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Bird migration across the Mediterranean: ringing activities on Capri within the Progetto Piccole Isole

Fågelflyttning over Medelhavet: ringmärkning på Capri inom Projekt Piccole Isole

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Abstract

Palearctic-African spring migrants are faced with the challenging crossing of the double ecological barrier of the Sahara Desert and the Mediterranean Sea. Islands represent unique opportunities to stopover and rest during these prolonged endurance flights. To study spring migration across the Mediterranean, the Italian Ringing Centre at INFS has co-ordinated the Progetto Piccole Isole since 1988 with Capri being among the most active stations. Islands are used as stopover sites by huge numbers of birds belonging to a wide range of species and irrespective of physical conditions of migrants. Clearly defined species-specific seasonal migration patterns are observed, and also differential migration of sex and age classes. Wide-front movements over the sea of typical nocturnal migrants occur also during daytime. Physiological studies confirm the importance of the short stopovers observed on the islands, which permit the birds to adjust their metabolic state, rest and rely, in many cases, on easily accessible nectar as an energetically rich food. Strong links with habitats both in Africa and within the Mediterranean confirm the need for internationally coordinated conservation strategies for Palearctic-African migrants.

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Introduction

Ecological barriers represent the most challenging part of a migrant's journey. For terrestrial birds, crossing large stretches of sea implies the need for prolonged endurance flights. The Mediterranean acts as an important barrier for Palaearctic-African migrants heading north while moving towards their breeding quarters in spring (Moreau 1972, Alerstam 1990). Within the larger historical framework of migration studies in Europe, spring movements have been less intensively investigated than the autumn flyways and migratory patterns. It has also become increasingly clear that bird populations breeding in Europe can be significantly affected by ecological factors acting on the African winter quarters. For these reasons, in 1988 the Istituto Nazionale per la Fauna Selvatica, Italian Ringing Centre, launched the 'Progetto Piccole Isole' (PPI) (Spina et al. 1993). The main aims of the project are to investigate spring migration across the Mediterranean through a network of ringing stations operating together on the basis of standardised field protocols. An important aspect is also to obtain sound scientific evidence of the conservation value of Mediterranean islands and coastal habitats for staging migrants during a particularly delicate phase of their annual cycle. This knowledge is needed in order to develop reliable policies for the conservation of migratory birds within the Mediterranean, a geographical area characterized by intense harvesting (Woldhek 1980, Hepburn 1985, Fenech 1992).

Capri within the PPI

The PPI was started as an effort of Italian ringers, also in order to test their potential in such a network research project. For this reason only four islands were involved at the beginning: Montecristo, Giannutri, Ventotene and Capri. Capri in particular was chosen since the very start of the project based on the long-lasting experience of ringing activities carried on at the Castello Bar-

barossa of Anacapri (Petterson et al, 1990), firstly by Swedish ringers and later through a cooperation between Swedish and Italian ringers, thanks to the local support kindly offered by the Axel Munthe Foundation.

Since then, Capri has always been active within the project, providing one of the longest time series of ringing data available in Italy and within the Mediterranean. It is important to mention here that such data would have not been collected without the continuous support offered by the Axel Munthe Foundation to ringers working there, and the Italian Ringing Centre is grateful for such a crucial help and for the positive cooperation with the Swedish ringers.

The seasonal and geographic coverage

One of the most fascinating aspects of return migration is represented by the mechanisms governing the start of return migration by birds wintering south of the Sahara, where they have no cues to predict ecological conditions north of the desert. Trans-Saharan migrants are also represented by a significant number of species showing negative population trends in Europe (Burfield & van Bommel 2004). When launching the PPI, we therefore decided to concentrate on long-distance migrants.

The project also aimed at having a good geographical coverage, at least within the Thyrrenian Sea, through the original group of four islands. Given the human resources available, we have decided to concentrate our activities in a period of peak migration of the species we were mostly interested in.

Hence, in order to properly define the seasonal period to be routinely covered, during the first two years different periods were sampled, i.e. mid-April to mid-May in 1988 and mid-March to mid-April in 1989. The earlier phase showed a prevalence of intra-Palaearctic migrants, while trans-Saharan species accounted for more than

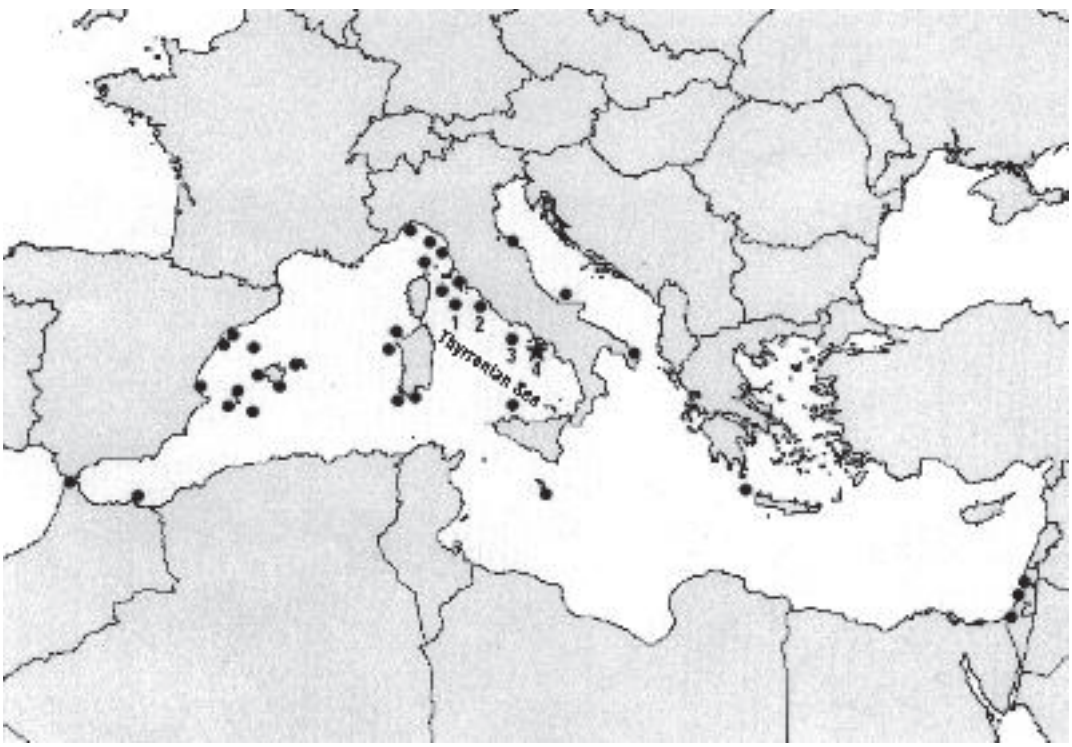

Figure 1. Capri within the network of PPI ringing stations. The four pioneer sites of the project are marked with 1 (Montecristo), 2 (Giannutri), 3 (Ventotene), 4 (Capri).
Capri inom PPIs nätverk av ringmärkningsstationer. De fyra pionjärplatserna inom projektet har markerats med 1 (Montecristo), 2 (Giannutri), 3 (Ventotene), 4 (Capri).

90% of ringings in the later one, which has therefore been chosen as the standard period of activity for the project (Spina et al. 1993).

During the years we have also occasionally sampled earlier and later periods, and we have now data available between mid-March and end of May.

In terms of geographic coverage, the project has surely seen a significant development. During the years, a total of 46 sites in 7 different countries have been covered by over 600 ringers, offering a good sample for the central-western Mediterranean, while more scanty information has been collected in Greece and Israel (Figure 1).

Ringing effort and ringings on Capri

When analysing the activity of a series of Italian ringing stations (Macchio et al. 2002) a total of 476 ringing days have been carried out at Capri between 1985–1994, with a peak of over 80 days in 1994 and an annual mean of over 40 days during the period. In more recent years Capri has always been following the PPI protocols in terms of seasonal coverage. The overall total of birds ringed on the island in the period 1985–2005 amounts to 81,007, with an annual mean of 3857 and a peak of over 6000 in 1993.

Species diversity on Capri

On Capri 91 different species have been mist-netted during the PPI, with an annual mean of 56, and a peak of 68 in 1994. Out of a total of over 34,425 ringings analysed, the first ten species are Whinchat *Saxicola rubetra* (17%), Common Whitethroat *Sylvia communis* (11%), Pied Flycatcher *Ficedula hypoleuca* (10%), Wood Warbler *Phylloscopus sibilatrix* (9%), Garden Warbler *Sylvia borin* (9%), Spotted Flycatcher *Muscicapa striata* (7%), Willow Warbler *Phylloscopus trochilus* (7%), Icterine Warbler *Hippolais icterina* (7%), Wheatear *Oenanthe oenanthe* (5%), Redstart *Phoenicurus phoenicurus* (3%), (Messineo et al. 2001). In terms of community structure, the peak in species richness is reached during the late spring migration period (11 April – 20 May, Macchio et al. 2002), and the minimum in the late autumn passage (21 September – 3 October). Richness values are always higher than the national annual means for the different periods, confirming how the island concentrates a very diverse avifauna.

Seasonality of passage

The standard sampling period offers a good coverage of the peak period for trans-Saharan migrants; in fact, in a sample of over 190,000 birds out of 38 species of long-distance migrants collected on the four islands mentioned above, the mean of median dates of migration was April 30, with a normal and unimodal distribution, i.e. the central date of our sampling period. The different species show a strong consistency in their migration timing in spring, and the inter-annual, within-species variability in the mean date of passage is significantly lower than the variation recorded among species (Rubolini et al. 2005). The general seasonal pattern of passage of trans-Saharan migrants across the Mediterranean has been found to be influenced by factors acting on the wintering and breeding quarters. The importance of Africa is confirmed by the earlier spring movements within the Mediterranean of species wintering in more northern quarters; equally, species overcoming a complete wing moult on the wintering grounds show delayed northward movements. As for the influence of the breeding quarters, we found that early migration is related to cavity nesting, a strategy which implies direct competition for limited nesting opportunities, hence a selective advantage for an early arrival on the breeding grounds (see Rubolini et al. 2005 for a detailed discussion).

The data collected on Capri have also contributed to describe and investigate differential migration of sex- and age-classes, an aspect which the PPI results have shown to be very widespread among spring migrants across the Mediterranean (Spina et al. 1994; Messineo et al. 2001).

Migratory routes

Songbird species are generally characterized by a very low recovery rate, implying the need for a huge effort and long time in order to come to sound recovery samples. Data collected on 21 stations during the PPI offered a first example of the use of ringing (and not recovery) data to describe the geographical distribution of species-specific flyways based on networks of ringing stations across wide geographical areas (Pilastro et al. 1998). This method allowed to show flyways followed by species with particularly low recovery rates, like *Phylloscopus* sp. The case of Bonelli's Warbler *Phylloscopus bonelli* and Melodious Warbler *Hippolais polyglotta* in particular also offered interesting examples of detours in migratory routes

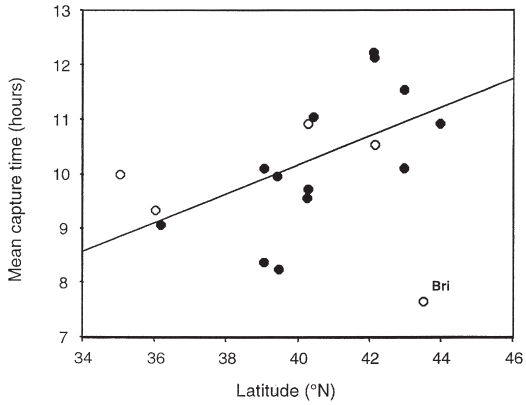

Figure 2. Garden Warbler: the mean time of capture during the day in relation to the latitude of the different ringing stations (open circle= mainland station; filled circle= island station). The line is the least square regression fitted to the points, excluding Monte Brisighella, BRI. From: Grattarola et al. 1999.
Trädgårdssångare: medeltid under dagen för fångst i förhållande till märkstationernas breddgrad (öppen cirkel = fastlandsstation, fylld cirkel = östation). Linjen är minsta kvadrat-regressionen för punkterna, med Monte Brisinghella, BRI utesluten. Från Grattarola et al. 1999.

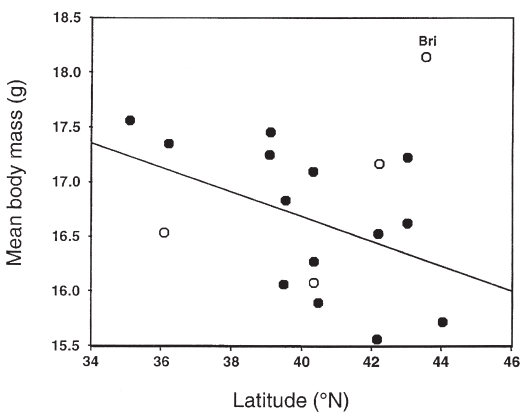

Figure 3. Garden Warbler: mean body mass against latitude of the different ringing stations (open circle= mainland station; filled circle= island station). The line is the least square regression fitted to the points, excluding Monte Brisighella, BRI. From: Grattarola et al. 1999.
Trädgårdssångare: genomsnittlig kroppsmassa i förhållande till märkstationernas breddgrad (öppen cirkel = fastlandsstation, fylld cirkel = östation) Linjen är minsta kvadrat-regressionen för punkterna, med Monte Brisinghella, BRI utesluten. Från Grattarola et al. 1999.

(Alerstam 2001). Both species are extremely rare on islands like Capri, being on the contrary very numerous in the Western Mediterranean Spanish islands and coastal sites, suggesting an avoidance of direct barrier crossing by birds which are regularly breeding also in continental Italy.

The collection of biometrical data on all PPI stations allows also to infer on different populations of a same species crossing different areas of the Mediterranean. In the case of the Garden Warbler, a progressive increase in wing length with longitude has been found (Grattarola et al. 1999), matching the W-E dimensional cline observed in breeding populations across Europe. This suggests similar migratory directions followed by birds heading towards the breeding areas, irrespective of the distance to be covered across the sea.

Progression of the fronts of migration

A network of ringing stations also provides data on the daily distribution of catches at different stages of barrier crossing. In this case, by considering a general S-N pattern of movements across the Central Mediterranean, is has been possible to confirm a progressive movement of fronts of migration, with a delayed arrival on islands at higher latitudes, like in the Garden Warbler (Figure 2, Grattarola et al. 1999). It is interesting to note that such daily patterns refer also to classical night migrants, suggesting that once they have embarked on sea crossing, birds perform prolonged endurance flights, given also the impossibility of stopping over when islands or coasts are not available.

Progressive use of energy reserves

Based on the same model of progressive movements across the sea, we should expect energy reserves being depleted with increased duration of flight and distance migrated. This has been found in the Garden Warbler both for standardized body mass and fat score (Figure 3, Grattarola et al. 1999). In the same species, the observed values on the PPI stations also match the predicted pattern of progressive decrease in body mass as estimated using Pennycuick's model (Pennycuick 1998). This suggests that in fact birds are able to cross the extended barrier represented by the Sahara and Mediterranean in spring without significantly refuelling en route.

Physical conditions of staging migrants and physiology of endurance flights

In spring selection favours an early arrival on the nesting grounds, hence optimal migration theory predicts that spring migrants should minimize time (Lack 1968, Alerstam & Lindström 1990). When thinking of the Mediterranean crossing in spring, we should therefore expect only exhausted migrants to stopover on the islands, with those in better conditions continuing their flight. Equally, we should expect staging migrants to show generally negative physical conditions, with a low within-species variability in conditions among different sites, and a low among-species variability in conditions. Quite interestingly, we found a clearly different situation in a large sample referred to 28 species of trans-Saharan migrants ringed on Ventotene island. Here a clear inter-annual consistency in species-specific average physical conditions was found, but a strong difference among species, with different taxa being represented by large numbers of staging migrants in good, medium or very low conditions, respectively. Hence it is not only exhausted migrants that decide to land on the Mediterranean islands, but also birds with still very high potential flight ranges. One could therefore wonder why species differ so strongly in their physical conditions, and why do all these birds stopover despite being potentially able to continue their flight.

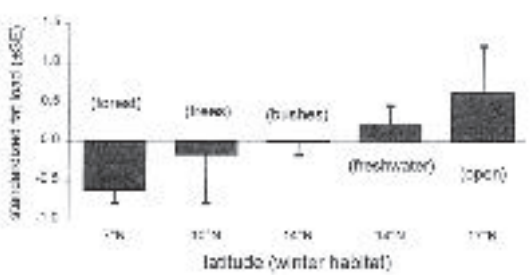

Figure 4. Mean residual fat load, standardised for the flying efficiency of each species, of 28 trans-Saharan passerine spring migrants at their arrival in southern Europe. Species are grouped according to their preferred wintering habitat. The northernmost latitude at which each habitat can be found in tropical Africa is indicated. From: Pilastro & Spina 1997.
Medelvärden för fettlagrets residualer, standardiserade för flygeffektiviteten för varje art, hos 28 tropikflyttare när de anländer till södra Europa efter vårflyttningen. Arterna är grupperade enligt deras favoritbiotop under vintern. Den nordligaste breddgrad är varje habitat kan påträffas i tropiska Afrika har markerats. Från Pilastro & Spina 1997.

Among-species differences in conditions

The most important variable in explaining these between-species differences is represented by the northernmost latitude of the preferred wintering habitat for each species in Africa. Hence, the crossing of the Sahara and the Mediterranean in spring is constrained by the distribution of preferred habitats south of the Sahara (Figure 4, Pilastro & Spina 1997). The overall width of the ecological barrier that the different species will cross without significantly refuelling is not necessarily the same for all species, as not all species are reaching their departure physical conditions in the same geographical area in Africa. This has also been confirmed by the relatively low number of species of Palaearctic songbirds ringed in spring in the Lake Chad region of Northern Nigeria (Ottosson et al. 2002).

Why do so many birds stopover?

This intriguing aspect has been addressed through analyses of the physiology of migrants staging on Ventotene island after a prolonged flight of some 500 km from North Africa (Jenni et al. 2000, Schwilch et al. 2001, Schwilch et al. 2002). Birds with appreciable fat stores are not stressed by endurance flights; however, below a threshold adiposity, the breakdown of proteins regulated by corticosterone levels increases, and an emergency situation of stress, with high corticosterone levels, is reached when muscle proteins get dangerously low. When birds have still over 5–10% body fat, proteins will derive from all organs, but especially from breast muscles. This can be regarded as adaptive, since the decrease in flight muscles matches the one in total body mass. The situation changes when fat stores further decrease; protein catabolism then increases, the mass of the digestive organs is reduced fastest, and flight performance is also reduced.

Nectar for warblers on Mediterranean islands: two birds with a stone!

The already mentioned reduction in mass of different organs entails a reduced digestive capacity in staging migrants after a prolonged flight across a barrier. The risky protein breakdown, together with glycolisys and lipolysis, is triggered by low blood glucose levels. In spring we have recorded intense feeding especially of *Sylvia* and *Phylloscopus* warblers on flowers. On Capri these are chiefly

Brassica fruticulosa; the same plant is visited on Ventotene, together with the tall flowers of *Ferula communis*. Field observations and cage experiments could confirm that nectar is the target food for these birds, rather than pollen or insects. When thinking of the situation of a migrant after an endurance flight, with reduced digestive capacity and an urgent need for recovery, nectar might be the ideal solution, as monosaccharides do not need digestion and are absorbed directly. The uptake of glucose would also reverse the process of protein breakdown and initiate the synthesis of glycogen, lipids and proteins. Hence, nectar feeding would allow migrants to efficiently compromise between the need to minimize the overall duration of their return migration, in the meantime resting after prolonged and energetically very costly flights, and avoid the risk of reaching threshold low levels of blood glucose which would trigger a dangerous process of protein breakdown. Brief stopovers on Mediterranean islands therefore offer spring migrants a chance to 'get two birds with one stone': regardless of their physical conditions, they can rest, get some energy (through nectar or insects, in the case of exclusive insectivores), if necessary increase again blood glucose levels, and still minimize time. It is in fact a common experience on these islands to see 'night-migrants', like warblers or thrushes, resuming their northward migration during daytime.

Conclusions

The Mediterranean is a significant ecological barrier for spring migrants originating from their African winter quarters. Mediterranean islands represent important 'bottleneck areas' for migrants, where intense human activities may represent major threats for their conservation. There is a strong functional link between staging migrants and the islands' habitats; this aspect needs being taken properly into account when planning local and international conservation strategies. Long-term and large-scale monitoring of spring migration in the Mediterranean is useful also to better understand the relationships between ecological factors acting in Africa during the boreal winter and breeding performances of a large array of species within the Palaearctic. Recoveries originating from ringing activities on the Mediterranean islands through the PPI project confirm the key international responsibility of Mediterranean countries within the wider international framework of migratory birds conservation. The case of the long-term ringing activities carried on by Swedish ornithologists on Capri, with the later positive developments of an intense co-operation with Italian ringers through the PPI, is an example of how migratory birds may stimulate international links for environmental research and conservation.

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Sammanfattning

Vårflyttande fåglar på väg norrut från vinterkvarteren i tropiska Afrika till häckningsområden i Europa måste passera en dubbel ekologisk barriär – först Sahara-öknen och ofta direkt därefter Medelhavet. Öar i detta hav ger dock vissa av fåglarna möjlighet att rasta under dessa utdragna flygningar och sedan 1988 har italienska ornitologer inom ramen för det s.k. öprojektet PPI (Progetto Piccole Isole) studerat dessa rastande flyttfåglar. Ett stort antal ringmärkningsstationer deltar i projektet (Figur 1). Capri har varit en av huvudlokalerna för denna verksamhet och den här uppsatsen ger en översikt över PPI-projektet och dess uppnådda resultat.

Fåglar av många olika arter och i ytterst varierande fysisk kondition rastar på öarna, med väldefinierat säsongsmässigt uppträdande både vad gäller de olika arterna och deras respektive köns- och ålderskategorier. Bredfrontssträck av annars typiska nattsträckare noteras även under dagen – inte oväntat, då fåglarna ju först måste nå land innan de kan rasta. Fåglarna anländer till de olika märkstationerna vid olika klockslag, senare ju längre norrut de ligger. Ett exempel på detta ges i Figur 2 för trädgårdssångare. Olika arter kommer fram i olika grader av fysisk "utmattning", alltså med högre eller lägre relativa kroppsvikter. Det beror bland annat på hur långt söder om Sahara deras respektive startområde ligger och därmed hur lång deras totala flygsträcka varit. Figur 3 visar hur kroppsvikten hos trädgårdssångare varierar med läge.Väl framme på öarna i Medelhavet kan fåglarna både vila och justera sitt metaboliska system – det senare inte minst genom att äta nektar från olika blommor och via dess i blodet direktupptagna sockerarter snabbt komma i form igen.

Flyttfåglarna är under olika tider på året beroende av olika biotoper i Afrika, kring Medelhavet, och för många även områden mycket längre norrut i Europa. Dessa olika biotopers gynnsamhet för fettupplagring avspeglar sig i form av olika mängder fett hos fåglar som anländer från olika biotopzoner söder om Sahara (Figur 4). Detta faktum utgör ett starkt argument både för internationell koordination inom naturskyddet och för flyttfågelforskning längs hela vägen från häckningsområdena till vinterkvarteren.