

## CIRCUITOUS AUTUMN MIGRATION IN THE SHORT-TOED EAGLE (*CIRCAETUS GALLICUS*)

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**ABSTRACT.**—The Short-toed Eagle (*Circaetus gallicus*) uses mainly soaring flight during migration and avoids long water crossings between Italy and Africa by crossing at the Strait of Gibraltar. Observations were made 15–26 September 2000 at four sites in the central Mediterranean area: Arenzano (Ligurian Apennines, northwest Italy), Circeo promontory (central Italy), Marettimo (southern Italy) and Malta. In addition, 68 hr of observations were made 18–24 September 1998, 1999, and 2000 over the Apuane Alps along the western slope of central Italy. At Arenzano, 476 Short-toed Eagles were counted (5.4/hr) consisting of 368 adults, 6 immatures, and 102 juveniles, with an overlap in the migration periods of age classes. The Short-toed Eagles migrated in flocks averaging  $4.3 \pm 0.9$  (SE) birds. Over the Apuane Alps, 289 Short-toed Eagles, all migrating northwest, were counted (4.3/hr). Few birds were seen at the other three sites, with a maximum of eight individuals recorded at Marettimo. These results confirm the circuitous autumn migration around the Mediterranean of Short-toed Eagles breeding in central Italy and suggest that at least some juveniles learn this route by following the adults.

**KEY WORDS:** Short-toed Eagle; *Circaetus gallicus*; migration; orientation; flocking; navigation.

Circuito de migración de otoño de *Circaetus gallicus*

**RESUMEN.**—*Circaetus gallicus* usa principalmente el vuelo de planeo durante la migración y evita los largos cruces sobre el agua entre Italia y África cruzando por el estrecho de Gibraltar. Se hicieron observaciones entre 15–26 de septiembre de 2000 en cuatro sitios en el área mediterránea central: Arenzano (Apeninos Ligurianos, noroeste de Italia), promontorio de Circeo (Italia central), Marettimo (sur de Italia) y Malta. Además, 68 horas de observaciones fueron entre 18–24 de septiembre de 1998, 1999, y 2000 sobre los Alpes de Apuane a lo largo de la vertiente oeste de Italia central. En Arenzano, 476 águilas de pies cortos fueron contadas (5.4/hr) incluyendo 368 adultos, 6 inmaduros, y 102 juveniles, con un traslape en los periodos de migración en las clases de edades. Las águilas de pies cortos migran en bandadas que promedian  $4.3 \pm 0.9$  (SE) aves. Sobre los Alpes de Apuane, fueron contadas 289 *Circaetus gallicus* (4.3/hr), todas emigrantes del noroeste. Pocas aves fueron vistas en los otros tres sitios, con un máximo de ocho individuos registrados en Marettimo. Estos resultados confirman el circuito migratorio de otoño alrededor del mediterráneo de *Circaetus gallicus* que anidan en Italia central y sugiere que al menos algunos juveniles aprenden esta ruta siguiendo los adultos.

[Traducción de César Márquez]

The Short-toed Eagle (*Circaetus gallicus*) is a summer resident in Europe, wintering in tropical North Africa (Cramp and Simmons 1980). Italy has

a breeding population of 380–415 pairs, most of them in the Ligurian Apennines (northwest Italy) and along the western slope of central Italy (Cattaneo and Petretti 1992; Fig. 1). A small number of pairs breed in southern continental Italy and

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Figure 1. The study area (A = Arenzano, MC = Mount Colegno, C = Circeo promontory, P = Ponza, M = Marettimo; the breeding areas of the Short-toed Eagle in the Ligurian Apennines and central Italy are shown in gray).

probably winter in Sicily (Mascara 1985, Cattaneo and Petretti 1992, Cattaneo 1997, Agostini and Logozzo 1997). In the Mediterranean basin, the greatest concentration of individuals has been observed at the Strait of Gibraltar both during autumn and spring movements (Finlayson 1992).

Information in support of a circuitous migration route for Short-toed Eagles has been circumstantial to date. In the central Mediterranean, passage of these birds is virtually non-existent during spring (Beaman and Galea 1974, Agostini and Malara 1997, Agostini and Logozzo 1998, Agostini 2001). Individuals breeding in both northern and central Italy are expected to cross the Mediterranean at the Strait of Gibraltar, traveling along the Ligurian Apennines (northwest Italy, Agostini and Malara 1997), where their greatest concentration in Italy occurs during spring migration (Baghino and Leugio 1989, 1990,

Baghino 1996). In autumn, a few birds are recorded in southern continental Italy and over the islands of Malta and Capri (Beaman and Galea 1974, Sultana and Gauci 1982, Agostini and Logozzo 1995a, 1995b, 1997, Jonzén and Pettersson 1999), although over Malta, Short-toed Eagles are occasionally recorded in November (Coleiro 1999). These results suggested the hypothesis that Short-toed Eagles breeding in central Italy avoid the long water crossing between Italy and Africa and that they move across the Mediterranean at the Strait of Gibraltar rather than via southern Italy (Agostini and Logozzo 1997). Because this route involves circuitous migration (Fig. 1), it suggests information transmission and, thus, a contemporaneous migration of adults (experienced individuals) and juveniles (inexperienced individuals). The aim of this study was to verify these hypotheses through observations at five sites of the central Mediterranean: the Ligurian Apennines, the Apuane Alps (central Italy), the Circeo promontory (central Italy), the islands of Marettimo (western Sicily, southern Italy) and Malta. At the last three sites, remarkable concentrations of raptors occur in autumn (Beaman and Galea 1974, Corbi et al. 1999, Agostini et al. 2000), while, to date, on the Ligurian Apennines and on the Apuane Alps observations of migrating individuals in this period were lacking.

#### STUDY AREA AND METHODS

With the exception of those observations made in the Apuane Alps, we collected our data from 15–26 September 2000, the peak of the autumn migration of the Short-toed Eagle in the Mediterranean basin (Cramp and Simmons 1980). The entire observation period was divided into four 3-d periods for recording the migration of adult, immature, and juvenile individuals. Observations were aided with binoculars and telescopes. Age determination was possible only when birds flew very close (<150 m) overhead. An estimated total of adults, immatures, and juveniles was derived by multiplying their proportions in the sample of identified individuals during each period, following the method used by Kjellén (1992) in his study on the autumn migration of raptors at the Falsterbo peninsula (Sweden). Characters used in separating age were those given by Forsman (1999).

In the Ligurian Apennines, the observation post was at the northernmost point of the midwestern Mediterranean basin, near Arenzano (Fig. 1), where the ridge of Apennines, after running parallel to the coast, reaches its closest proximity to the sea (6 km) as well as the minimum transverse width for the entire Italian peninsula. The observation post was on the closest culmination to the sea at 500 masl.

The Circeo promontory is at the southernmost point of the Pianura Pontina (Fig. 1) reaching 541 masl. In autumn 1998, hundreds of Marsh Harriers (*Circus aeruginosus*) and juvenile Honey Buzzards (*Pernis ptilorvus*)

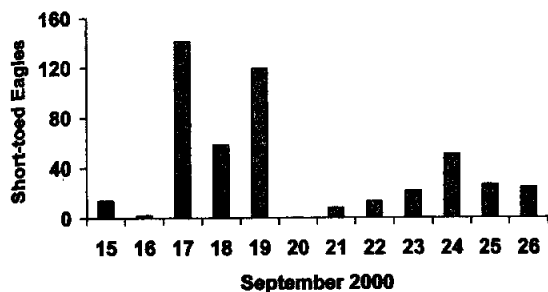


Figure 2. Occurrence of migrating Short-toed Eagles in the Ligurian Apennines between 15–26 September 2000.

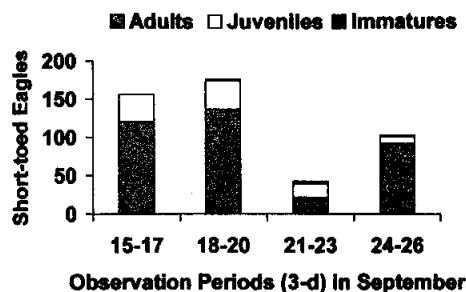


Figure 3. Adult, juvenile, and immature Short-toed Eagles estimated in the four 3-d periods, according to their proportion among the identified individuals.

were seen leaving the coast toward the island of Ponza from this point (Corbi et al. 1999; Fig. 1), but only five Short-toed Eagles. The observation post was along the southern slope nearly at its highest point.

Marettimo is a small mountainous island (12 km<sup>2</sup>) about 30 km off western Sicily (Fig. 1). Monte Falcone is its highest relief at 686 m. At this site, observations were made between the end of August and the first half of September 1997 and 1998 when a maximum of 5227 raptors were counted, nearly all Black Kites (*Milvus migrans*) and adult Honey Buzzards; only one Short-toed Eagle was reported in 1997 (Agostini et al. 2000). To date no observations have been carried out after mid-September. The observation post was located at the altitude of ca. 500 m.

The Maltese Islands are ca. 90 km south of Sicily and 335 km north of Libya (Fig. 1). Raptors, mostly Marsh Harriers and juvenile Honey Buzzards (Agostini and Logozzo 1995c), concentrate along the cliffs (Beaman and Galea 1974). The observation post was on the western side of the island of Malta, at one of the highest points of the island (250 masl). At the Ligurian Apennines and at the Circeo promontory, no monitoring was done on 20 September because of heavy rainfalls.

At the Apuane Alps site, observations were made between 18–24 September 1998 (16 hr), 1999 (20 hr), and 2000 (32 hr). The observation post was located on the slope of Mount Colegno, about 370 km NW of the Circeo promontory and 130 km SE of Arenzano (Fig. 1), at the altitude of ca. 200 m. This site was used to detect the direction of Short-toed Eagles migrating along the western slope of central Italy.

#### RESULTS AND DISCUSSION

On the Ligurian Apennines (Arenzano), we counted a total of 476 Short-toed Eagles (5.4/hr) with about 55% of birds seen in two days (Fig. 2). This species was the most abundant at this site (79.6%,  $N = 598$ ). During the four 3-d periods, a total of 368 adults, six immatures, and 102 juveniles was estimated, with an overlap in the migration periods of individuals belonging to different age classes (Fig. 3). The Short-toed Eagles showed a strong tendency to migrate in flocks of two or

more ( $N = 96$ ), although 62 (13.1%) individuals were seen alone. On average, groups consisted of  $4.3 \pm 0.9$  (SE) individuals and 64% (61 of 96) of flocks contained two or three birds. It was possible to age all birds migrating together in 23 (24%) cases, seven of these groups consisted of juveniles and adults while 16 comprised only adults. In at least four of the remaining 73 flocks recorded, juveniles and adults were seen migrating together. Few Short-toed Eagles were counted at the other three sites. However, three birds were seen on the Circeo promontory (0.4%,  $N = 832$ ), two over Malta (0.2%,  $N = 957$ ) and eight over Marettimo (2.8%,  $N = 286$ ). Finally, over the Apuane Alps, a total of 289 Short-toed Eagles was counted (4.3/hr) and all individuals were seen migrating north-west toward the Ligurian Apennines (Fig. 1).

Our observations are consistent with the predictions based on the circuitous migration hypothesis. During autumn migration, Short-toed Eagles breeding in central Italy migrate over the Ligurian Apennines en route to the Strait of Gibraltar, thus avoiding a longer sea crossing between Italy and Africa. Flights suggestive of circuitous migration during autumn have been recorded in genera such as *Hirundo* and *Motacilla* (Alerstam 1990) and, among raptors, in Griffon Vultures (*Gyps fulvus*) breeding in the island of Cres (Croatia; Susic, in Zalles and Bildstein 2000, p. 220). Along the coastal zone in southern Sweden, many birds are seen regularly migrating north or northeast. However, these movements seem to be made in order to find suitable stop-over sites inland before crossing the sea (Alerstam 1990) and they are not the result of a true migration movement. In the case of our study, both the strong tendency of Short-toed Eagles to migrate together and flocks containing in-

dividuals belonging to different age classes, are consistent with the prediction that at least some juveniles belonging to the population breeding in central Italy are able to learn this circuitous route by following the adults (Agostini and Logozzo 1997). Before this study, among migrating raptors, information transmission concerning orientation and navigation has been recorded in Black Kites and, occasionally, Honey Buzzards migrating across the central Mediterranean (Agostini and Logozzo 1997, Agostini et al. 1999, 2000).

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