

Sex and age ratios of marsh harriers *Circus aeruginosus* wintering in central-southern Italy

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Abstract – In this study we analyse the age and sex ratios of marsh harriers wintering in central Italy and Sicily. Among adults, most individuals were females (88%), whereas males accounted for only 12% of the observations. There was no difference in the proportion of juveniles and adults. The remarkable difference in numbers of males and females seems to support the hypothesis that, at least among adults crossing the central Mediterranean, males show a stronger tendency to migrate over longer distances. Among the proposed hypotheses explaining intraspecific differences in avian migration patterns, the Bergmann's rule, which predicts that larger individuals (i.e. females in this case) are better adapted to survive in colder climates, appears to be in agreement with our results, whereas other hypotheses based on social dominance are less supported by our data, as suggested by the similar proportion of juveniles and adults.

Riassunto - *Rapporto tra classi di sesso ed età nei falchi di palude svernanti in Italia centro-meridionale.* In questo studio analizziamo il rapporto tra classi di sesso ed età nel falco di palude in Italia centrale e Sicilia durante lo svernamento. Gran parte degli individui adulti osservati erano femmine (88%), mentre i maschi costituivano solo il 12% del totale. Non è stata invece riscontrata alcuna differenza tra la frequenza di giovani ed adulti. La notevole differenza osservata nei contingenti dei due sessi durante l'inverno in Italia centro-meridionale sembra confermare che, almeno tra gli adulti attraversanti il Mediterraneo centrale, i maschi mostrano una maggiore tendenza a migrare su lunga distanza verso i quartieri di svernamento dell'Africa sub-Sahariana. Fra le ipotesi proposte per spiegare le differenze intraspecifiche nelle strategie di migrazione degli uccelli, la regola di Bergmann, che prevede che animali di maggiori dimensioni (in questo caso le femmine) siano meglio adattati a climi più rigidi, sembra essere la più idonea a spiegare i risultati di questa ricerca, mentre l'assenza di differenze nella frequenza di giovani e adulti suggerisce che le ipotesi basate sulla dominanza non siano in grado di spiegare la migrazione differenziale nel falco di palude.

Among migratory birds, differential migration (i.e. the intraspecific variation in migratory timing or distances in different classes of individuals) is a widespread phenomenon. A review by Cristol *et al.* (1999), which examined 69 species of migratory birds showing differential migration, revealed that, in 71% of the species, the individuals migrating further were usually the smallest members of population classes. This pattern has been observed also among diurnal raptors (Newton 1979, Kjellen 1994), the largest individuals wintering closer to the breeding areas than the smaller ones.

Intraspecific differences in migratory and wintering patterns can be explained by different hypotheses, which we briefly summarize below (Cristol *et*

al. 1999). The 'body-size hypothesis' predicts that larger individuals should prevail over smaller ones in colder climates, according to the Bergmann's rule. This could be due to a more favourable surface area-to-volume ratio or the ability to fast longer; thus, large-bodied individuals should be more likely to survive to cold temperatures and better adapted to winter in colder climates (Cristol *et al.* 1999, Ashton 2002, Meiri and Dayan 2003, De Queiroz and Ashton 2004, Meehan *et al.* 2004). The 'social-dominance hypothesis' suggests that the dominant class takes up areas closest to breeding ranges, while the subordinate class is forced to migrate farther (Gauthreaux 1978, 1982, Cristol *et al.* 1999). The 'character-divergence hypothesis' explains the difference in wintering ranges as a result of differences in prey selection (Koplin 1973). The 'migration-cost hypothesis' states that small birds are more likely to

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migrate farther and across water surfaces than large ones, because a large size makes powered flight disproportionately more costly for large than for small birds (Pienkowski and Evans 1985, Kerlinger 1989). Finally, the 'arrival-time hypothesis' assumes that the distance of migration affects the arrival time at the breeding sites, so that individuals which are under greater selective pressure to arrive earlier should migrate to shorter distances from the breeding grounds (Myers 1981, Cristol *et al.* 1999).

The marsh harrier is a widespread migratory raptor in Europe. Populations of northern, eastern and central Europe migrate entirely, while populations breeding in western and southern Europe are partially migratory or resident (Cramp and Simmons 1980, Gensbøl 1992, Bavoux *et al.* 1997, Martelli and Parodi 1992). The main wintering areas of the European population of the marsh harrier occurs in the Mediterranean region, Middle East and sub-Saharan Africa (Cramp and Simmons 1980). An average of 778 wintering marsh harriers was counted each year in Italy between 1991 and 2000 (Baccetti *et al.* 2002), and among sexed birds only a few of these were adult males (Chiavetta 1986, Agostini and Logozzo 2000). On the other hand, during the autumn migration over the central Mediterranean, more adult males than females are generally observed (Agostini and Logozzo 2000, Agostini *et al.* 2003). Winter observations on the western coast of France showed that, in this region, marsh harriers are mostly resident or partially migratory, and no differences in sex ratio were observed (Bavoux *et al.* 1992, 1994, 1997, Fritz *et al.* 2000).

The aim of this study is to provide quantitative data on the sex and age ratios of marsh harriers wintering in central and southern Italy and to compare them with those reported in the literature for Europe, in light of the proposed hypotheses for the evolution of differential migration in avian species.

STUDY AREA AND METHODS

Surveys of wintering marsh harriers were conducted during winter 2002-2003 at 9 sites in Sicily and 6 sites in central Italy. During winter 2003-2004, surveys were conducted at 6 sites in Sicily and at 11 sites in central Italy (Fig. 1). Observations were made between the half of December and the beginning of February. Each site was visited an average of two times per season. Some marshes in central Italy

are both wintering and breeding areas for the marsh harrier (Martelli and Parodi 1992). Age and sex classes were determined according to Forsman (1999) and Clark (1999). Birds were observed at the roosting sites or during daytime. For daytime observations, we recorded all the birds observed in the area when the wetland was small, with the presence of one or few individuals. In other cases, to avoid a repeated counting of the same individuals, we considered the maximum simultaneous number of individuals observed. When the conditions were not suitable for the observations, the survey was repeated the following days. To reduce the bias resulting from easier identification of adult males, the percentage of females and juveniles was estimated by assigning unidentified individuals of the female/juveniles group ($N = 53$) to age classes according to the proportion observed among identified birds (Kjellen 1992, Agostini and Logozzo 2000, Agostini 2001, Agostini *et al.* 2001, 2003, 2004, Panuccio *et al.* 2002, 2004). The numbers reported in the results are thus based on the individuals actually assigned to age and sex classes plus the estimated number of females and juveniles.

RESULTS AND DISCUSSION

A total of 176 individual marsh harrier observations was considered in the analyses (Tab. 1), 97 of which were recorded in 2002-2003 and the remaining 79 in 2003-2004. Among adults, females (87.9%) outnumbered males (12.1%) ($\chi^2 = 27.6$, d.f. = 1, $P < 0.01$) in both years ($\chi^2 = 13.8$, d.f. = 1, $P < 0.01$; $\chi^2 = 13.2$, d.f. = 1, $P < 0.01$) and in both areas ($\chi^2 = 12.9$, d.f. = 1, $P < 0.01$; $\chi^2 = 14.0$, d.f. = 1, $P < 0.01$). On the other hand, there was no difference in the proportion of adults (56.3%) and juveniles (43.7%) ($\chi^2 = 1.3$, d.f. = 1, $P > 0.05$). The percentage of juveniles observed is lower than that previously reported for southern Italy (64%, Agostini and Logozzo 2000), which could reflect annual fluctuations of the breeding success in the European populations of marsh harriers. Concerning the sex ratio, our data agree with those previously recorded in Italy (Chiavetta 1986, Agostini and Logozzo 2000), while studies made in other European areas confirm only partially our observations (Tab. 2). Along the Atlantic coast of France, only 12.4% of a great number of marsh harriers observed ($N = 3966$) showed 'grey plumage' (Bavoux *et al.* 1997). However, captured individuals in



Figure 1. Map of Italy showing the sites where marsh harrier age and sex ratios were recorded. – *Cartina dell'Italia mostrante le stazioni dove sono state compiute le osservazioni di falco di palude.*

the same area ($N = 236$) showed no significant difference in sex ratio (108 males vs. 128 females), which is also confirmed by a further survey made in France on a smaller number of birds ($N = 28$) (Bavoux *et al.* 1997, Fritz *et al.* 2000).

In the Netherlands, Zijlstra (1987) reported one adult male every nine females/juveniles. In the same country, Clarke *et al.* (1993), during surveys in two different winters, did not observe a single adult male among 64 individuals. In Britain, most sightings of wintering adults concern females (Underhill-Day 2002). The differences in sex ratio of wintering marsh harrier observed in several European areas can be at least partly explained by considering that individuals breeding in central, eastern and northern Europe are entirely migratory, whereas those breeding in the Mediterranean area and along the Atlantic coast of

western Europe are resident or partially migratory (Gensbøl 1992, Martelli and Parodi 1992). In particular, in western France, 79% of marked adults and 63% of juveniles were found during winter within 25 km of their nesting site (Bavoux *et al.* 1992, 1994). For this reason we suggest that the observed imbalance of sexes among wintering marsh harriers should be more evident in entirely migratory populations, or, at least, for birds migrating through and wintering in the central Mediterranean area (Agostini and Logozzo 2000, Agostini *et al.* 2003). Moreover, the Italian peninsula is used for wintering and migration by marsh harriers belonging to the populations of central, eastern and northern Europe (Cramp and Simmons 1980, Martelli and Parodi 1992), as suggested by the analysis of recoveries, most of which originate from Germany and Finland, followed by the former Czechoslovakia, Sweden, former USSR and Poland (Chiavetta 1986). The Italian breeding population of marsh harriers consists of 70-100 pairs, of which only 5-10 occur in our study area: this may also explain why we observed few males in the present study, in comparison with western France, where most of the winter population consists of resident individuals (Martelli and Parodi 1992).

Previous observations (Agostini and Logozzo 2000, Agostini *et al.* 2003) suggested that the difference in size between females and males could be the reason of the differential migration strategy in this species, males migrating earlier during autumn and spring and over longer distances than females, in accordance with the 'body-size hypothesis' for the evolution of differential migration (see also Introduction). Indeed, male marsh harriers are smaller than females, capture smaller preys, are disadvantaged in competition with females at carrions and less efficient in preying on waterfowls (Clarke 1995); thus, they could be strongly disadvantaged in resource competition with females at northern wintering areas. Moreover, small preys (like e.g. insects and amphibians) are scarce during winter in temperate wetlands. Finally, because of their large body size, females are better

Table 1. Frequency (%) of age and sex classes of marsh harriers observed during winters 2002-2003 and 2003-2004 in central Italy and Sicily. – *Frequenza (%) delle diverse classi di sesso ed età nei falchi di palude osservati negli inverni 2002-2003 e 2003-2004 in Italia centrale e Sicilia.*

Areas	Adult males (%)	Adult females (%)	Juveniles (%)	Sample size (N)
Central Italy	7.8	48.1	44.1	102
Sicily	5.4	51.4	43.2	74

Table 2. Frequency (%) of adult male and female marsh harriers reported in three different European areas during winter. – *Frequenza (%) di maschi e femmine adulti di in tre diverse aree di studio europee nel corso dell'inverno.*

Areas	Adult females (%)	Adult males (%)	Sample size (N)
Italy ^a	87.9	12.1	176
Netherlands ^b	100	-	64
Western France ^c	45.8	54.2	236

a: this study; b: Clarke *et al.* 1993; c: Bavoux *et al.* 1997

adapted to tolerate cold weather and can sustain longer fasting (Newton 1979, Searcy 1980, Kerlinger 1989, Clarke 1995, Simmons 2000). The observed differences in sex ratio are however compatible also with the 'social-dominance hypothesis', because females should be dominant over males, and, therefore, subordinate males should migrate farther also as a result of intraspecific competition. In this context, Cristol *et al.* (1999) observed that "it will be very difficult to determine whether the shorter migrations observed in larger individuals of many species are due to size-related thermal efficiency or to the ability of larger birds to dominate smaller birds". However, in our case, the lack of difference in the proportion of juveniles and adults may argue against this hypothesis, because adults birds are normally socially dominant over juveniles, and the latter are therefore predicted to be scarcer in northern wintering grounds (Cox 1968, Mueller *et al.* 1977, Gauthreaux 1978, 1982, Kjellen 1994). On the other hand, the predictions of the 'arrival-time' hypothesis (i.e. the farther individuals migrate the later they arrive at the breeding grounds; Myers 1981, Cristol *et al.* 1999) are not upheld in the marsh harrier, because males migrate earlier than females in spring in the central Mediterranean (Panuccio *et al.* 2002, 2004). Finally, it should also be noted that the sexual size dimorphism and the observed differences in prey selection between sexes (Cramp and Simmons 1980, Fritz *et al.* 2000) are also compatible with the 'migration-cost' and the 'character-divergence' hypotheses for the evolution of differential migration in this species (Cristol *et al.* 1999).

Therefore, the 'body-size hypothesis' may better explain differential migration in the marsh harrier, although other hypotheses may also apply, and the selective forces leading to the observed segregation may also result from the multifactorial costs of migration and intraspecific competition for resources.

Within this framework, future studies should verify the existence of an imbalance towards males among adults marsh harriers wintering in the sub-Saharan region, though a previous survey conducted in Senegal reported that only 15% of marsh harriers observed were adult males; unfortunately, this study reports both females and juveniles in the same class (Arroyo *et al.* 1995). Since large numbers of juveniles migrate across the central Mediterranean region during autumn and winter, Agostini *et al.* (2003) hypothesized a prevalence of females also among juveniles wintering in the Mediterranean area. In this species, the sexual size dimorphism is more pronounced among juveniles than in adults (Cramp and Simmons 1980). It is interesting to note that an imbalance among juveniles in wintering areas has been observed also in the goshawk *Accipiter gentilis* (Newton 1979). Since it is impossible to sex juvenile marsh harriers by visual observations, further investigation is needed to test this hypothesis.

In conclusion, the observations reported in the present study suggest that the remarkable differences in counts of marsh harriers of different sex classes wintering in the central Mediterranean area could be explained by a latitudinal segregation of the sexes. This implies that, at least among entirely migratory populations of central Europe, males should mostly winter in sub-Saharan Africa.

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