41	43	43	44
Light male	43	46	49	48	48	45	47	48
Dark female	10	10	8	10	9	7	7	6
Dark male	7	4	1	2	2	5	3	2

DISCUSSION

Finding of Eleonora's Falcons during March in the Mediterranean is very uncommon, since most of the spring observations for this species fall in May (Brichetti *et al.*, 1992; Ristow *et al.*, 1979; Walter, 1979). The earliest record over the breeding range regards one dark falcon in Cyprus on 7th March (Bannermann & Bannermann, 1958). This means that the first birds may leave winter quarters in February. Whereas the falcons depart from their breeding territories at the beginning of November, late records are reported for two individuals in Sardinia on 13th December 1970 (Mocci Demartis, 1973). Spina *et al.* (1985) saw also two juveniles wintering in the study area in 1981, but no further evidences of this have been reported subsequently.

Dates of the breeding cycle, the first given for the study area, are similar to those gathered by Walter (1979) in other colonies of the southern Aegean Sea and Morocco. However the incubation period seems to be longer compared with the 33 and 30 days reported by the same author and by Ristow *et al.* (1991). Also the hatching interval observed between two eggs (four days) appears slightly longer than the two days interval known.

In this area the preference for nesting in sites providing shade and protection is the same as has been found for other colonies. However the percentage of pairs nesting on completely open ledges is higher compared with the 6-21% observed for the Aegean and Morocco colonies (Walter, 1979; Wink *et al.*, 1982). This may be due to the low predation seen for this colony. Furthermore, most of the nests, being oriented to west-northwest, are fully exposed to the strong northwest winds (the *mistral*); the reason for this could be an advantage for hunting (Brichetti *et al.*, 1992). Pairs show a higher nesting site tenacity, in comparison with the data of Ristow *et al.* (1979). Inter-nests distances are higher compared with the 20-30 m reported by Walter (1979), suggesting a great availability of nest sites.

The percentage of dark phased falcons seems low, compared to the figures given for some sites of Morocco (18-28%) and for the Aegean Sea (21-39%) by Ristow *et al.* (1989) and Walter (1979). This percentage seems to have been constant during the last 8 years, according to the observations made by Wink *et al.* (1978) in an Aegean colony.

The data collected on the breeding biology of Eleonora's Falcon in this Sardinian colony are comparable to the observations reported from the Eastern and Western Mediterranean colonies (Ristow & Wink, 1985; Vaughan, 1961; Walter, 1979). As these data have been collected in different years and from different populations, it is not possible to compare them statistically.

The mean of clutch sizes matches more closely the high mean reported

for the Atlantic colonies than the lower one gathered in the Aegean (Table 4).

This suggests a high prey availability in the study area, according to the observations of Wink *et al.* (1985). High percentage (57%) of 3-eggs clutches, as observed in Morocco (Walter, 1979), supports this hypothesis. Egg loss is low compared with the 38-47% found by Ristow & Wink (1985) in the Aegean and due mainly to Rats (*Rattus rattus*). This suggests that the colony is hardly affected by natural predation. The lower production of eggs in 1994 could be related to a lack of prey, caused by days with strong southern winds that limited the migrant flow.

Breeding success is intermediate compared with that reported for the Atlantic and Aegean colonies (Table 4), showing the good productivity of the falcons in this colony. This suggests that prey availability is not a limiting factor for this population, and it is supported by the fact that many preys are often caught and not eaten. Data from this long-term study lead to the hypothesis that weather conditions can influence the breeding performance of Eleonora's Falcon. Significant negative correlations have been found between breeding success, rainfall and rainy days in September (Badami, 1993a); also the speed of southern winds has a negative influence on

Table 4: Clutch size and breeding success of Eleonora's Falcon in different colonies.

Study Areas	Mean Clutch Size	Breeding Success	Source
Morocco	3.15	2.60	Vaughan, 1961
Morocco	2.85	2.48	Walter, 1979
Balearic Islands	2.55		Mayol, 1977
South Aegean Sea	1.99	1.67	Walter, 1979
South Aegean Sea	2.30	1.20	Ristow & Wink, 1985
South-west Sardinia	2.56	1.49	Present study

reproduction (A.Badami, unpubl.). All these weather factors limit or interrupt the migrant flow, causing a dramatic lack of prey and the consequent death of the chicks from starvation, as observed in 1989 and 1994. In the latter year some cases of predation by unknown mammals led to the lowest breeding success.

CONSERVATION

Like all diurnal raptors, Eleonora's Falcon is legally protected in Italy; yet it suffers from human disturbance. The biggest threats come from poachers, collectors and tourism. The Sardinian colonies are more threatened than those in Sicily (Brichetti *et al.*, 1992). Even if locally threatened, the Italian population of *Falco eleonora* seems to be stable.

The colony of the present study was visited by poachers in 1979 and 1980. In an attempt to stop poaching, since 1980 LIPU (Italian League for the Protection of Birds) has organized a camp for the wardening of the nests from mid-August to mid-October each year; volunteers coming from various European countries kept continuous watch on the easily accessible cliffs. This led to the gradual increase in the number of breeding pairs, from 60-70 (Spina *et al.*, 1985) to about 90 (Badami, 1993). Considerable data on the breeding biology of these falcons at the nest were also collected during all these years. These efforts for the protection of the species led to the creation of the Carloforte Natural Reserve in 1991.

Being restricted to so few breeding sites in the Mediterranean the species is extremely vulnerable. For this reason all breeding islands should be protected by means of Natural Reserves; it is also important that a thorough census is carried out on several colonies for the continuous monitoring of the species' status.

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