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Combined use of radar and mist net trapping to detect species composition of nocturnal migrants

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Abstract - The Strait of Messina, in southern Italy, is a well-known migration hotspot for diurnal migrants such as raptors. Radar studies have also shown that there is a considerable rate of nocturnal passage of migrants during spring migration. During the spring season 2015, we combined mist net trapping with radar observations at a site on the Calabrian side of the Strait, to characterize the species composition of nocturnally migrating passerines, and to investigate the relationship between the numbers of birds flying over and the ones stopping at the study site. Despite the radar counted nearly four millions tracks of birds flying overhead, only 242 individuals were captured with mist nets during the same period. Of these, only 70 (28.9 %) were potential migrants. There was no correlation between the number of daily captures and the number of tracks recorded by radar on the previous night. The application of radar observations clearly shows that a large proportion of passing migrants may go undetected when relying on counts of birds at a watchpoint for diurnal observations only. The Strait of Messina seems to be a passage site for nocturnally migrating birds including songbirds. However, most favourable stopover sites for these birds might be found further South, possibly not far from our study site.

Keywords: stopover, Strait of Messina, spring migration

INTRODUCTION

During spring migration, nocturnal passerines that migrate from Africa to Europe have to cross the Mediterranean Sea during their northward journey. Since this is a major ecological barrier that offers no chances to rest, birds usually gather at coastal sites and small islands in large numbers after the crossing to recover from the flight (Spina et al. 1993, Pilastro et al. 1998). At these sites, the numbers of passing migrants can easily be monitored by catching the birds during their stopover with standard methods, as e.g. mist-netting. In Italy, migration monitoring is carried out as part of an ongoing program which coordinates the simultaneous bird netting at several locations, that has been running for over 30 years (Spina et al. 1993). Data from this project indicate that the largest numbers of birds are using islands of the central/southern Tyrrhenian Sea as stopover sites, indicating that these birds might take a direct route of several hundreds of km across the Mediterranean after departing from the North African coast in Tunisia. This route is confirmed by several ring recoveries (Spina & Volponi 2008).

An alternative for birds to avoid such a long flight over the sea is a detour over Sicily, that allows the birds to reduce the distance flown over the sea to about 160 km and to perform most of their flight over land. There is evidence from Sicilian islands that good numbers of birds might choose this route (Spina et al. 1993), but data are lacking from the Sicilian mainland to locate additional important stopover sites.

If birds follow the Sicilian flyway, the Strait of Messina, located between Sicily and mainland Italy, should act as a bottleneck for migration and is an obligate passage point. It is known to be passed by large numbers of soaring diurnal migrants during spring migration (Agostini et al. 1994, Panuccio 2011), but the intensity of nocturnal migration has not been investigated so far. If nocturnal migration through the Strait of Messina would involve large numbers, there is a possibility of it being used as a stopover site as well.

We investigated the role of the Strait of Messina as both a corridor for nocturnal migration and as stopover site for passerine migrants. A preliminary study conducted in 2014 revealed that the area is interested by the passage of nocturnal migrants, likely passerines, but no information is available on what are the species involved (unpubl. data). During one season of spring migration, we combined radar observations to quantify the passage and mist-netting during the day, to characterize species composition and compare the number of birds stopping over with those flying overhead. We expected to find a correlation between the number of migrants passing through the night and the number of captures on the following day, as observed in previous studies at stopover sites (Zehnder & Karlsson 2001, Simons et al. 2004, Peckford & Taylor 2008, Komenda-Zehnder et al. 2010, Horton et al. 2016).

METHODS

The work was carried out between April 15th and May 15th, 2015, during the period of migration of several long-distance Afrotropical-Palearctic migrants. The field station was on Piano Scapolella (Solano, RC, hereafter called "Aspromonte"; 38° 23'N, 15° 79' E) at the edge of a flat highland (the Aspromonte plateau) at about 1000 metres above sea level (Fig. 1A), on the eastern side of the Strait of Messina. The radar was positioned near the edge of the plateau and the bird netting took place with 400 m distance from the radar instrumentation.

Radar equipment

We used a 10 kW, X-band radar (9.1 GHz), with a 2.16 m antenna set vertically and rotating at 38 rounds per minute (GEM, Italy). The radar operated in long pulse mode (200 ns and PRF 1000Hz). This type of radar can detect bird movements in any weather condition except during rain. The radar range was approximately 1.2 kilometres long and the detection area was limited to a 180° sector above ground (to reduce clutter) and oriented from East to West, perpendicular to the direction of the migratory flow (which is South-North to Southwest-Northeast, pers. obs.), while the remaining sector was blank. The perpendicular setup was chosen because the aim was counting the number of echoes crossing the radar beam rather than identifying flight direction and speed of migrating birds. Since the density and frequency of the echoes and the RCS were similar to visually detected daily migrants of the size of martins or bee-eaters (pers. obs.), we confirmed that the tracks recorded were most likely of migrating birds. Radar measurements were carried out continuously every night during the study period and interrupted only by the onset of heavy precipitation (on eight nights during the study period). We recorded screenshots with the radar echoes every second and compiled 1-hour periods as videos. We then processed the videos with the radR 2.5.1 package in the R software (Taylor et al. 2010). We used radR to calculate the number and length of the tracks of echoes recorded by the radar. To exclude disturbance caused by insects (which are usually detected by the radar only at closer range and for shorter time than birds) we ignored (i) tracks shorter than 200 metres, (ii) tracks with less than four subsequent echoes, (iii) all tracks within 300 m from the radar, and (iv) tracks characterized by a ground-speed lower than 30 km/h and higher than 100 km/h (Bruderer & Boldt 2001, Schmaljohann et al. 2008, Kemp et al. 2010, McLaren et al. 2012, Nilsson et al. 2018). We also documented flight altitudes of 121,046 traces of nocturnal migrants recorded between April 30th and May 25th, 2015. These traces were selected for being within 200 m left to 200 m right from the radar position to ensure that the altitude estimate was based on a vertical distance.

Mist netting

Birds were captured using mist-nets every day from one hour before sunrise until sunset and checked every hour. We deployed 240 m of mist-nets of 2.4 m height and interrupted capture only during precipitation and strong winds which occurred on two days (April 23rd and April 27th) during the study period. After capture, birds were measured using standard methods (Bairlein 1995), ringed with an aluminium ring and immediately released.

Data analysis

We quantified the intensity of nocturnal passage by calculating the average number of radar tracks per minute during the night. Averaging was necessary since in some nights (n = 6) the radar did not operate continuously. We also considered the hourly total of tracks throughout the season to identify the peak time of passage. Since radR has the tendency to split tracks into more than one unit, thus overestimating the number of passing individuals (Nilsson et al. 2018), we reported the relative number of radar tracks as a measure of passage intensity. To calculate this, we standardized the average number of tracks per minute in a given night by subtracting the mean and dividing by the standard deviation. We correlated relative radar track number with the number of birds captured on the next day using linear regression, excluding recaptures that had been present at the site for longer than one day. Many species might have been local breeders, and as such not representative of the migratory flow. We excluded from the analysis all species that are known to be sedentary or to migrate earlier than our study period (following phenology data from Spina & Volponi 2008). All analyses were performed using R 3.4.3 (R Core Team 2017).

RESULTS

3,808,745 tracks were recorded by radar during one month of observations (N = 29 nights, on two nights the radar did not operate because of adverse weather). On average, this amounted to 209 tracks/minute. The night with the highest intensity of migration was April 19th, while the night with the lowest intensity was May 12th. The daily relative number of radar tracks is shown in Fig. 1B. The hourly distribution of tracks shows that nocturnal passage peaked at the beginning of the night and then decreased constantly (Fig. 1C). The majority of traces was recorded around 400 m altitude above the radar (i.e. ~1400 m asl, Fig. 1D). During the same period, 242 individuals were captured with mist nets. Of these, only 70 (28.9 %) were potential migrants (Tab. 1). There was no significant relationship between the number of daily captures and the number of tracks recorded by radar on the previous night ($R^2 = 0.011$, $p = 0.62$; Fig. 2).

DISCUSSION

Nocturnal migrants were passing our study area in large numbers, as shown by the radar tracks. In peak nights of passage, we recorded over 400,000 tracks in the small area covered by the radar. Although this might be an overestimate of the real number of passing birds (Nilsson et al. 2018), the night with most intense passage had over 100-fold numbers compared to the night with the lowest passage. This shows that the Strait of Messina lies along a commonly used migratory flyway. Radar observations at other sites in the Mediterranean, such as the small islands in the Tyrrhenian Sea, would provide information about the fraction of the migrant population that is actually using each flyway. There is some consensus that spring migration occurs on a broader front than au-

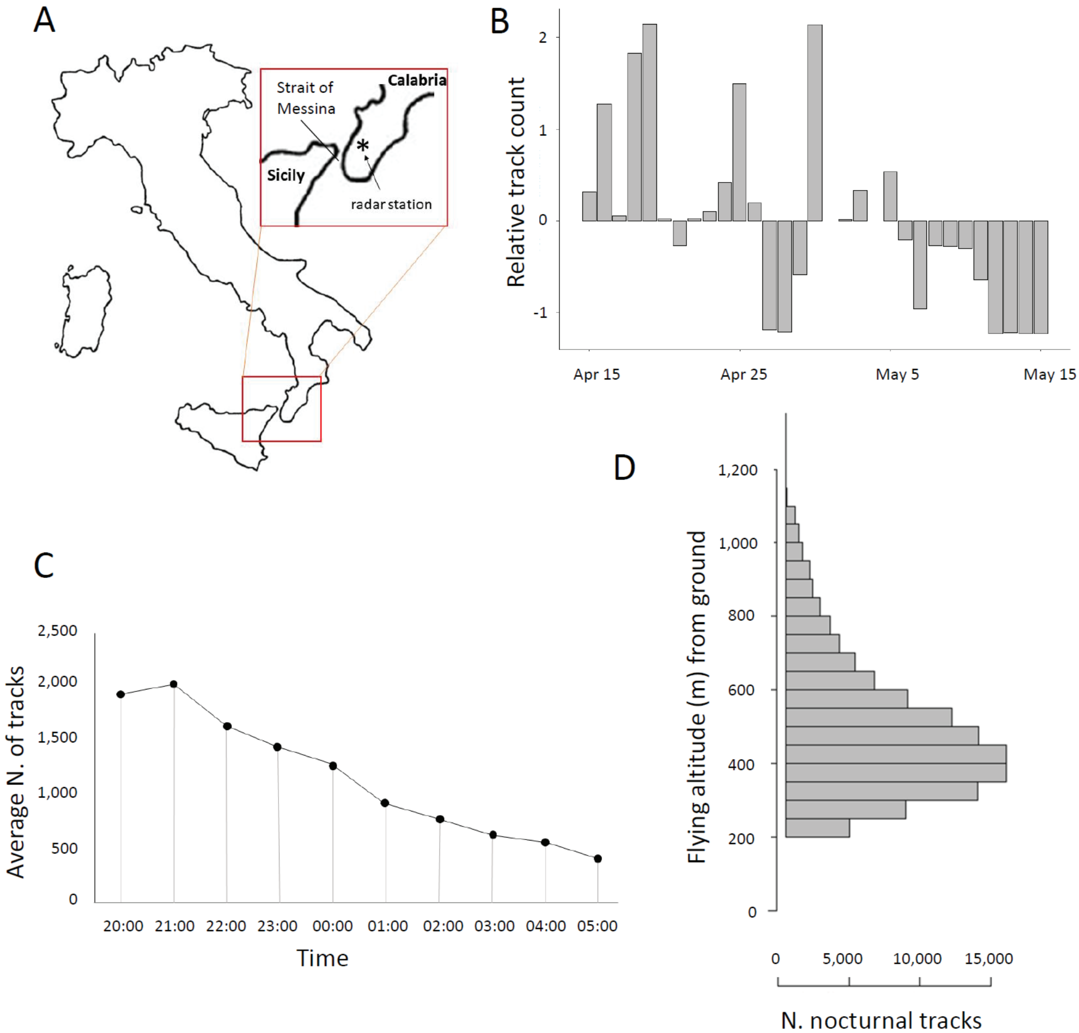

Figure 1. A) Geographic location of the study site. The radar and mist-netting stations are indicated by the asterisk; B) Relative number of radar tracks per night recorded at Piano Scapolella between April 30th and May 25th, 2015. Data were not recorded on two nights: May 1st and May 4th; C) Hourly number of radar tracks averaged over all nights in the study period, excluding those when the radar was not operating (N = 29); D) Altitudinal distribution of radar tracks over Piano Scapolella, averaged over all nights in the study period, excluding those when the radar was not operating (N = 29). The zero altitude refers to the position of the radar, which was at approximately 1000 m asl.

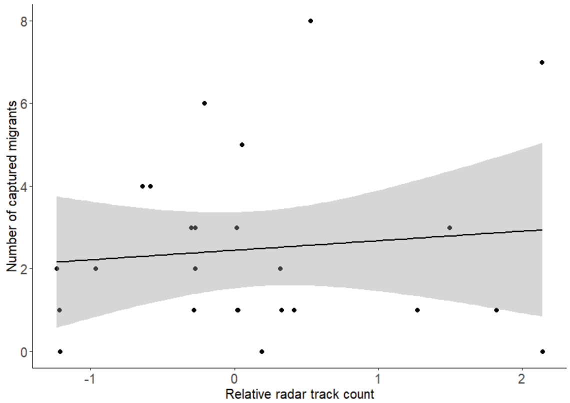

Figure 2. Number of migrant birds trapped plotted against the relative number of tracks recorded on the previous night. We show a regression line with standard error range.

tumn migration (Nilsson et al. 2014), but this is mostly based on observations of single tracked individuals and on the fact that the central Mediterranean hosts larger numbers of migrants in spring than in autumn (Moreau 1961, Grattarola et al. 1999). The latter does not exclude, however, that the birds follow different flyways than in the autumn, but without spreading over a broader front of migration.

Despite the large number of birds flying through the area, only a very small fraction was observed stopping over at the study site. Most birds were flying 400 or more meters above the ground, which shows that they were performing migratory flights. Given the very low number of birds caught during the mist netting and the lack of relationships with the echoes detected by the radar it is clear that our study area has little importance as a stopover site for nocturnal migrants. The migratory conditions at the Strait of Messina are very different and therefore hard to compare to those related to the observations carried out e.g. on an Alpine pass (Komenda-Zehnder et al. 2010). Unfortunately, we also were not able to compare the migration traffic rate (MTR) to other studies conducted in the Mediterranean (e.g. Bruderer & Liecthi 1999), because the radar systems used were of a different type.

Our data suggest that the habitat around our study site might not have been suitable for stopover. The study site is located at a relatively high elevation and stopover sites are available along the Calabrian coast. During spring migration, birds might not be highly selective of habitats, especially when performing only a short stopover before progressing with their journey (Biebach et al. 1986, Schmaljohann et al. 2007). Therefore, they might simply pick locations that are easier to reach. Alternatively, migrants would not stop in this area because it is too close to their last stopover. Nocturnal migrants observed by radar might also include non-passerine birds such as waders or swifts (Newton 2010), which would be less likely to use the study site as stopover. However, although the proportion of non-passerine birds in the aerial traffic over the radar station was not known, a previous study on an Alpine pass reported that trapping numbers were strongly correlated with migratory intensities measured by radar (Komenda-Zehnder at al 2010). Therefore, we expected to find a similar correlation in our study, which was not the case, probably for the reasons stated above. The peak of passage during the study season was in the early part of the night. Assuming that nocturnal migrants start their flights around sunset (Alerstam 1990), an early peak of passage indicates that their last stopover was at a rather close distance. In our study system, this suggests that the birds flying over the Strait of Messina did, indeed, choose the Sicilian flyway to cross the Mediterranean Sea. Future studies might reveal whether these birds belong to different species or populations (i.e. directed towards different destinations) to the ones found crossing the sea through the more direct flyway to the Tyrrhenian islands (Spina et al. 1993), or whether birds from the same populations might choose to use different flyways depending on endogenous (body condition, experience) or exogenous (weather) factors.

The use of radar observations clearly shows that a large proportion of passing migrants may go undetected when relying on counts of birds at a trapping site or on diurnal observations only. The Strait of Messina seems to be an important site funneling a large number of nocturnal migratory birds but our

Table 1. Number of captures per species during one month of mist-netting. Migrant species are shown in bold.

Species	Total captures
Cirl Bunting *Emberiza cirlus*	32
Whitethroat *Sylvia communis*	**23**
Stonechat *Saxicola torquata*	18
Linnet *Carduelis cannabina*	16
Rock Bunting *Emberiza cia*	16
Blackcap *Sylvia atricapilla*	15
Blackbird *Turdus merula*	15
Whinchat *Saxicola rubetra*	**14**
Red-backed Shrike *Lanius collurio*	**13**
Greenfinch *Chloris chloris*	11
Great Tit *Parus major*	10
Italian Sparrow *Passer italiae*	9
Corn Bunting *Miliaria calandra*	7
Wryneck *Jynx torquilla*	**7**
Sardinian Warbler *Sylvia melanocephala*	6
Chiffchaff *Phylloscopus collybita*	4
Pied Flycatcher *Ficedula hypoleuca*	**3**
Garden Warbler *Sylvia borin*	**3**
Wren *Troglodytes troglodytes*	3
Coal Tit *Periparus ater*	2
Blue Tit *Cyanistes caeruleus*	2
Firecrest *Regulus ignicapillus*	2
Robin *Erithacus rubecula*	2
Tree Pipit *Anthus trivialis*	**2**
Hoopoe *Upupa epops*	**2**
Northern Wheatear *Oenanthe oenanthe*	**1**
Chaffinch *Fringilla coelebs*	1
Meadow Pipit *Anthus pratensis*	**1**
Short-toed Treecreeper *Certhia brachydactyla*	1
Subalpine Warbler *Sylvia cantillans*	**1**

study site, despite being an optimal location for radar studies, was not suitable as a stopover location. For this reason, unfortunately the species identity of these birds could not be determined. Rapid advances in radar technology and in analytical tools might improve this in the future (Chen 2015), and the analysis of data from networks of ringing stations (such as the Progetto Piccole Isole in the Mediterranean, Spina et al. 1993, Pilastro et al. 1998) combined with radar sites (such as the ENRAM project, Shamoun-Baranes et al. 2014) will provide a broad-scale characterization of the flow of migrants across the large barrier of the Mediterranean Sea and at a continental scale.

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