Dataset: bird traffic rate at Bolle di Magadino Natural Reserve, Lake Maggiore (Switzerland)

Silvia Giuntini,[1*] Clara Tattoni,[1] Alessandra Gagliardi,[1,2] Alessio Martinoli,[1,2] Nicola Patocchi,[3] Roberto Lardelli,[3] Adriano Martinoli,[1] Damiano G. Preatoni[1*]

[1]Environment Analysis and Management Unit - Guido Tosi Research Group, Department of Theoretical and Applied Sciences, University of Insubria, Varese, Italy; [2]Oikos Institute, Milan, Italy; [3]Bolle di Magadino Foundation, Magadino, Switzerland

ABSTRACT

In this paper we describe a 2-year (2021-2022) dataset of bird traffic rate measured with the avian vertical-looking radar BirdScan MR1, installed near the Bolle di Magadino Natural Reserve protected area (Switzerland), an important stop-over site on the northern shore of Lake Maggiore. The dataset includes over 200,000 records of hourly traffic rates measured from 0 to 3000 m above ground level, with altitude bins of 100 m. This dataset is available on Zenodo, under an "Attribution-NonCommercial" Creative Commons 4.0 International license (CC BY-NC 4.0) at doi:10.5281/zenodo.7783993.

INTRODUCTION

Since the 1950s, the use of radar in ornithology has grown steadily, first by utilising existing technologies used in other fields such as weather radar, tracking radar, aviation radar (Alerstam, 2011), and marine radar (Hüppop *et al*., 2006), and later by utilising ad-hoc designed devices derived from short-range nautical radars operating in the X-band. Radars designed for ornithology allow researchers to understand the direction and intensity of bird migration and use this information in the fields of bird ecology and conservation, in particular to study bird migration modifications in relation to environmental changes due to human activities (Nathan *et al*., 2008). In this paper we present the data collected with BirdScan MR1 #270, an avian vertical-looking radar (AVLR) manufactured by the company Swiss Birdradar Solution AG (SBRS, Winterthur, Switzerland; https://swiss-birdradar.com/company), a spin-off of the Swiss Ornithological Institute (Bruderer *at al*., 2012). This instrument can automatically detect and classify birds and other types of flying animals, with different accuracy according to the size and distance of the targets. The BirdScan MR1 is an X-band radar that can detect small objects (*e.g.*, small passerines, insects, and bats) up to 1000 m and large birds (*e.g.*, gulls) up to 2000 m altitude (Nilsson *et al*., 2018). The radar design is of the vertical type (vertical looking radar) that is, the antenna, projects vertically (instead of horizontally, as in conventional nautical and meteorological radars) a cone-shaped wide aperture microwave beam. The instrument records several parameters for each target detected (wing beat pattern, height above the ground, flight direction and speed, target shape, and section surface), that are saved in a local database. Using size and wing-flapping pattern analysis, the software classifier can identify non-biological echoes and several types of echoes attributable to flying animals, assigning them to different subcategories (Schmid *et al*., 2019; Zaugg *et al*., 2008; Bruderer *at al*., 2010). The classifier is based on a Machine Learning software developed by the manufacturer, running on the radar internal processor. The output of the classification is saved in a Microsoft SQL Server database that can be downloaded and analyzed (Zaugg *et al*., 2008).

Data downloaded from the radar database were later analyzed with the birdscanR R package (Haest et al., 2023), an R package designed to analyze data coming from BirdScan MR1 databases and calculate the

Corresponding author: damiano.preatoni@uninsubria.it

Key words: radar; birds; migration; MTR.

Citation: Giuntini S, Tattoni C, Gagliardi A, Martinoli A, Patocchi N, Lardelli R, et al. Dataset: bird traffic rate at Bolle di Magadino Natural Reserve, Lake Maggiore (Switzerland) *J Limnol 2022;81:2137.*

Edited by: Angela Boggero, *National Research Council, Water Research Institute (CNR-IRSA), Verbania Pallanza, Italy.*

Received: 28 March 2023.
Accepted: 15 July 2023.

J. Limnol., 2022; 81(s2):2137
DOI: 10.4081/jlimnol.2022.2137

migratory traffic rate (MTR; Trosch *et al*., 2005; Welcker *et al*., 2017), an index that defines the number of individuals crossing an ideal 1 km wide transect, perpendicular to the migration direction for specific altitude strata and time intervals. The data set preparation was carried out in the R environment (version 4.0.5; R Core Team, 2021) with RStudio (version 1.4.1103; RStudio Team, 2020).

The BirdScan MR1 radar that produced the dataset was installed near Bolle di Magadino Natural Reserve, an important stop-over location in Switzerland on Lake Maggiore, whose waters are artificially regulated by a dam. The data collected in this wetland were used to study the effects in lake level changes on passerine birds migration (Giuntini *et* al., 2022; Tattoni *et al*., 2022).

This data set includes other bird classes, so users interested in other groups could extract the data of their interest and compare them with the lake level or other meaningful environmental variables, for example anthropic disturbance such as air traffic or agriculture treatments. The information about bird traffic could be useful for environmental assessments needed to approve interventions and events in the protected area. Finally, as more data of this kind will be available from other radars/locations, the possibilities of investigation will increase. In this data paper we aim to share the dataset of bird traffic rates collected with BirdScan MR1 measured at Bolle di Magadino (Switzerland).

Dataset description

The dataset is a single R dataframe, stored in RDS (R serialized data) format, where each row contains MTR [more appropriately bird traffic rate (BTR), since recorded echoes do not belong exclusively to migrating birds] values for given bird classes (see further), along with the relevant time and altitude bin information, according to the structure reported in Tab. 1. The total row number is

Tab. 1. Field structure of the dataset, showing column names, type and description. All temporal information is in "Europe/Zurich" time zone (CET/CEST).

Column name	Type	Description
timeChunkId	integer	Measurement time span unique identifier
timeChunkDate	Date	Date of the measurement, format: "2021-02-09"
timeChunkBegin	POSIXct	Start of the measurement time span, format: "2021-02-09 00:00:00"
timeChunkEnd	POSIXct	End of the measurement time span, format: "2021-02-09 01:00:00"
timeChunkDateSunset	POSIXct	Sunset date for the measurement time span, format: "2021-02-09"
timeChunkDuration_sec	numeric	Duration of the measurement time span (seconds)
observationTime_sec	numeric	Duration of the effective measurement time span (seconds)
operationTime_sec	numeric	Duration of the operational phase of the measurement (second)
blindTime_sec	numeric	Radar "blind time" (seconds)
proportionalTimeObserved	numeric	1 – (blindtime_sec / observationtime_sec)
dayOrNight	character	Measurement time span occurrence (according to civil sunrise/sunset)
altitudeChunkId	integer	Altitude bin unique identifier
altitudeChunkBegin	numeric	Minimum elevation of altitude bin (m above ground level)
altitudeChunkEnd	numeric	Maximum elevation of altitude bin (m above ground level)
altitudeChunkSize	numeric	Altitude bin width (meters)
altitudeChunkAvgAltitude	numeric	Average (center) elevation of altitude bin (m above ground level)
nEchoes.allClasses	numeric	Number of echoes recorded for the whole measurement time span
nEchoes.bird_flock	numeric	Number of echoes recorded classified as "bird flock"
nEchoes.unid_bird	numeric	Number of echoes recorded classified as "unidentified bird"
nEchoes.large_bird	numeric	Number of echoes recorded classified as "large bird"
nEchoes.passerine_type	numeric	Number of echoes recorded classified as "passerine-like"
nEchoes.swift_type	numeric	Number of echoes recorded classified as "swift-like"
nEchoes.wader_type	numeric	Number of echoes recorded classified as "wader-like"
mtr.allClasses	numeric	MTR (BTR) value for the whole measurement time span
mtr.bird_flock	numeric	MTR (BTR) value for "bird flock" events
mtr.unid_bird	numeric	MTR (BTR) value for "unidentified bird" events
mtr.large_bird	numeric	MTR (BTR) value for "large bird" events
mtr.passerine_type	numeric	MTR (BTR) value for "passerine-like" events
mtr.swift_type	numeric	MTR (BTR) value for "swift-like" events
mtr.wader_type	numeric	MTR (BTR) value for "wader-like" events

209,460, classified by the BirdScan MR1 classifier as reported in Tab. 2.

Object name: MTR_data_BollediMagadino20230329.RData

Data set citation: Giuntini S, Tattoni C, Gagliardi A, Martinoli A, Patocchi N, Lardelli R, Martinoli A, Preatoni DG. Dataset: bird traffic rate at Bolle di Magadino Natural Reserve, Lake Maggiore (CH). Available from: https://zenodo.org/record/8075532

Character encoding: UTF-8

Format name: RDS data file, R default serialization format version 3 introduced in R 3.5.0. https://cran.r-project.org/doc/manuals/r-release/R-ints.html#Serialization-Formats

Distribution (permanent link): https://zenodo.org/record/8075532

Date of creation: 29 March 2023

Date of last revision: 23 June 2023

Date of publication: 30 March 2023

Update policy: no updates scheduled, any possible updates will be handled according to Zenodo versioning system. Permanent all-versions doi is: https://doi.org/10.5281/ zenodo.7783992

Language: English

Licence of use: Open Access data set, "Attribution-NonCommercial" Creative Commons 4.0 International license (CC BY-NC 4.0)

The reference to the original dataset link (https://zenodo.org/record/8075532) and the citation of the present paper are warmly encouraged by the Authors. Stakeholders interested in additional information can contact authors via the contact information provided in the metadata.

Metadata language: English

Metadata managers:
Damiano G. Preatoni (prea@uninsubria.it),
Silvia Giuntini (sgiuntini@uninsubria.it),
Clara Tattoni (clara.tattoni@gmail.com)

Management details

Project title: EU–INTERREG Italia Svizzera 2014/2020 "Parchi Verbano Ticino".

Database managers: Damiano G. Preatoni, Silvia Giuntini, Clara Tattoni.

Temporal coverage: 526 days from 9 February 2021 to 19 July 2022.

Data are available for the following sampling epochs:

1. 10/02/2021 - 07/07/2021, 148 days of monitoring
2. 01/03/2022 - 19/07/2022, 141 days of monitoring

Record basis: Instrumental sampling by BirdScan MR1 Avian Vertical Looking Radar.

Taxa: Birds. Please note that the radar echoes are not classified using standard taxonomy, since the classifier can only be trained to identify "object classes" according to the size of the bird and the pattern of wing beat (Tab. 2). For example, the "swift_type" class includes small-medium sized birds that fly like a swift *i.e.*, glide and flap. Swift_type class possibly includes: Hirundinidae such as swallows and house martins as well as different species of swifts from the family Apodidae. However, some species of falcons and corvids could show such patterns at certain speeds. Echoes from a continuously flapping bird are classified as "wader type" that includes several species belonging different families and even orders. Continuous flapping occurs for "waders" (suborder Charadrii), as well as to the "sandpipers" (suborder Scolopacidae) but also in "waterfowl" (grebes, ducks, geese and others). "Passerine_type" is assigned to small sized birds that fly by flapping intermittently. Please note that this category may not include all the species belonging to the order Passeriformes. Large sized birds, gliding or soaring without flapping are labeled as "large_bird" a very general class where raptors, cranes and storks can be found. When a flock of many birds moves above the radar, the wing flapping patterns cannot be detected with sufficient accuracy and so the echoes of many birds are grouped into the "bird_flock" class. Finally, when the classifier is not able to put an echo in any of the above classes, but it is not an insect or a non-biological echo, it labels it as "unid bird" unidentified bird. This happens also when the birds move at high elevation. For a detailed description of the species and their flight patterns,

Tab. 2. Number of observations (records) per object class and description according to Bruderer *et al.* (2010) and Zaugg *et al.* (2008).

Object class	Description	Migratory traffic rate records
bird_flock	Group of birds flying close together	8492
unid_bird	Bird cannot be assigned to any of the other classes	37,435
large_bird	Large bird, gliding or soaring without flapping	7991
passerine_type	Small bird flapping intermittently	20,254
swift_type	Small bird flapping and gliding	13,895
wader_type	Continuously flapping bird	11,962

please refer to Bruderer *et al*., 2010, and for the classification process to *Zaugg et al*., 2008.

So, each class can encompass a wide range of species belonging to even different genera and families.

IT specialist: Damiano G. Preatoni

Quality control: the radar performs a check at the start of every measurement session, and in case of rain or other covering objects (leaves, dirt, any unidentified signal scattering source) logs the percentage of blind time in seconds (Tab. 1), blindTime_sec. Any observation having proportionalTimeObserved values less than 80% can be considered unreliable.

Funding grants: this data collection was carried out within the project "Parchi Verbano Ticino" supported by Regione Lombardia/EU–INTERREG Italia Svizzera 2014/2020.

Geographic coverage

The BirdScan MR1 Avian Vertical Looking Radar was placed in the Magadino Plain at the Agroscope Research Campus, A Ramél 18, 6594 Cadenazzo, Switzerland. The instrument was installed in the closest possible location to Bolle di Magadino Natural Reserve (Canton Ticino, Switzerland, 8°51'56.90"E, 46°9'42.17"N), an important stop-over and nesting site for numerous bird species (RSIS, 2017; Lardelli and Scandolara, 2023). The area is a Ramsar Wetland of International Importance, an Important Bird and Biodiversity Area (IBA) and it also belongs to the European-African Songbird Migration Network, a research initiative that focuses on passerine birds migration (Bairlein, 1995). Data are georeferenced according to WGS 84 datum (EPSG:4326, https://epsg.io/ 4326.wkt).

Coordinates: Latitude: 46.16022 N, Longitude: 8. 933954 E.

Habitat type: wetland located in an estuarine landscape.

Biogeographic region: Within the Palearctic realm, according to the definitions of the European Environmental Agency (2017).

Country: Switzerland.

Sampling protocol

The radar was set to operate every 5 min continuously, during the first minute it warms up and checks signal transmission and receiving, and then it records for the following 4 min. The transmitter unit generates about 1800 microwave pulses per second, which are eventually reflected by flying objects and returned to the antenna. The onboard hardware converts the analogue data to digital data and then processes the echoes. The change of body shape caused by wing flapping leads to a periodic fluctuation of the echo intensity, which is distinctive among birds or insects. Data are stored in the onboard database and were downloaded at different times during the operating time from February 2021 to September 2022. Data of recordings covers two periods: from 09/02/2021 to 07/07/2021 and then from 01/03/2022 to 19/07/2022. With the birdscanR R package (Haest *et al*., 2023) we calculated the MTR for 1-h time bins (3600 seconds, as the unit of measure in the RDS file is seconds) and 100 m altitude bins (Figs. 1 and 2).

Data availability

The data are available on Zenodo at: https://doi. org/10.5281/zenodo.7783993.

Link for direct data download: https://zenodo.org/ record/7783993#.ZCwA5nZByWc

ACKNOWLEDGMENTS

This research was funded by "Parchi Verbano Ticino" project, supported by Regione Lombardia/EU–INTERREG Italia Svizzera 2014/2020. We would like to thank the Agroscope agricultural competence centre in Cadenazzo for their kind cooperation. We are grateful to Dr. Michelangelo Morganti and another anonymous reviewer who greatly contributed to improve this data paper.

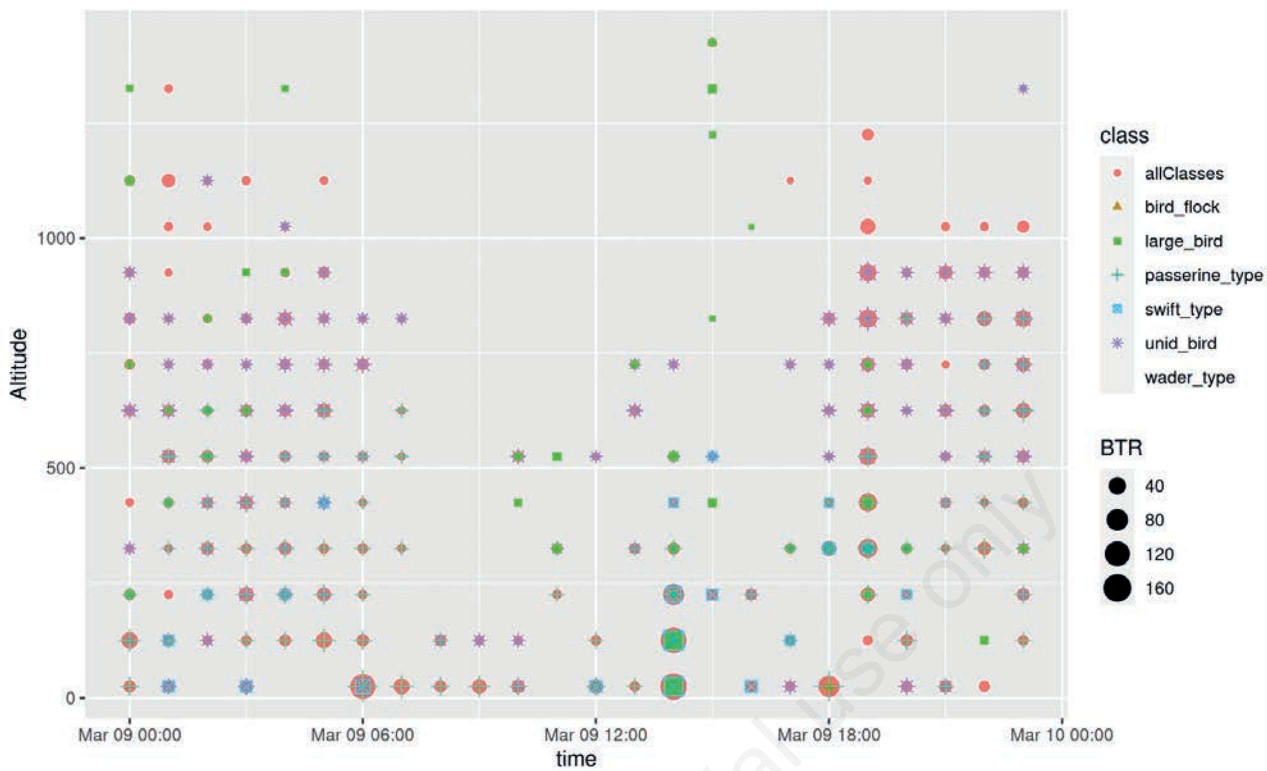

Fig. 1. Example of hourly (migratory) bird traffic rate for 50 m wide altitude bins up to 3000 m above ground level, measured on 9 March 2022. Size of symbols is proportional to bird traffic rate values. The code used to generate the plot is reported below.


```
Code example
R code example used to load the data file and produce Fig.1.
#### Examples for the bird traffic rate at Bolle di Magadino Natural Reserve, Lake Maggiore (CH)
   dataset.
library(dplyr)
library(tidyr)
library(ggplot2)
# how to load data
MTRData <- readRDS('MTR_data_BollediMagadino20230329.RData')
# reshape to 'long' format
MTRData.long  <-  MTRData  %>%  select(starts_with("timeChunk"),  starts_with("altitudeChunk"),
   proportionalTimeObserved, dayOrNight, starts_with("mtr.")) %>% pivot_longer(cols=starts_with
   ("mtr."), names_prefix="mtr.", names_to="class", values_to="mtr") %>% filter(!is.na(mtr)) %>%
   filter(mtr>0)
# pick data for a given date
theDate <- "2022-03-09"
# filter out data
plotData <- MTRData.long %>% filter(timeChunkDate==theDate)
ggplot(plotData, aes(x=timeChunkBegin, y=altitudeChunkBegin)) + geom_point(aes(colour=class,
   shape=class, size=mtr)) + scale_alpha_continuous(plotData$mtr)
# plot passerine-type only, from 500 to 1000 m elevation
plotData <- MTRData.long %>% filter(timeChunkDate==theDate, class=='passerine_type', between
   (altitude ChunkBegin, 500, 1100))
ggplot(plotData, aes(x=timeChunkBegin, y=altitudeChunkBegin)) + geom_point(aes(colour=class,
   shape=class, size=mtr)) + scale_alpha_continuous(plotData$mtr)
```

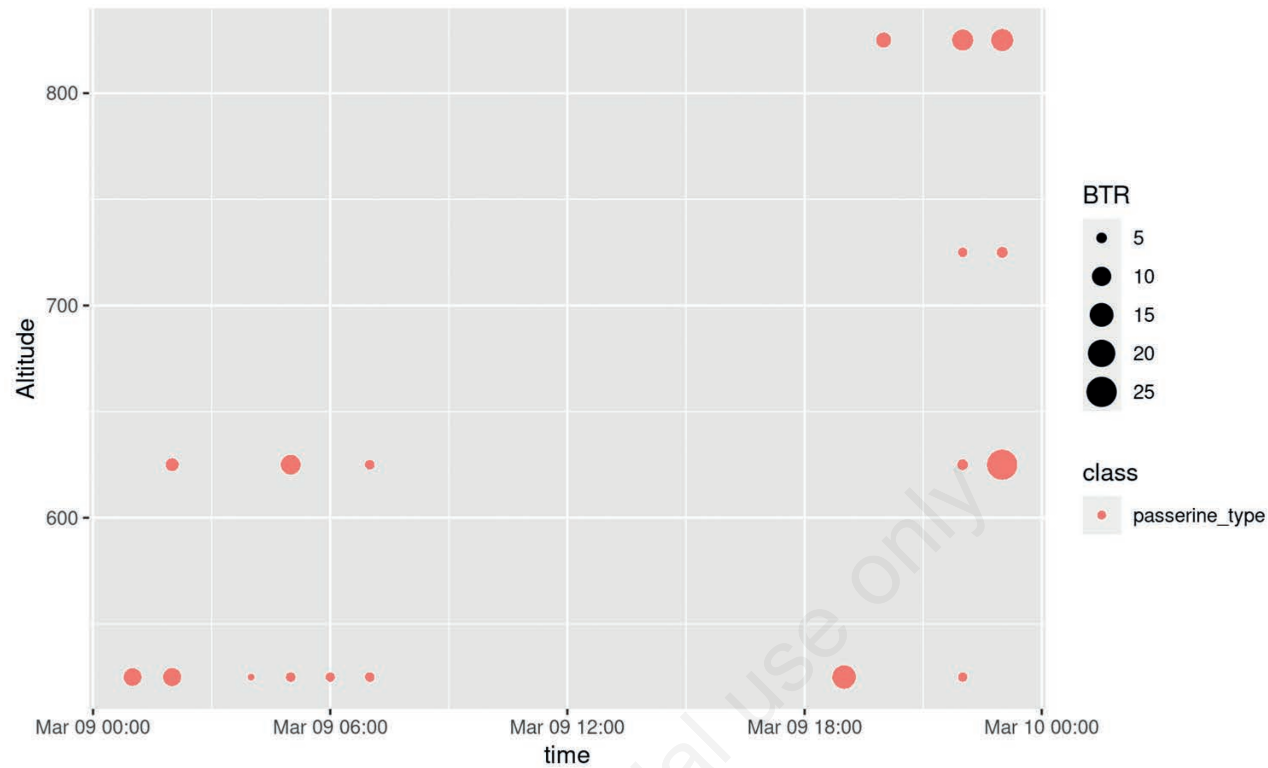

Fig. 2. Example of hourly bird traffic rate for passerine class only at altitude range above 500 and 100-0 m above ground level, measured on 9 March 2022. Size of symbols is proportional to bird traffic rate values.

REFERENCES

Alerstam T, 2011. Optimal bird migration revisited. J Ornithol 152:5-23.

Bairlein E, 1995. European-African Songbird Migration Network. Manual of Field Methods. Wilhelmshaven.

Bruderer B, Peter D, Boldt A, Liechti F. 2010. Wing-beat characteristics of birds recorded with tracking radar and cine camera. Ibis 152:272-291.

Bruderer B, Steuri T, Aschwanden J, Liechti F, 2012. [Vom militärischen Zielfolgeradar zum Vogelradar].[Article in German]. Ornithol Beob 109:157-176.

Giuntini S, Tattoni C, Gagliardi A, Martinoli A, Patocchi N, Lardelli R, Martinoli A, Preatoni DG, 2022. Limnology for the ornithologist: effects of Lake Maggiore water level on migratory flows. J Limnol 81:2123.

Haest B, Hertner F, Schmid B, Preatoni D, De Groeve J, Liechti F, 2023. "birdscanR: Migration Traffic Rate Calculation Package for Birdscan MR1 Radars." Available from: https://CRAN.R-project.org/package=birdscanR

Hüppop O, Dierschke J, Exo K-M, Fredrich E, Hill R, 2006. Bird migration studies and potential collision risk with offshore wind turbines. Ibis 148:90-109.

Lardelli R, Scandolara C, 2023. [In volo tra Africa ed Europa].[Book in Italian]. Ed. Ficedula & Fondazione Bolle di Magadino; 160 pp.

Nathan R, Getz WM, Revilla E, Holoyak M, Kadmon R, Saltz D, Smouse PE, 2008. A movement ecology paradigm for unifying organismal movement research. Proc Natl Acad Sci USA 105:19052-19059.

Nilsson C, Dokter AM, Schmid B, Scacco M, Verlinden L, Bäckman J, et al., 2018. Field validation of radar systems for monitoring bird migration. J Appl Ecol 55:2552-2564.

R Core Team, 2021. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna. Available from: https://www.R-project.org

RSIS, 2017. Bolle di Magadino. Ramsar Sites Information Service. Available from: https://rsis.ramsar.org/ris/231

RStudio Team 2020. RStudio: Integrated Development for R. RStudio PBC, Boston. Available from: http://www.rstudio.com

Schmid B, Zaugg S, Votier SC, Chapman JW, Boos M, Liechti F, 2019. Size matters in quantitative radar monitoring of animal migration: estimating monitored volume from wingbeat frequency. Ecography 42:931–941.

Tattoni C, Giuntini S, Gagliardi A, Martinoli Al, Lardelli R, Patocchi N, et al., 2022. Effect of water level on migratory birds habitat at Lake Maggiore. Int Arch. Photogramm Remote Sens Spatial Inf Sci XLVIII-4/W1-2022:473-478.

Trosch B, Lardelli R, Liechti F, Dieter P, Bruderer B, 2005. Spatial and seasonal variation in nocturnal autumn spring migration patterns in the western Mediterranean area: a moon-watching survey. Avocetta 292:63-73.

Welcker J, Liesenjohann M, Blew J, Nehls G, Grünkorn T., 2017. Nocturnal migrants do not incur higher collision risk at wind turbines than diurnally active species. Ibis 159:366-373.

Zaugg S, Saporta G, van Loon E, Schmaljohann H, Liechti F, 2008. Automatic identification of bird targets with radar via patterns produced by wing flapping. J R Soc Interface 5:1041-105.