Universidade de Évora - Escola de Ciências e Tecnologia

Mestrado em Biologia da Conservação

Dissertação

Análise de tendências populacionais e demografia de passeriformes através de dados de anilhagem científica

Pedro Miguel dos Santos Ribeiro

Orientador(es) | Carlos António Pereira Godinho
Rui do Nascimento Fazenda Lourenço

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To all my friends and family that supported me throughout the years and helped me make this dream a reality.

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For my Mom and Dad

Studying population trends and demography of passerines from standardised ringing data.

Abstract

Scientific Bird Ringing has been conducted for over 100 years. The data collected has been used for numerous purposes, studying population trends of particular species, discovering migratory routes, survival rates and assessing climate change and environmental pollution by using birds as bioindicators. Constant Effort ringing Sites are now used to collect years of data in a standardized way, making it possible to compare results with other sites and better study bird trends and communities. Portugal has hundreds of thousands of ringing records covering decades of data, most of these records are not being used or published. From the data collected in one Constant Effort Site in *Herdade da Mitra* (Portugal) we show how to sex different species based on biometric data, assess breeding site fidelity in migratory species, population trends for the study area and longevity records, as well as provide suggestions to improve ringing in the future.

Key words: Ringing; Population Trends; Constant Effort Sites; Biometrics; Passerines

Análise de tendências populacionais e demografia de passeriformes através de dados de anilhagem científica.

Resumo

A anilhagem científica de aves é feita há mais de 100 anos. Estes dados têm sido usados de várias formas, para estudar tendências populacionais de uma espécie, descobrir rotas migratórias, taxas de sobrevivência e para avaliar alterações climáticas e níveis de poluição através do uso de aves como bioindicadores. Estações de Esforço Constante recolhem dados durante anos, de forma padronizada, sendo possível comparar resultados com outras estações e estudar melhor as comunidades de aves. Portugal tem centenas de milhares de dados de anilhagem recolhidas durante décadas, a maioria destes dados não são usados ou publicados. A partir dos dados recolhidos na Estação da Herdade da Mitra (Portugal), mostramos como determinar o sexo de diferentes espécies de passeriformes com base em dados biométricos, avaliamos filopatria em aves migradoras, tendências populacionais para a área de estudo e recordes de longevidade, também são dadas sugestões para melhorar a anilhagem no futuro.

Palavras-chave: Anilhagem; Tendências populacionais; Estação de Esforço Constante; Biometrias; Passeriformes

Part 1 – Introduction to Ringing

1.1 Introduction

Birds have been used by man for many centuries, for food (hunting, egg poaching), as a hunting tool (falconry), communication (Hayhurst, 1970) and fishing (Hertzberg, 2018). Some of the most outstanding examples of this relationship are the use of Cormorants by fisherman to catch fish in Asia (Hertzberg, 2018) and the use of Rock pigeons (*Columba livia [var. domestica]*) for communication in both World Wars. A pigeon named Cher Ami even received a medal for delivering a message, after being wounded, that saved 194 American soldiers.

The ringing of birds for scientific purposes was started by Hans Mortensen in Denmark in 1899 using aluminum rings on European Starlings (*Sturnus vulgaris*) (Preuss, 2001). Since then, thousands of people around the world have been ringing birds to study, for example, population trends, migratory routes, distribution in wintering and breeding grounds or dispersion of young (Robbins et al., 1987; Balmer et al., 2008).

Studies involving bird ringing range from capture and recapture protocols focused on studying overall bird numbers and demography (Peach et al., 1999; Robinson et al., 2007), age and mortality, population trends (Dunn et al., 1997), arrival of migratory birds and stop-over length, to individual marking with advanced technology (GPS systems) to study migratory routes (Cuckoo Tracking Project by BTO – British Trust of Ornithology), monitor reintroduced (Bearded vultures (*Gypaetus barbatus*) in the Life Gypconnect project) and endangered species (Egyptian vultures (*Neophron percnopterus*) in the Life Rupis project).

After decades of ringing, studies have become more complex, studying geographical expansions, migratory routes, arrivals/departures and their shifts due to climate change (Tombre et al., 2019; Jenni & Kéry, 2003), true survival, juvenile abundance or migration strategies (resident, full migrant and partially migrant strategies), like that of the Blackcap (*Sylvia atricapilla*) (Berthold, 1988).

These studies can also yield new discoveries and answer questions we have not foreseen. For instance, on a study to assess the origin of a migratory population in the British Isles resulted the discovery of new migratory routes and the hypothesis of a 180º reversion of the Blackcap's migratory direction (Kopiec & Ozarowska, 2012). Unpredictable migration routes and patterns have been discovered in a subspecies of

Knot (*Calidris canutus*) by Piersma & Davidson (1992). These discoveries provide strong evidence that disturbances at a local scale (on regions the birds use to migrate) can have global consequences (on wintering and breeding grounds).

Although we can find studies using bird ringing across the five continents, most of the work and data available come from Europe and North America, where ringing has around 100 years of history, which results in more structured ringing schemes. Ringing is also prevalent in Russia, but unfortunately the majority of information is in Russian.

Both continents have similar long term bird monitoring schemes, North America and Europe conduct a Breeding bird survey (North American Breeding Bird Survey - BBS and the Common Bird Census PECBMS) where volunteers follow standardize protocols to record every bird seen or heard. These monitoring schemes provided long time series of data on population trends for hundreds of species. Similarly, countries started to implement structured ringing monitoring schemes to gather long term data which can complement the traditional monitoring programs. To better achieve this goal, the concept of Constant Effort ringing Sites (CES), places were ringing is conducted regularly and in a standardize way, was created.

Constant Effort ringing Sites have the same benefits of providing long time series of data collected in the same way across several years. This type of data collection allows researchers to make direct comparisons between years, calculate accurate trends and learn patterns like migration and stop-over times for example.

The main objectives of this dissertation are to make an overview of the bird ringing in Portugal, and to assess the potential of the data from the Constant Effort Sites to improve the knowledge on bird populations. First, we provide an introduction to bird ringing, its purpose and place in science, its different techniques and the current status in Portugal.

Secondly, we present a scientific paper focused on the potential of collecting structured and standardized data to understand bird populations and abundance changes overtime, using a Constant Effort Site as a case study.

1.2 Ringing techniques

There are different capture techniques suitable for each group of species. Regardless of the capture technique, the study, or the monitoring scheme, all birds captured are ringed with a metal (aluminum/stainless steel) ring. This ring has information on the country and on the scientific organization responsible for the ringing premises, and a unique identification number. This ensures that every bird ringed can be identified and the data of the capture event can be tracked.

Figure 1 - Mist nets with passerines caught

Figure 2 - Rocket nets for waterfowl

Probably the most widely used capturing technique for most passerine species is the mist net (Fig.1). These mist nets are usually placed early in the morning and are checked periodically for birds. Rocket nets are used for waterfowl like ducks. These rocket nets can catch an entire flock of several dozens of birds, attracted by bait that is placed in front of the nets (Fig. 2). For raptors, a live bait, recording or a dummy (fake prey item), is used to attract a bird into a mist net or other specialized traps.

Shorebirds are often marked with several plastic color bands on each leg, the unique combination of color and number of bands identifies the individual and sometimes the scientific research program and country. When using color bands it's important to use as few colors as possible in order to reduce observer error. Varland et al. (2007) recommend the use of highly contrasting colors such as red, white and blue and to avoid pairs of colors like white and yellow or orange and red as they can be easily confused in the field, leading to reading errors. In recent years, the marks were upgraded, and shorebirds are being tagged with color flags (Fig 4) (in addition to color bands and the standard aluminum rings), more easily identified and with the advantage of carrying unique characters. According to the Shorebird Marking Protocol by Pan American Shorebird Program (PASP) (Lesley-Anne et al., 2016) tagged birds in the

Western Hemisphere will have a unique color to their flag according to the region they were tagged in and a unique band color according to the specific country within the region they were first captured in (Fig. 6). So instead of having to take a picture of color combinations and sending it to the project manager to know information about the bird, this technique tells the observer as much information as possible in the field.

In waterfowl, nasal disks and plastic collars are used, due to their behavior leg bands are virtually impossible to read in the field, as the birds legs are underwater most of the time (Fig. 4) (Sherwood, 1966).

Wing markers pierced into the patagium (Fig. 3) and feather painting (temporary mark) are widely used in raptor species, and other soaring birds, across the world (Varland et al., 2007), these techniques are used along with regular leg bands because it is easier to identify a raptor in flight from big numbered wing markers than it would be reading a small plastic or aluminum leg band, even though these typically carry more information.

As we can see bird tagging is always evolving and new techniques and markers are constantly being developed, like the use of GPS tracking or the substitution of simple nasal disks (Fig. 4), used to mark ducks, with smaller markings using unique geometric shapes and color combinations (Fig. 5).

Figure 3 - Wing Tag in a Golden Eagle (*Aquila chrysaetus*). Credit: RAPTOR VIEW RESEARCH INSTITUTE

Figure 4 - Nasal Disk. Credit: L'OFFICE NATIONAL DE LA CHASSE ET DE LA FAUNE SAUVAGE

Figure 5 - Geometric shapes marking

Figure 6 - Color flag in Shorebird. Credit: Dorian Anderson

1.3 Bird Ringing in Portugal

Scientific bird ringing in Portugal was pioneered by William C. Tait, a British national residing in Porto. With no scientific background he started ringing birds with his own metal bands in late XIX century. He went on to release a book called “Birds of Portugal” in 1924 based on his observations and ringing activities. His nephew, Geoffrey M. Tait, co-founded the Portuguese Society for Ornithology in 1966. The first Portuguese to have an impact in ringing in Portugal was Prof. Joaquim Rodrigues dos Santos Júnior that started his ringing activity in 1953. In 1957 he would be instrumental in creating the first ornithological reserve in the country (still running to this day), and for the next 11 years more than 130.000 birds were ringed at “Reserva Ornitológica do Mindelo”.

As of 2012 around 35.000 birds were ringed annually by 220 ringers in the whole country, there is a steady increase in the number of ringers but a stable number of birds caught per year (CEMPA, 2013).

Long term monitoring schemes in Portugal include the winter Monitoring scheme (MAI) (started in 2011, Rocha & Araújo, 2011), Constant effort site project (PEEC) (started in 2006, Cardoso & Tenreiro, 2006), Waterfowl Capture and Marking (1993) (Rodrigues et al., 2014) and yearly European Storm-petrel (*Hydrobates pelagicus*) monitoring by *A Rocha* since 1990 (Bolton & Thomas 1999). The MAI and PEEC schemes are run at a national level, existing several other programs (n=75) running in mainland Portugal and in the archipelagos of Azores and Madeira. Many of which focus on a single species while others focus on more specific issues like studying the ecology of feather parasites and other diseases, as well as social behavior and the use of isotopes and biomarkers (Roque, 2017; Lopes et al., 2006; Davis, 1966).

The Portuguese Institute for Nature Conservation and Forests (ICNF) is the national authority for ringing in Portugal. Inside the ICNF this is done by the Portuguese National Ringing Centre (CNA) that manages all ringers and active programs in the country. This Centre gathers all the information collected by every ringer in Portugal and is responsible for organizing and analysing it. This Centre is also responsible for providing ringing information to EURING which is the coordinating organization for European bird ringing schemes.

As of 2016 there were about eight Constant Effort Sites in the country involved in both these programs. For PEEC there are no results available to the public through APAA's (Portuguese Association for Bird Ringers) website and for MAI we only have access to the total number of birds and species caught from 2011-2015 and the population trend for five species. Data dissemination on these programs is also not carried out by ICNF.

The CNA has released reports from 1977 to 2012. The first 30 years of reports are only comprised of the detailed captures and recaptures, species name, date and location of capture, etc. From 2000-2012 the three reports released identify the number of projects currently capturing birds, the number of ringers, how many birds were caught and where they are distributed in the country, the evolution in the number of ringed birds throughout the years and what they call "Significant records", mainly birds that were recaptured in a short period of time outside Portugal, oldest birds and longer distances travelled by one bird (CEMPA, 2013).

The National ringing centre also operates as a CES and they publish very detailed data, showing their ringing effort and the effects of meteorology on captures for example (Encarnação & Encarnação, 2013).

One reason for this is that CNA, one the most important organizations when it comes to ringing in Portugal, is extremely low funded and relies on the help of volunteers. In their latest report (CEMPA, 2013) CNA alerts to the fact their computer lacks the quality to sustain large data sets, the data base used was set to be replaced in 2013 or it would simply stop working in the future given all the data it had (no update information is available on this issue). CNA also admits that the quality of their reports has suffered due to these problems and some analyses are no longer made as their hardware and software are insufficient.

The success of bird ringing schemes is heavily dependent on volunteers and citizen science, most certified ringers do not get paid to run these schemes or to contribute to national and international studies. Recoveries of birds in the field (by reading tags or photographing birds) are also made by amateur ornithologists and photographers, giving the scientists vital information about the movements of the birds they ring.

The study of bird populations and individuals can give society an insight on the quality of our environment and give us tools capable of predicting future changes in other species, like marine fish stocks (Furness & Camphuysen, 1997) and even help us measure pollutant levels (Furness, 1993) or identify marine oil spills that would otherwise go unnoticed.

1.4 Constant Effort Sites – CES

Constant Effort Sites (CES) are places where ringing is done regularly throughout the year. Apart of specific projects, in these sites, standardized monitoring schemes are conducted aiming to collect long time series of data. Currently there are 10 CES in the country running the MAI and PEEC projects. During spring each CES should do 12 ringing sessions between April and July in 10 day intervals, and in winter six sessions between 15th of November and 15th of February every 15 days. In both cases the effort, number and place of the mist nets should be the same across all sessions and years. With this consistency in gathering data, CES become an extremely valuable source of information and can be used to measure long term changes in bird populations and species (Peach et al., 1998; Ballard et al., 2003).

An international network of CES running common programs allows researchers to compare how bird populations evolve through time in different locations, for example by comparing trends between Southern and Northern European populations, and evaluating if changes are a result of climate change, urban development, forestry and agricultural practices, etc.

A few examples of valuable data that can be retrieved from CES are the study of migration strategies, like migration speed, route or average fuel deposition rate differences between juvenile and adult birds using 65 years of data on the Wood Sandpiper (*Tringa glareola*) (Iwajomo et al., 2013), the ability of 20 common passerine species to adjust their breeding phenology to spring temperature variations, understanding what traits make a species more likely to survive a change in environmental timing of ecosystems caused by climate change, using 20 years of data (Moussus et al., 2010).

At national level, a network of Constant Effort Sites has the potential to improve knowledge on species distribution and population trends, which in the end can contribute to more targeted conservation measures.

A particular example are the routes birds use during migration. Different populations of the same species might use different flyways or migration routes (Uttley et al., 1987), so ringing can be a valuable tool in identifying these flyways and stop-over sites and protecting them (Birdlife International, n.d). This can only be achieved by working at a national level (on the flyways) and international level (stop-over sites, breeding and wintering grounds).

1.5 The Mitra Constant Effort Ringing Site

The data used in this dissertation came from one CES in Alentejo and was collected over the past 8.5 years (2010 - 2017), comprising 64 species and 4.456 captures.

Herdade da Mitra is an experimental farm belonging to the University of Évora, located about 13 km away from Évora's city center and it has 268 ha dominated by Montado (an agro-forestry-pastoral extensive livestock production system characterized by cork oak *Quercus suber* and/or holm oak *Quercus rotundifolia*), but also with some rough bushy patches, a small river with well-developed riparian vegetation, arable crops, vineyards, small vegetable gardens, pinewood forests and olive trees as well as Mediterranean temporary and permanent ponds, an important source of water during the drier months (Mitra Nature, 2014). This diverse landscape contributes to the large biodiversity that can be found here, being possible to observe 150 species of birds during the year, from forest to open land species (eBird, 2012).

Évora has a Mediterranean climate, classified as Csa following Köppen, (IPMA, n.d) characterized by hot and dry summers, with the hottest month averaging 23.4 ºC. The year temperature mean is 15.9 ºC with a mean of 629 mm of rain (Climate Data, 2015).

The location of this CES makes it almost unique in Portugal, as out of the 10 sites contributing to MAI and PEEC programs, only three are located more than 50 km from the seacoast. These Constant Effort ringing Sites cover different habitats, like forest areas and riparian galleries, from the ones in the coast (mainly wetlands). Consequently, different species will be captured and monitored which contribute to characterize species populations in poorly studied areas like the interior of Portugal. The loss of this particular CES would mean the loss of 1/3 of inland bird ringing leaving these habitats extremely poorly represented.

The ringing of the birds occurs in and around the riparian zone, in the winter the mist nets are placed in the riparian zone, around a garden and on an arable crop. In the spring the mist nets are also located near the riparian zone of the river but also in a pinewood forest. In any given year, these nets are placed across an area of about 5.5 ha and have a grand total of 711 m^2 of catching area. This allows the capture of different bird species with distinct ecological niches.

Standard mist nets are used, ranging from 9 to 18 meters long and standing around 3 m tall (30 cm off the ground) supported by 4 m poles. Each mist net has four pockets which allow an easier capture of the birds by entangling them.

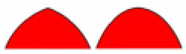
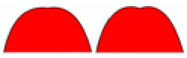
Most of the birds are removed, in under two minutes and without any visual injuries, by experienced licensed ringers while the rest is removed by trainees under the former's supervision. The birds are then placed in white opaque cloth bags and transported to the ringing station (away from any mist nets, to not disturb the wild birds and influence ringing results). Each bird is processed by one person and several biometric data is taken before being released with a numbered ring around one of the legs which uniquely identifies each bird. Sometimes birds are recaptured (either ringed in the same station or coming from another one, occasionally from different countries) and to account for this, a note is taken in the ringing work sheet stating the bird is a recapture. This is very useful in knowing the longevity of animals, where they migrate to and from where, if they are resident (recaptures throughout the year in the same place), if there is breeding site fidelity, etc.

In all ringing sessions the following biometric information is collected (Whitworth, 2007); **"Wing"** (the length of a closed wing taken from the carpal joint to the end of the primary feathers), **"Bill"** (the length from the tip of the premaxila to the point where the frontal and nasal bones meet, also called culmen or bill length), **"Tarsus"** (length of tarsometatarsus, measured from the intertarsal joint to tarsometatarso-phalangeal joint), **"WingPri"** (length of the 8^{th} primary feather, counting from the inside of the wing out, the outermost primary feather being P10, taken from the insertion point to its tip (Svens, 1992); **"Muscle"** (ranked from 0-3 based on the shape of the muscle, Fig. 7), **"Fat"** (ranked from 0-8 based on Kaiser (1993)); **"Age"** (from 1-6 following Table. 1), these codes are used mainly for passerines, for other groups of birds such as seagulls or raptors, it is possible to give more accurate ages due to sequential moulting); **"Weight"** (measured in grams of the total weight of the bird). Additionally to the biometric measures, we also collect data on the date and hour of the ring session, and which mist net the bird was caught in.

Table 1 - Age codes used in ringing birds – Cardoso & Tenreiro (2006)

	Description
1	Non flying juvenile in the nest
2	Flying bird of uncertain age
3	Born in the current year
4	Not born in the current year (exact year unknown)
5	Born last year
6	Not born in the current or last year

Musculature

Code	Description	Look
0	Very sharp keel Concave musculature	
1	Noticeable keel Flat musculature	
2	Barely noticeable keel Convex musculature	
3	Unnoticeable keel Very convex musculature	

Fat: Kaiser (1993) fat scores, red represents fatty deposits

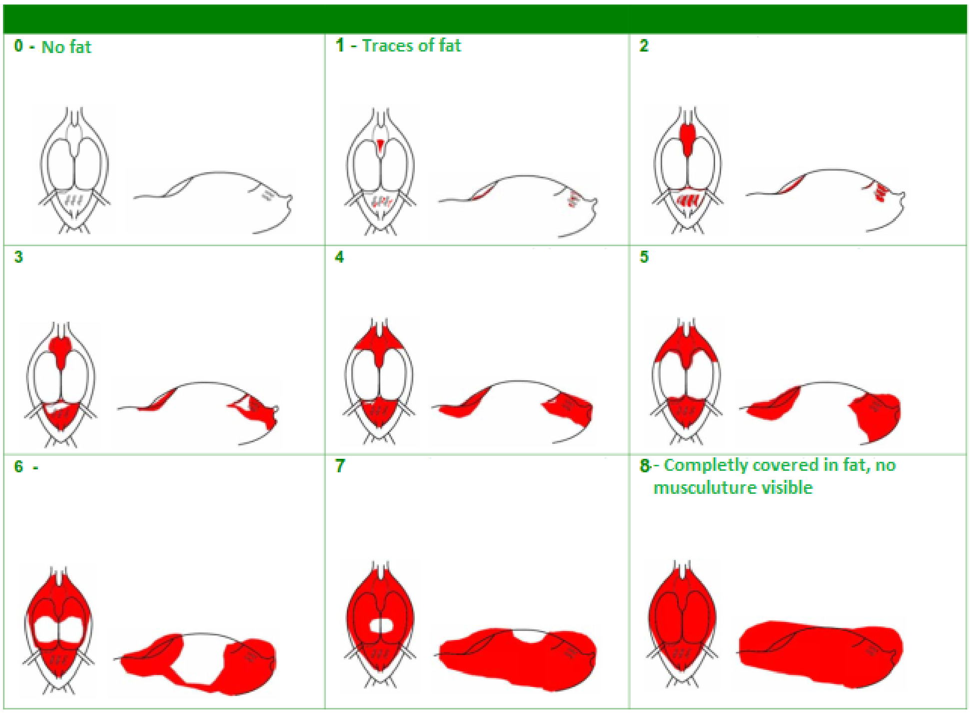


Figure 7 – Musculature (above) and fat scores (below) used in ringing - Cardoso & Tenreiro (2006)

1.6 Data preparation

Data preparation is a fundamental step in any scientific work. This case revealed to be a very time-consuming task deserving a specific chapter in this dissertation. Data from ringing sessions is susceptible to different error sources from the data collection to the final database: (1) it is common during ringing sessions to have situations with several birds being ringed at the same time, consequently different ringers provide measures simultaneously, (2) it is also frequent that the person writing is the least experienced in this activity, (3) sometimes the person who inserts the data in the computer is not the same that has been on the sessions, (4) the input of data into spreadsheets is also susceptible to common errors like missing commas in measurements, misspelling and general deformation in columns.

Acknowledging all these potential sources of error, the first task was the preparation of the database for future analysis, searching for all types of errors, correcting them when possible and removing the records if the correction was not possible.

Most of the corrections made to the database involved human error during the copying of data from the field notes to the computer, they ranged from wrong age categories to wrong use of decimal points, using the same ring number on different birds, etc. Other significant source of errors came from the person ringing the bird, this was evident when comparing recapture data to other captures of the same bird, a bird could be recaptured and identified as a juvenile but had already been captured a year and half ago (correct age should be an adult), or that bird was captured and identified as a male three times but on one or more occasions was identified as a female or simply the sex could not be determined, differences in measurements of body parts that should be the same (tarsus in adult birds) were also common. However, some of these errors are inherent to ringing, as some birds can have atypical plumage and confuse even the most experienced ringer. The aging of Dunnocks (*Prunella modularis*) for example, is based on the color of the bird's iris, something that can be subjective and differently interpreted between ringers.

The software errors were based on presets for words or numbers (e.g. MAI turns to Maio, Portuguese word for the month May; time, 12:30h would turn to decimal numbers like 0.3894629, etc.).

Missing data also needed to be addressed, certain individuals and ringing sessions as a whole had one or more values missing, forcing the analyst to turn to the old paper records and find the particular missing value or ringing session, this was recurrent as some birds proved to have wrong data that could not be corrected by the information already present in the spreadsheet. Turning to the paper records (sometimes hard to find or even missing) proved to be very valuable as more mistakes could be corrected.

Species names also needed amending, since the data base is about eight years old some scientific names have changed (e.g. *Saxicola torquata* to *Saxicola rubicola*). RINGACCESS, the database used to report to ICNF and EURING, doesn't have regular taxonomic updates.

The main and easiest mistake to recognize was the wrong use of decimal points in measurements, like 11.5 turns into 115 or the other way around. Very significant but difficult mistakes to pin point were the wrong identifications of sex and age. Sometimes they can be identified just by looking at the capture records of the bird, but other times, only by analyzing their other measurements and knowing from experience what to look for, could you find misidentifications.

After the correction of more than 200 records, some errors could not be safely amended, either the paper records were unavailable or they had the same wrong information, for example having the same ring number on two different individuals. This led to the loss of data, 85 records were dismissed as they had significant amounts of missing data and another 100+ were loss due to errors. This comprises a rough estimate of 4% of the total database, but at a global scale this low percentage translates into thousands of man hours lost and thousands of birds being manipulated and stressed in vain, when most of these errors can be fixed.

This proved to be an exceptionally time consuming and mostly avoidable task. As well as it may raise questions about the legitimacy of some ringing data. About 10% of all rows in the spreadsheet had at least one error or were incomplete, which is a conservative estimate. These are the errors that could be identified and solved, several other errors certainly passed unnoticed.

However, the use of spreadsheets for storing such data has its advantages. Some errors are easily identified using software tools and can be easily corrected. RINGACCESS does not give the ringer that option, leaving the task of correcting errors to whomever decides to analyze the data. That person might not expect such a high frequency of errors, and might not be able of making corrections as they will probably be dealing with hundreds of thousands of birds and no access to the original paper records. The data set used for this project came from one CES with around 4.500 bird capture/recaptures and it took dozens of man hours to correct and complete.

1.7 Problem solving suggestions

Solving some of these sources of error would be simple and highly beneficial to improve the quality of data collected but also to improve the ringer's and scientist's experience. Swapping from paper sheets to a digital record in the field would eliminate common problems like difficulty in understanding someone's hand writing or overall poor legibility caused by cross-outs/smudges/corrections.

Organization and discipline in data collection should also play an important role while ringing birds. Usually there are large amounts of down-time between visits to the mist nets and very active times where everyone is working and ringing birds. It is during these active times that mistakes are made, it is key to take the time to properly ring every bird and communicate, in an orderly fashion, to the person writing the data. It is very common for more than one person to talk at the same time and the person writing has to deal with a lot of information at once, making this person's job easier will greatly diminish the amount of errors, which are already common as they are usually the least experienced person in the group.

The most important suggestion is to revise the spreadsheets used to keep data. These spreadsheets should have data validation on every column, making it impossible to have spelling mistakes (writing a species name in two different ways results in one additional species when you analyze data for example) or to write something that is incorrect (when using a sexing code, M-F-U, it would be impossible to use any other letters by mistake). Taking data validation to a more complex level, every species should have an interval for any morphological measurements, this interval should be initially based on the measures known for the species and then adjusted to the local population. Each time a value outside a specified range (e.g. 95% confidence intervals) is recorded, a warning is provided. This would solve another common problem pointed out earlier where an 11.2 turns into a 112. For ringers using more than one spreadsheet file for the various ringing programs it is recommendable that all records should be in the same file regardless of the data collected in each program. Mitra CES had four different spreadsheet files with different formats and organization, making it more time consuming to compile everything and have no duplicates.

A better solution would be to switch from common spreadsheets to a specifically designed database that uses these types of warnings and is designed to limit input errors. This technique is already being used in Germany where they use an ORACLE-based database (Bird ringing centre, n.d.). The Institute of Avian Research organizes an annual course, which is mandatory for new ringers, where people can learn about this database, proper ringing techniques and learn from more experienced ringers.

This type of data validation should not only be adopted by ringers but also by the National Ringing Center in order to identify more potential errors as they receive data from ringers, and to give them feedback and suggestions.

When implementing new rules and techniques to be adopted by ringers nationwide it is important to organize an annual meeting to discuss and solve problems.

In order to potentiate ringing in Portugal we believe it would be important to motivate more ringers and volunteers, improve the engagement with local communities and create more Constant Effort Sites. These CES and ringers should be managed by at least two Ringing Centers, each responsible for a part of the country. For example, one study in Germany, used data from three Ringing centers active for around 100 years, that together, cover most of the country (North, South and Center regions), to evaluate the effects of climate change on migrating birds (Fiedler et al., 2004).

These ringing centers would pool all data from ringers, process and analyze it, give feedback and spread this information to the local communities, engaging locals and motivating new people to join. This would simplify CNA's job which, as previously discussed cannot handle all this information alone.

1.8 Conclusion

Bird ringing is a valuable tool, not only for scientific research but also as an environmental education tool as it allows people to have direct contact with birds and makes the learning experience more dynamic and enjoyable, from children to adults, public ringing sessions are always a success (Fig. 8).

In research, ringing and tagging birds has resulted in amazing findings like we discussed earlier, from unknown migratory routes to discovering how birds sleep while flying (Rattenborg et al., 2016). There is still a tremendous potential for future use of ringing techniques, parasite studies are becoming more common (Vila-Viçosa et al., 2016), connecting ecology and biology to other fields like veterinary medicine, and the use of bird feathers as bio monitors for environmental contamination and toxicology makes ringing a perfect source of data (Roque, 2017).

According to Fiedler et al. (2004), some of the most important advantages of CES and ringing centres are: (1) ringing and recovery databases at ringing centres cover larger areas and longer time-spans than most single studies, (2) in contrast to pure observations and bird counts, individuals with deviant behaviour (like wintering at northern latitudes by migrants) can be assigned to distinct populations, and (3) the datasets are rapidly available in standardised, electronic format.

So, Constant Effort Sites are an important and versatile asset that should be taken advantage of. They provide valuable data on dozens of species for several years in a standardized manner, making it possible to compare data across years and across different sites. Unlike dedicated ringing projects that are focused on one species or one research topic, CES data can be used for numerous purposes, from population analysis to studying migration patterns, assessing the effects of land use on bird assemblages and numbers and to develop conservation strategies (Mendes, 2016). This data is also used to confirm breeding in some species for Breeding Bird Atlases and can also provide records of extremely rare or less conspicuous bird species that would otherwise go unnoticed by birdwatchers or even ornithologists during field work. Ringing records were very important in the detection of Sedge Warbler (*Acrocephalus schoenobaenus)* during migration in Portugal, for example (Equipa Atlas, 2018).

Ringing in the same location for many years also increases the chances of recapturing the same bird and thus providing more accurate information on the longevity of wild species. From all the recaptures we had, we highlight one Cirl Bunting (*Emberiza cirlus*), more than 7 years old, which can be an international record of longevity for the species.

There is, however, a need to standardize the collection of ringing data, every volunteer across the country takes the same measurements and uses the same ringing techniques, but the way this data is written down, collected and processed varies wildly. This variation means that different ringing groups will have different error rates. We propose that data collection and processing should be standardized and it should follow the suggestions presented earlier, meaning there would be fewer errors in the national database and at the same time, it would be easier and more direct to compare data between regions.

In Portugal, it is extremely difficult to find any analysed data or any results from ringing, the few reports that exist are outdated and don’t provide detailed information but rather curiosities. This lack of access to useful information means that most of the data collected is not being maximised. Scientists do not have easy access to it and cannot use it for their own research, schools and NGO’s cannot use it for environmental education and the massive databases that exist are being mostly wasted and stored away.

This data is only useful when it's shared. In Portugal there are hundreds of thousands of records on birds that are not being used. By making ringing results public every year it is possible to reach a greater audience, raise awareness to conservation problems and encourage more people to join science. Even if this data cannot be shared (for the protection of sensitive species, for example), the type of data, its coverage and the rules of use should be made public.

One of the reasons for the lack of dissemination is that ringing is extremely underfunded and the work is usually carried out by volunteers that have little interest in statistical analysis and science production. The National Ringing Centre is so underfunded that their computer's hardware and software can no longer handle the datasets and no analysis has been published in seven years.

Funding is obviously the largest obstacle, one option to open new ringing centres would be to charge a yearly fee to every ringer that applies for a permit that year (usually around 200 ringers apply). This would provide the ringer with detailed information and statistical analysis of his or her data and professional support for any questions or concerns regarding ringing. It might be a difficult and controversial subject, but a fee of, for instance, 100€ per year would mean roughly 20.000€ a year to improve ringing in Portugal.

Ringing sites and groups should also try to have more presence in social media and interact with the public so they know how important the activity is and bring awareness to the challenges and lack of funding to this scientific sector.

To motivate new ringers, ringing events should be created and made open to the public, especially inland, where ringing is rare. New software to enter data should be put in place as the current software by EURING (RINGACCESS) is overly complicated and time consuming. You can't upload a text file (*.txt) or any other format and have to write every observation one by one. While it provides a very detailed platform to introduce massive amounts of data, from meteorology to dead captures and colour rings, it only provides the ringer with very basic information like species captured by year/month/day. Furthermore, you can't edit your observations or modify something after you upload it, so errors would be common.

The absence of real incentives to ring and publish ringing data in Portugal limits the number of people to volunteers who only ring birds as a hobby in their spare time, most ringers in Portugal do this type of work only because they like the activity and not to see any results or data processing. Having an organization analysing their data, publishing it and showing how important ringing is might make it more appealing and ultimately encourage more people to join this activity. Currently, only curiosities are published, like a Common Tern (*Sterna hirundo*) with ring number G8696 that travelled 8818 km since ringed as a juvenile (from Azores to Argentina) (CEMPA, 2013). Although these might be interesting and could help engage the public, we think ringers would be much more interested in seeing more "hard science" and their hard work being recognized, published and used to discover new things.

In conclusion, ringing, and particularly Constant Effort ringing Sites, are extremely valuable to science as they provide massive amounts of data that can be used to study a large number of fields, from behaviour to migration, climate change and even other species populations (like fish, from sea bird monitoring), and this data will surely be used in the future to test theories we can't yet formulate.

Figure 8 - Ringing session with children in Algarve, Portugal

Part 2 – Scientific Paper

Results and Importance of one Constant Effort ringing Site in Portugal

Pedro Ribeiro

Abstract

Bird ringing in Constant Effort Sites allows many types of studies and analyses. We analysed data from a Constant Effort Site in *Herdade da Mitra* (Portugal), collected from 2010-2017, comprising of 4.456 captures of 3550 individuals belonging to 64 species. In order to understand the importance that one Constant Effort Site has at a national and international level, we assessed recapture rates; site fidelity; population trends; longevity and sexual dimorphism based on biometric measures. 25.5% of the records are recaptures, coming slightly above the national 24% average, and 17% of individuals are recaptured. The Cetti's Warbler had a 45% recapture rate and the abundant House Sparrow (*Passer domesticus*) 5%. 23% of Nightingales (*Luscinia megarhynchos*) return to Mitra in different years to breed, with 7 individuals returning for 4 years and one male returning for 5 years. Bird populations in Mitra seem to be stable but some migratory species show years of high abundance, the Common Chiffchaff (*Phylloscopus collybita*) tripled their numbers in 2014. The oldest birds caught in Mitra did not surpass 7 years of age, however one >4 year old Short-toed Treecreeper (*Certhia brachydactyla*) could be close to an international record, we also have a >7 year old Cirl Bunting (*Emberiza cirlus*), a species that has no international data on longevity (provided by EURING). Sexual dimorphism, based on biometric differences, is present in 20 species yearlong, and only during winter for the Sardinian warbler (*Sylvia melanocephala*), these differences should be used to sex young birds or individuals belonging to species with little visual sexual dimorphism.

2.1 Introduction

Monitoring species is extremely important for their conservation (Goldsmith, 1996) and long term ringing programs are a popular way to monitor birds, from passerines to waterfowl and raptors. These surveys rely mostly on volunteers and the locations of these programs are largely determined by their convenience. They collect data on dozens of species that can then be used to estimate abundance, population trends, survival, productivity of young, and other demographic parameters. In the U.K., Biodiversity Action Plans are influenced by abundance indices that incorporate ringing data (Gregory et al., 2004).

In the 70's ringers started to question themselves on how they could add more value to their ringing activities, and the development of a standardized mist net effort was one of the ways to do it (Robinson et al., 2009). After a trial period, in 1986 the Constant Effort ringing Sites (CES) was formally included on the Integrated Population Monitoring Programme from BTO. This monitoring scheme rapidly spread through Europe and, as of 2004, 13 countries were active (EURING, n.d.). The main goals of these programs are monitoring (to provide long-term estimates or indices of abundance, productiveness and survival of common species), research (e.g. population dynamics) and management (how habitat can be managed to promote biodiversity) (Robinson et al., 2009).

Most of the studies using data from CES are focused on productivity, survival and recruitment. These parameters are directly linked to the number of juveniles, adult survival and number of new adults entering the breeding population (Balmer & Milne, 2002; Baillie, 2008; Robinson et al., 2009),

Using data from 2010 to 2017 from one CES located outside the wetland areas (the most represented habitat by CES in Portugal – 80% of all sites), we assessed the potential of this data to provide information on (1) recapture rates by species, (2) site fidelity in spring and in winter, (3) species and capture trends, (4) longevity and (5) morphologic traits to improve sexual identification skills and population characterization.

2.2 Methodology

2.2.1 Study area

Our study was conducted in Southern Portugal on an experimental farm from the University of Évora, located 13 km away from Évora's city centre. The farm has 268 ha dominated by Montado (an agro-forestry-pastoral system dominated by cork oak *Quercus suber* and/or holm oak *Quercus rotundifolia*), with patches of Mediterranean scrublands, a small river with well-developed riparian vegetation, arable crops, vineyards, small vegetable gardens, pinewood forests and olive trees (Mitra Nature, 2014).

The climate is typically Mediterranean characterized by low annual precipitation and hot and dry summers. The annual mean temperature is 15.9 ºC and the annual mean precipitation is 629 mm (Climate Data, 2015).

The geographical, climatic and habitat conditions makes this location a particular site for conducting regular ringing monitoring programs, especially when most of the Constant Effort Sites in Portugal are located near the coast, in wetland areas.

2.2.2 Data collection

We used standardized data collected between 2010 and 2017 in two monitoring schemes conducted in the spring and winter. In all ringing sessions the following biometric data was collected: wing length, bill, tarsus (following Whitworth, 2007); length of the 8th primary feather (counting from the inside of the wing); muscle and fat (Kaiser, 1993); and weight.

2.2.3 Data analyses

To assess the potential of the data collected on a CES at the local scale and how it can be enhanced to national level, we analysed: (1) species recapture rates, (2) species trends, (3) species longevity, (4) site fidelity and (5) sexual dimorphism.

Species recapture rates were calculated based on the number of individuals recaptured by the total of captures for each species. For species trends we used the total of captures normalized by the number of sessions in each year.

Site fidelity was inferred from the recapture rates of particular migratory species between different years. Instead of calculating total recapture rates (including within-year recaptures) we only considered a record in a subsequent season as recapture. Looking at how many migratory individuals of a given species were recaptured in Mitra in different years/seasons gives us the percentage of birds that have some degree of site fidelity to their breeding or wintering sites.

Individual's longevity was assessed by the difference between the age on the recapture event and the age on the day of capture. For birds whose age it was possible to determine precisely on the capture day (typically first and second years) we provide an exact age, for all the other cases (birds with an uncertain year of birth) we provide the minimum age possible.

The mean and standard deviation of the biometric measures were calculated for all species in the database. Boxplots were made for every species and biometric measure (available in the attachments only for the species with significant (p-value < 0.05) sexual dimorphism in the biometrics measured, Figures 1 to 5 in Attachments). Then a t-test to the biometric data was performed to detect differences between sexes. First, we applied this procedure to all individuals regardless of the season where they were captured, then for weight, fat and muscle we analysed the spring and winter separately.

2.3 Results

2.3.1 Recaptures

Between 2010 – 2017, 3.550 birds were caught in all ringing schemes, from those there were 906 recaptures, which gives a recapture rate of 25.5%, slightly above the national average (CEMPA, 2013). Seventeen percent of all individuals were recaptured along the study period, with 18 species showing higher recapture rates than average (Attachments – Table 1). Most of this species are resident in the study area, with the exception of the Nightingale (*Luscinia megarhynchos*) with a recapture rate of 35%. Cetti's Warbler (*Cettia cetti*) is the species with the higher recapture rate – 45%. On the opposite side a common species like the House sparrow (*Passer domesticus*) showed lower recapture rates, less than 10% for 279 captures.

2.3.2 Site fidelity in migrant species

Spring

The migratory species most captured during the breeding season are the Nightingale (captures n=94, recaptures n=33), the Iberian Chiffchaff (*Phylloscopus ibericus*) (captures n=44, recaptures n=8) and the Melodious warbler (*Hippolais polyglotta*) (captures n=14, recaptures n=0). Almost half of the Nightingale ringing events during the breeding season were recaptures (44.4%), highlighting the use of the study area as a breeding site.

To evaluate the breeding site fidelity, using the Nightingale as example, we looked at recaptures of the same individuals across years. Out of the 82 birds first caught before 2017, 23.2% returned more than once (12 returned 2 years, 7 returned 3 years, one returned 4 consecutive years and finally a 7 year old male was recaptured in 5 different years, from 2011 to 2017, which also represents the longest living Nightingale captured in Mitra).

The Iberian Chiffchaff had a recapture rate of 18% (out of 44 captured individuals) 7% of which were recaptured in different years.

The Melodious Warbler was not captured frequently (n=14) and we did not have any recapture event.

Winter

The Common chiffchaff is a wintering migrant in the study area, and out of 97 birds caught only 8.5% were recaptured in different years.

The European Robin (*Erithacus rubecula)* is a resident species in the study area, with an increase in numbers during the winter from central and northern European birds. The recapture rate of 26% may include birds from the wintering and resident populations, being impossible to distinguish between these two populations.

The Blackcap is also a resident species that suffers an influx of birds in the winter, had a total recapture rate of 14% and only 20 individuals were recaptured in different years during the winter.

2.3.3 Population trends

The overall trend in the number of birds captured in Mitra seems to be stable (Fig. 1), PEEC has registered an increase in 2017 after a slight gradual decrease between 2010 and 2013. During the winter there’s no apparent pattern, with high fluctuations between years.

The most abundant bird species during the winter monitoring is the Blackcap (Fig. 2), their wintering population has been increasing steadily since 2012 and is not responsible for the dips and raises in the Normalized MAI trends. This is a resident species but with a massive influx of individuals during the winter months, when they feed mainly on olives. We can also see that the resident population (represented by the birds caught in PEEC) is small but has been stable.

The European Robin (Fig. 4) is similar to the Blackcap in the fact that we have both a resident and a wintering population. The captures of individuals from the resident population increased slightly in 2016 and 2017 but were very small before. The wintering population however, is unstable, suffering a great decline in 2013-2015, recovering in 2016 and doubling the next year. Both populations follow a similar pattern, increasing and decreasing together.

In migratory species it is always difficult to predict the size of the population that will reach the wintering/breeding grounds because it depends heavily on their conditions in the country of origin. Some years might have a decline while others can see a considerable increase. This unpredictability can be seen in the migrant Common Chiffchaff (Fig. 3), usually being caught in low numbers, in 2014 their population tripled comparing to 2013, going back down in 2015 and tripling again in 2016. Potentially contributing to the Normalized MAI capture trend curve, as it follows a similar pattern.

The Serin (*Serinus serinus*) is a resident bird, and it shows its habitat preference in Figure 5 as the majority of captures, and all recaptures, are during PEEC, while only a marginal number of birds were caught in MAI. This illustrates the importance of mist net placing (at a local scale) and the location of Constant Effort Sites nationally.

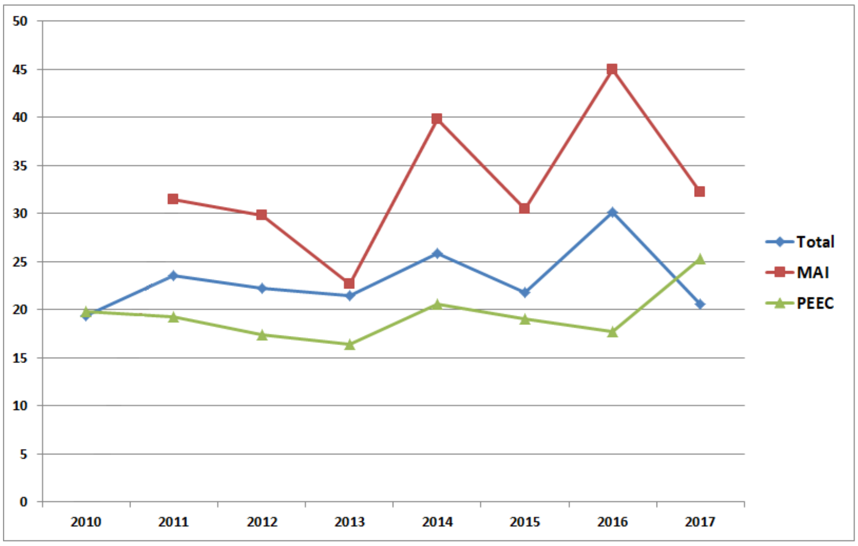


Figure 1 - Normalized bird captures of Mitra CES. Total (all programs); MAI (Wintering monitoring scheme); PEEC (Constant effort site project, including Breeding/Resident birds)

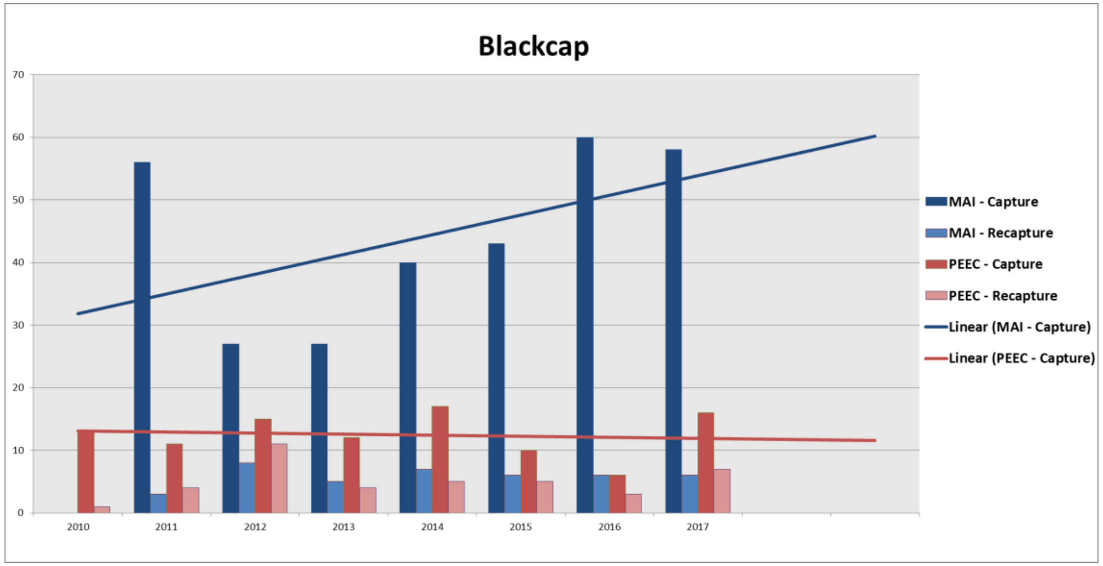


Figure 2 - Exact Captures and Recaptures for MAI (Winter monitoring scheme, in blue) and PEEC (Constant effort site project, in red) programs and the linear trend lines for captures for each program, for Blackcap (*Sylvia atricapilla*)

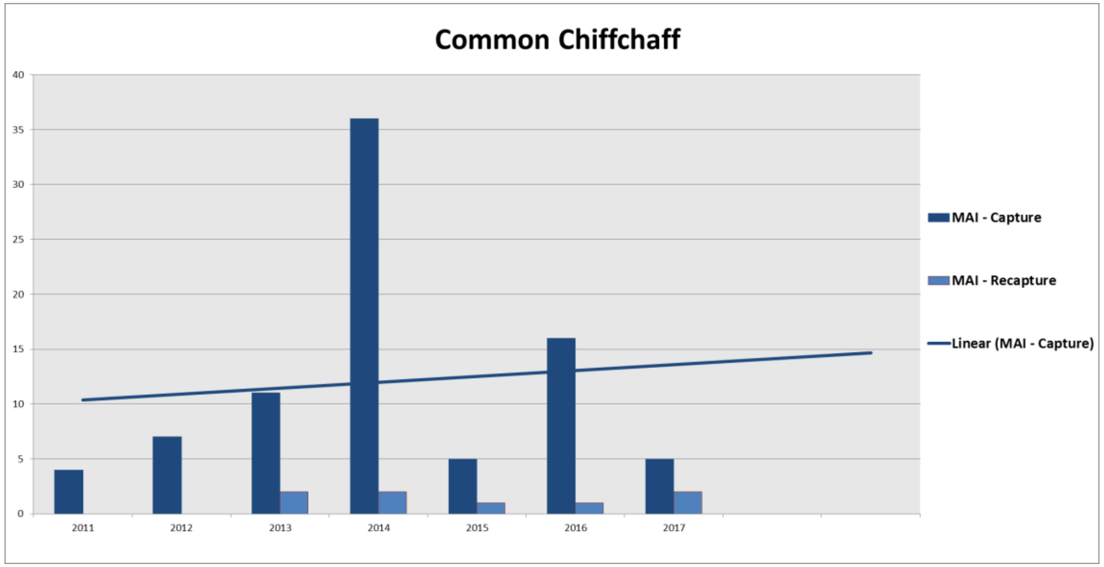


Figure 3 – Exact Captures and Recaptures for MAI (Winter monitoring scheme) and the linear trend line for captures, for Common Chiffchaff (*Phylloscopus collybita*)

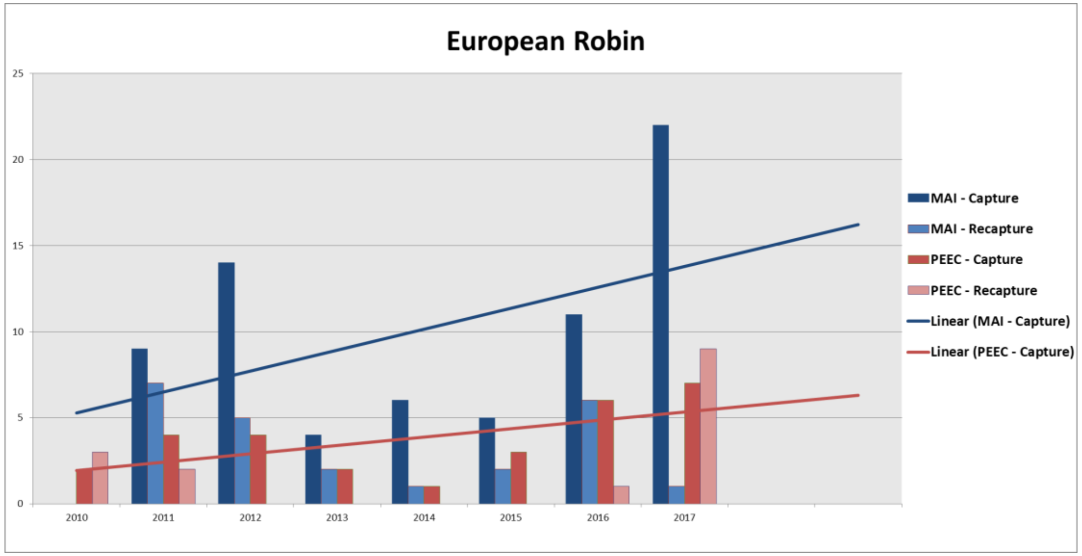


Figure 4 - Exact Captures and Recaptures for MAI (Winter monitoring scheme, in blue) and PEEC (Constant effort site project, in red) programs and the linear trend lines for captures for each program, for European Robin (*Erithacus rubecula*)

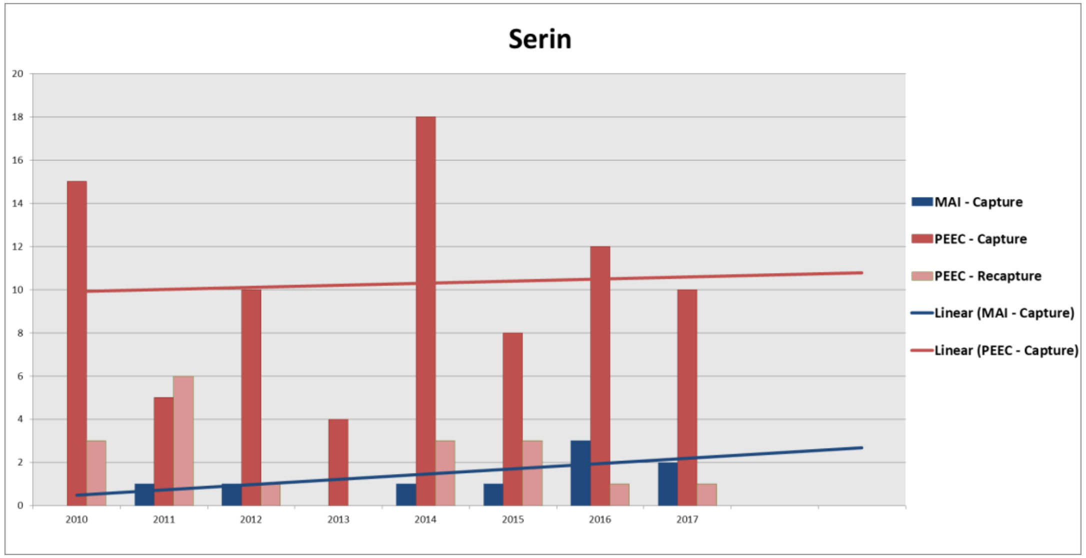


Figure 5 - Exact Captures and Recaptures for MAI (Winter monitoring scheme, in blue) and PEEC (Constant effort site project, in red) programs and the linear trend lines for captures for each program, for Serin (*Serinus serinus*)

2.3.4 Longevity

One of the advantages of marking individuals is to obtain data on species survival. The probability of recapture is higher when ringing is conducted on regular basis on the same location. Despite the limitation of the data (gathered in only one CES) we highlight the most relevant information in Table 1.

One of the captured Short-toed Treecreepers (*Certhia brachydactyla*) had an age that was very close to the EURING international record, and since the exact age could not be determined in the first capture, it might even represent an international record. One Cirl Bunting (*Emberiza cirlus*) is over 7 years old, a species that does not have any information on the EURING database (updated in September 2017), even though our record was in 2015.

Table 1 - Longevity records for Mitra, in years

Ring	Species	Sex	First Capture	Age at first capture	Last Capture	Days between captures	True Age	EURING Age Record
F24062	***Turdus merula***	F	06/02/2010	1	07/04/2016	2252	7	21
C58067	***Luscinia megarhynchos***	M	20/05/2011	1	09/06/2017	2212	7	10
A263677	***Sylvia atricapilla***	M	06/05/2010	1	02/04/2016	2158	7	14
A292050	***Fringilla coelebs***	M	06/02/2010	>2	22/04/2015	1901	>7	15
A263761	***Sylvia melanocephala***	M	24/06/2010	1	22/07/2015	1854	6	8
A263691	***Emberiza cirlus***	M	27/05/2010	>2	16/02/2015	1726	>7	NA
C58036	***Passer domesticus***	M	20/09/2010	<1	19/12/2014	1551	4	19
C58085	***Parus major***	U	03/07/2011	<1	12/05/2015	1409	4	15
O59458	***Serinus serinus***	M	24/06/2010	>1	22/04/2014	1398	>5	13
O93433	***Certhia brachydactyla***	U	12/02/2010	>1	12/09/2013	1308	>4	5

2.3.5 Morphological traits - population characteristics and sexing individuals

We used the biometric data from captured adults to (1) characterize the local population of each species and (2) to assess morphological differences between sexes and ages in the same species. We analysed, for each species and for each sex (Male, Female and Undetermined), the following variables: "Wing"; "WingPri"; "Weight"; "Tarsus", "Bill", "Muscle" and "Fat" (Table 2 – species with significant differences $p < 0.05$); Fig. 7 shows the variation for the Wing length measurement, derived from a t-test, and also the means and standard deviations (SD). The boxplots for the other variables are provided in the attachments.

Similarly, we used data on “Fat”, “Muscle” and “Weight” to assess individual fitness between sexes. We focused this analysis in two key moments of the year: winter - when food tends to be scarce, and spring – breeding season (Table 3 and 4).

All the statistical analyses were conducted in R Studio version 3.3.2 (R Core Team, 2016), with the packages “dplyr”; “ggplot2”; “ggplus” and “tidyr”.

2.3.6 Sexual dimorphism

A great percentage of the bird species most captured have sexual dimorphism, being possible to correctly sex adults. Nevertheless, the biometric information can characterize local and national populations, and help on identification of juveniles. Twenty-one species showed significant differences ($p < 0.05$) between sexes in the morphological variables. The males of Sardinian warbler (*Sylvia melanocephala*) have differences in weight, being lighter than females only in the winter.

The variables that contributed most for morphological differences were “Wing” and “WingPri”. Only two species, Blackcap and Short-toed Treecreeper, did not have differences in one of these variables (Table 2).

The amount of fat had no differences between sexes (an expected result since we did not have a migration monitoring scheme) and Muscle only accounts for a difference in three species in the breeding season, with the Chaffinch (*Fringilla coelebs)* having the most significant difference ($p < 0.01$).

For all the other species, Weight is the determining factor that distinguishes sexes. Probably it is directly linked to the individual fitness and therefore to survival (Monticelli et al., 2013).

Most species with differences in Wing length also express a difference in WingPri, since there is a correlation between the length of the 8^{th} primary feather and the total wing length in 75.5% of passerines (Jenni & Winkler, 1989).

Table 2 - Sexual dimorphism based on a t-test for the Yearlong data. Highlighted numbers show which variable, for each species, is significantly different between adult Males and Females based on a p-value < 0.05

Species	Sex	n	Wing (Mean +- SD)	p-value	t-value	WingPri (Mean +- SD)	p-value	t-value	Weight (Mean +- SD)	p-value	t-value	Beak (Mean +- SD)	p-value	t-value	Tarsus (Mean +- SD)	p-value	t-value
	F	11	71.8 +- 1.6			53.4 +- 1.6			13.5 +- 0.9			13.9 +- 1.2			14 +- 1		
Carduelis carduelis	M	7	75.4 +- 2.7	<0,01 *	-3,199	55 +- 2.8	0,237	-1,290	14.2 +- 0.8	0,076	-1,911	15.4 +- 1.3	<0,05 *	-2,437	15 +- 0.8	<0,05 *	-2,355
	U	15	75.2 +- 2.1			56.6 +- 2.6			14.4 +- 1			14.4 +- 0.9			14.7 +- 0.8		
	F	7	58 +- 2			43.8 +- 2.8			8.1 +- 0.6			18 +- 0.8			15.5 +- 0.4		
Certhia brachydactyla	M	4	59 +- 1.8	0,427	-0,844	45 +- 0	0,352	-1,025	8.2 +- 0.6	0,702	-0,398	19.6 +- 0.8	<0,05 *	-2,726	16.1 +- 0.3	<0,05 *	-2,384
	U	29	60 +- 2.3			44.3 +- 2			8.5 +- 0.6			19.3 +- 2			15.6 +- 0.7		
	F	33	80.1 +- 2			60.2 +- 2.3			22.8 +- 1.8			14.8 +- 1.3			17.6 +- 0.7		
Chloris chloris	M	39	81.9 +- 1.8	<0,001 **	-3,793	61.8 +- 1.6	<0,01 *	-2,906	21.7 +- 1.4	<0,01 *	2,759	15.1 +- 1.6	0,396	-0,854	17.6 +- 0.6	0,818	0,231
	U	3	80.3 +- 1.5			60 +- 0			23.2 +- 0.8			14.4 +- 2.3			17.1 +- 0.8		
	F	26	99.5 +- 2.3			73.9 +- 1.9			46.3 +- 2.6			22.8 +- 2			21.4 +- 0.8		
Coccothraustes coccothraustes	M	12	101.9 +- 2.6	<0,01 *	-2,752	76.6 +- 2.6	<0,01 *	-3,126	47.8 +- 3.8	0,300	-1,088	24 +- 1.7	0,081	-1,817	21.5 +- 0.9	0,760	-0,310
	U	2	96 +- 1.4			71.5 +- 0.7			43.2 +- 1.1			23.1 +- 0.6			21.1 +- 0.1		
	F	24	58.2 +- 1.9			43.9 +- 3.4			9.5 +- 1			9.7 +- 0.6			15.8 +- 0.7		
Cyanistes caeruleus	M	27	60.9 +- 1.7	<0,001 **	-5,341	45.1 +- 1.2	0,177	-1,394	9.4 +- 0.7	0,530	0,634	9.3 +- 0.6	<0,05 *	1,993	16.1 +- 0.8	0,116	-1,614
	U	175	59.2 +- 2.5			44.4 +- 2.2			9.4 +- 0.8			9.3 +- 1.3			15.9 +- 1.3		
	F	8	129.1 +- 3.8			92.5 +- 3.8			70.6 +- 6.8			27.4 +- 0.7			34.4 +- 1.1		
Cyanopica cooki	M	2	133.5 +- 2.1	0,119	-2,183	97 +- 1.4	<0,05 *	-2,696	71.4 +- 5.1	0,874	-0,179	27.1 +- 2	0,855	0,229	35.3 +- 0	<0,05 *	-2,398
	U	23	130.9 +- 5.7			96.1 +- 3.8			71 +- 4.7			27.7 +- 2.5			34.1 +- 1.9		
Emberiza cirlus	F	15	76.5 +- 1.2	<0,001 **	-5,867	57.9 +- 1	<0,05 *	-3,467	24.2 +- 1.3	0,304	-1,057	14.2 +- 1	0,946	0,069	19 +- 0.8	0,625	0,507
	M	7	81 +- 1.8			62 +- 2.5			24.7 +- 0.8			14.1 +- 0.8			18.9 +- 0.7		
	F	58	80.6 +- 2.8			61.3 +- 2.5			19.9 +- 1.3			14.2 +- 0.9			18 +- 0.8		
Fringilla coelebs	M	29	86.7 +- 2.3	<0,001 **	-10,756	66 +- 2.7	<0,001 **	-6,813	20.9 +- 1.7	<0,05 *	-2,509	14.5 +- 0.7	0,144	-1,482	18.2 +- 0.8	0,300	-1,048
	U	6	78.3 +- 3.9			62.2 +- 3			18.5 +- 1.1			13.9 +- 0.3			17.8 +- 0.6		
	F	21	78.8 +- 2.5			59.8 +- 2.3			20 +- 1.9			16.6 +- 0.7			26.9 +- 0.9		
Luscinia megarhynchos	M	28	81.2 +- 2.2	<0,001 **	-3,484	61.6 +- 2.3	<0,05 *	-2,356	20.2 +- 1.4	0,655	-0,451	17 +- 0.8	0,133	-1,534	27.2 +- 0.7	0,294	-1,065
	U	13	80.6 +- 2.8			60.5 +- 3.8			21.4 +- 3.2			17.1 +- 0.7			26.8 +- 0.8		
	F	17	69 +- 1.7			51.5 +- 1.7			16.9 +- 1.4			12.9 +- 0.6			19.4 +- 0.7		
Parus major	M	43	72 +- 1.7	<0,001 **	-5,955	53.5 +- 1.3	<0,01 *	-3,516	17.4 +- 0.9	0,276	-1,120	12.9 +- 0.6	0,874	-0,160	19.6 +- 0.6	0,256	-1,168
	U	6	69.6 +- 1.5			50.3 +- 0.6			16.6 +- 0.5			12.6 +- 0.4			19 +- 0.9		
	F	78	75.6 +- 1.9			55.7 +- 2.2			26.8 +- 2.2			15.1 +- 1.1			18.9 +- 1.3		
Passer domesticus	M	126	78.1 +- 2	<0,001 **	-9,017	57.7 +- 1.8	<0,001 **	-4,784	26.8 +- 1.5	0,973	0,033	14.8 +- 1.2	0,100	1,657	19.3 +- 1.1	0,071	-1,825
	U	6	75.4 +- 1.3			52 +- NA			26.3 +- 1.3			15.9 +- NA			19.1 +- NA		
Phoenicurus ochruros	F	4	84.2 +- 2.6	<0,05 *	-2,396	66 +- 1.4	0,414	-0,945	17.2 +- 1.2	0,794	-0,281	15.3 +- 1	0,430	0,868	23.9 +- 0.5	0,182	1,581
	M	4	88.5 +- 2.4			67.7 +- 2.5			17.4 +- 0.9			14.7 +- 0.9			23.3 +- 0.5		
	F	7	55.1 +- 2			41.6 +- 1.1			7.2 +- 0.8			12 +- 1			18.8 +- 1.1		
Phylloscopus ibericus	M	5	61.4 +- 1	<0,001 **	-7,368	45.2 +- 2.4	<0,05 *	-3,154	7.7 +- 0.3	0,164	-1,536	12.7 +- 1	0,252	-1,230	20.2 +- 1	<0,05 *	-2,341
	U	17	58.4 +- 2.9			43.2 +- 2.6			7.4 +- 0.8			12.5 +- 1.1			19.4 +- 1.4		
Pyrrhula pyrrhula	F	4	79.7 +- 1.2	<0,01 *	-5,014	60 +- NA	NA	NA	22.9 +- 1.1	0,439	0,833	11.6 +- 1.3	0,964	-0,051	17.1 +- 0.9	0,857	-0,217
	M	5	81.7 +- 1.2			61.7 +- 1.5			22.8 +- 1			11.6 +- 1.7			16.9 +- 0.5		
Saxicola rubicola	F	2	64.5 +- 0.7	<0,05 *	-2,941	NA +- NA	NA	NA	16 +- 0.7	0,797	-0,279	14.8 +- 0.6	0,651	0,484	23.8 +- 0.3	0,173	1,589
	M	5	66.6 +- 1.1			49 +- 1			16.2 +- 1.2			14.5 +- 1.3			23.1 +- 0.9		
	F	35	68.6 +- 1.7			51.6 +- 1.6			11.3 +- 0.9			9.6 +- 0.8			14.3 +- 0.7		
Serinus serinus	M	63	71.4 +- 1.9	<0,001 **	-7,327	54.5 +- 2.1	<0,001 **	-7,008	10.6 +- 0.6	<0,001 **	3,877	9.7 +- 1.1	0,761	-0,306	14.2 +- 0.6	0,536	0,623
	U	4	68 +- 1.8			51.3 +- 1.5			10.9 +- 0.8			9.4 +- 0.8			14.1 +- 0.5		
	F	14	79.8 +- 1.8			60.5 +- 1.9			18.4 +- 1.1			19.2 +- 1.1			18.8 +- 0.5		
Sitta europaea	M	9	81.5 +- 1.8	<0,05 *	-2,164	60.5 +- 1.8	0,961	-0,050	19.1 +- 1.2	0,152	-1,503	19.8 +- 0.8	0,219	-1,279	19.3 +- 0.4	<0,05 *	-2,304
	U	6	81.5 +- 1.6			59.2 +- 1.9			19.1 +- 0.4			19.1 +- 0.6			18.9 +- 0.5		
	F	9	124.4 +- 3.3			91.3 +- 2.6			80.3 +- 5.5			28.7 +- 1.2			29.5 +- 1		
Sturnus unicolor	M	14	129.5 +- 3.9	<0,01 *	-3,314	94 +- 3.7	0,069	-1,926	88.1 +- 4.3	<0,01 *	-3,565	29 +- 0.9	0,588	-0,556	30 +- 1	0,336	-0,995
	U	1	127 +- NA			95 +- NA			86 +- NA			29 +- NA			29.7 +- NA		
	F	234	71.4 +- 2.3			53.7 +- 2.1			18.3 +- 1.6			14.7 +- 1.3			20.7 +- 1.3		
Sylvia atricapilla	M	244	71.8 +- 2.3	0,104	-1,631	53.7 +- 2.2	0,821	-0,226	17.9 +- 1.5	<0,05 *	2,256	14.4 +- 1	<0,05 *	2,057	20.6 +- 0.9	0,337	0,962
	U	2	64.5 +- 3.5			NA +- NA			16.6 +- 1.6			NA +- NA			NA +- NA		
	F	56	116.8 +- 3.3			86.6 +- 3.6			84.5 +- 6.4			25.9 +- 1.2			33.8 +- 1.3		
Turdus merula	M	98	121 +- 2.6	<0,001 **	-8,095	89.4 +- 3.9	<0,001 **	-3,986	81.8 +- 5.4	<0,01 *	2,530	25.9 +- 1.6	0,898	-0,128	34.1 +- 1.4	0,237	-1,188
	U	10	119.4 +- 3.8			88.5 +- 4.1			80.6 +- 8.7			24.6 +- 2.5			33.8 +- 1.6		

Table 3 - Sexual dimorphism based on a t-test for the Winter season data. Highlighted numbers show which variable, for each species, is significantly different between adult Males and Females based on a p-value<0.05. Highlighted species only show morphological differences in weight during this season.

Species	Sex	n	Fat (Mean +- SD)	p-value	t-value	Weight (Mean +- SD)	p-value	t-value	Muscle (Mean +- SD)	p-value	t-value
Parus major	F	5	0 +- 0	NA	NA	15.8 +- 0.8	<0,01 *	-4,161	2.4 +- 0.5	0,487	-0,742
	M	20	0 +- 0			17.4 +- 0.8			2.6 +- 0.5		
	U	1	0 +- NA			17 +- NA			3 +- NA		
Sylvia atricapilla	F	167	0.4 +- 0.8	0,369	-0,900	18.4 +- 1.4	<0,05 *	2,310	2.2 +- 0.4	0,089	-1,708
	M	190	0.5 +- 0.8			18.1 +- 1.4			2.2 +- 0.4		

Table 4 - Sexual dimorphism based on a t-test for the Reproduction season data. Highlighted numbers show which variable, for each species, is significantly different between adult Males and Females based on a p-value<0.05. Highlighted species only show morphological differences in weight during this season.

SPECIES	SEX	n	Fat (Mean +- SD)	p-value	t-value	Weight (Mean +- SD)	p-value	t-value	Muscle (Mean +- SD)	p-value	t-value
Chloris chloris	F	23	0 +- 0	NA	NA	23.2 +- 1.8	<0,01 *	3,109	1.7 +- 0.5	0,980	0,025
	M	27	0 +- 0			21.9 +- 1			1.7 +- 0.5		
	U	1	2 +- NA			24 +- NA			2 +- NA		
Emberiza cirlus	F	7	0.1 +- 0.4	0,356	1,000	24.1 +- 1.6	0,746	-0,340	2.6 +- 0.5	<0,05 *	2,714
	M	5	0 +- 0			24.3 +- 0.5			1.8 +- 0.4		
Fringilla coelebs	F	29	0 +- 0	NA	NA	19.4 +- 1.2	0,135	-1,567	1.8 +- 0.4	<0,01 *	-2,839
	M	12	0 +- 0			20.1 +- 1.4			2.2 +- 0.5		
	U	1	0 +- NA			19.5 +- NA			2 +- NA		
Passer domesticus	F	24	0 +- 0	0,163	-1,455	27.5 +- 1.7	<0,05 *	2,099	2.1 +- 0.5	0,233	-1,211
	M	19	0.1 +- 0.3			26.5 +- 1.4			2.3 +- 0.5		
	U	2	0 +- 0			27.1 +- NA			2 +- NA		
Phylloscopus ibericus	F	5	0 +- 0	NA	NA	7.2 +- 0.4	<0,05 *	-2,390	2.4 +- 0.5	0,580	-0,577
	M	5	0 +- 0			7.7 +- 0.3			2.6 +- 0.5		
	U	9	0 +- 0			7.4 +- 1			2.6 +- 0.5		
Serinus serinus	F	28	0 +- 0	0,322	-1,000	11.5 +- 0.9	<0,001 **	4,924	2 +- 0.3	0,467	0,732
	M	51	0 +- 0.1			10.5 +- 0.7			1.9 +- 0.4		
Sturnus unicolor	F	7	0 +- 0	NA	NA	79.1 +- 5.6	<0,01 *	-3,531	2.1 +- 0.4	<0,05 *	2,427
	M	11	0 +- 0			88.4 +- 4.9			1.6 +- 0.5		
Sylvia atricapilla	F	45	0.7 +- 1.4	0,067	1,865	18.1 +- 2.2	<0,001 **	3,377	2.2 +- 0.5	0,723	-0,356
	M	29	0.2 +- 0.8			16.7 +- 1.4			2.2 +- 0.4		
Sylvia melanocephala	F	15	0 +- 0	NA	NA	12.2 +- 1	<0,01 *	2,742	2.2 +- 0.4	0,129	1,572
	M	21	0 +- 0			11.3 +- 0.8			2 +- 0.3		
	U	2	0 +- 0			12.2 +- 0.4			2 +- 0		
Turdus merula	F	28	0 +- 0	0,183	-1,354	84.3 +- 6.3	<0,01 *	2,632	1.7 +- 0.5	0,962	-0,048
	M	52	0.1 +- 0.3			80.3 +- 5.2			1.7 +- 0.5		

These measurements and morphological differences can be useful when sexing juvenile birds. Even in species with sexual dimorphism juvenile birds can be hard to sex. Knowing that the Iberian Chiffchaffs have a significant ($p < 0.001$) difference in wing length and a significant difference ($p < 0.05$) in the 8th primary and in Tarsus, this information can help to correctly sex a juvenile or an adult. Figure 6 shows that most of the Common Nightingales that weren't sexed fit into the interval of measures of the male sex. Thus giving more tools to correctly identify birds and increase the quality of bird ringing data.

Figure 7 provides examples of species that are difficult to sex and have high numbers of unsexed (U) individuals, as juveniles and adults, but that showed significant differences in more than one biometry (Table 2). Sexing could be more efficient in these species using this information.

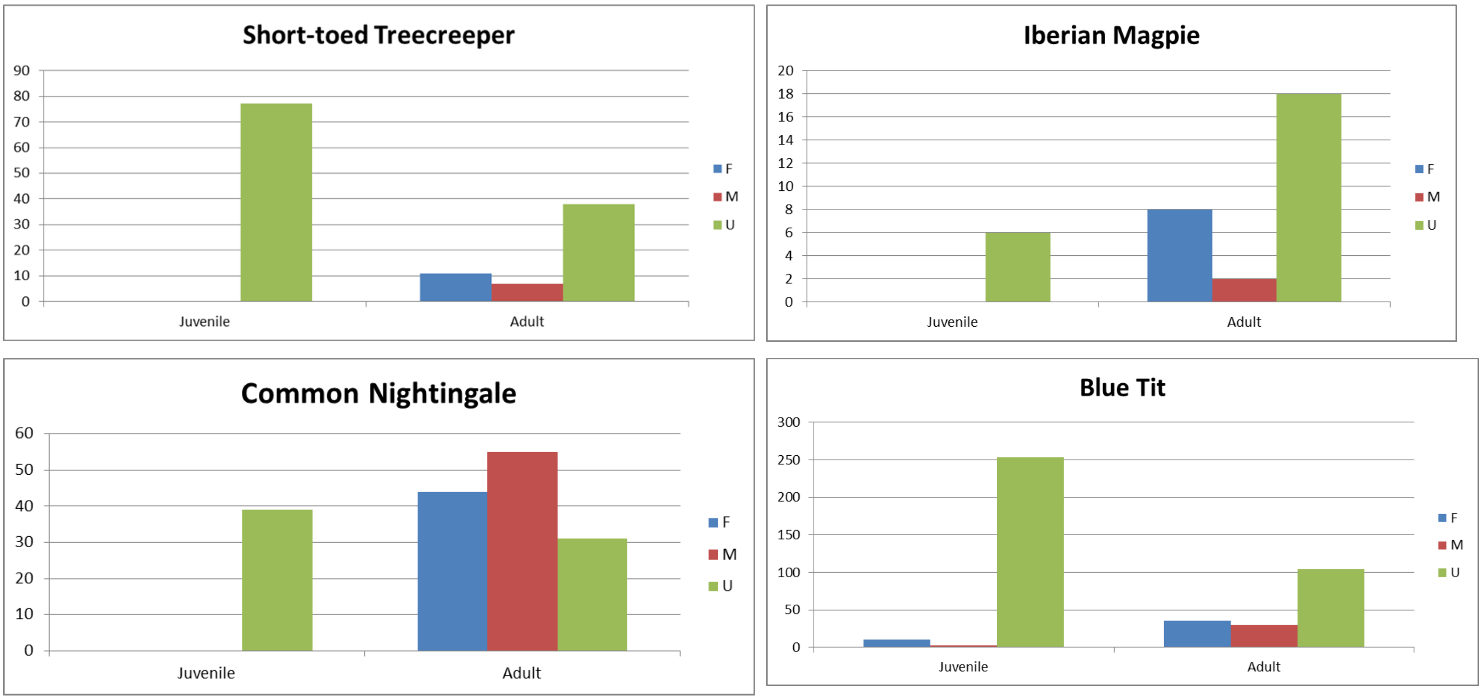


Figure 7 - Number of juvenile and adult birds sexed as "Males" (M, red), "Females" (F, blue) and "Undetermined" (U, green) for Short-toed Treecreeper (*Certhia brachydactyla*); Iberian Magpie (*Cyanopica cooki*); Common Nightingale (*Luscinia megarhynchos*) and Blue tit (*Cyanistes caeruleus*)

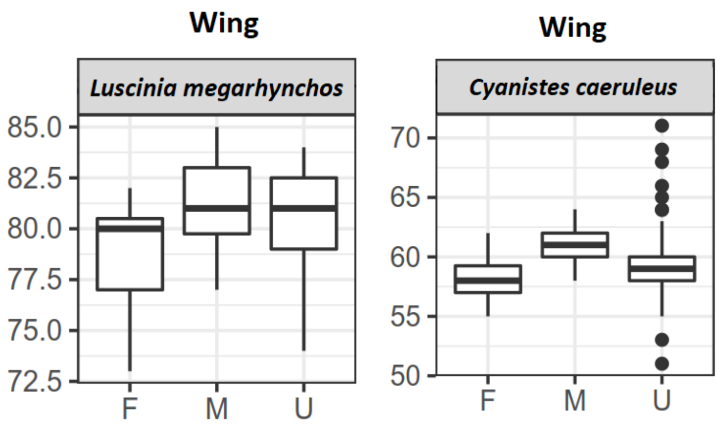


Figure 6 - Boxplots showing the difference for Wing length size between sexes. Common Nightingale (*Luscinia megarhynchos*) on the left and Blue tit (*Cyanistes caeruleus*) on the right. All other Boxplots for the other biometrics, in species with significant ($p < 0.05$) size differences, are available in the Attachments

2.4 Discussion

In this paper we showed that data provided by one Constant Effort Site (CES) is useful in many ways, we were able to calculate recapture rates that were used to study site fidelity in migrant species, population trends and longevity records were assessed and we were able to detect sexual dimorphism, based on biometric measures, in many species.

Mitra is an important breeding site for the Nightingale, with individuals returning for several years and having a high recapture rate of 35%, other migrant species did not show strong breeding site fidelity but, nevertheless, the high capture rates indicate the importance of the site. During the winter there is an increase in Robins and Blackcaps migrating from higher latitudes, being impossible to distinguish between resident and migrant populations with the current ringing program. Nevertheless, with few adaptations to the current protocol it would be possible to analyze a phenomena studied by Tellería & Pérez-Tris (2003) and Campos et al. (2011), which focused on the use of different territories between populations.

Considering the Total and PEEC numbers follow similar trends and are stable, it's reasonable to assume that wintering bird populations are not negatively affected by the conditions in Mitra but are dependent on other extrinsic factors like the conditions of their pre-migratory grounds and weather during migration. These factors can make one, or more, species have a particularly good year, consequently increasing the overall wintering populations and masking possible decreases in other species. The Common Chiffchaff (a wintering species) tripled its numbers in 2014, for example.

By analyzing the wintering populations of migratory species through ringing, we can also assess their status and trends in their breeding grounds. Years with lots of captures mean good breeding rates and vice versa.

On a global view, the integration of this type of data can bring new insights of the wintering migration, especially if related with weather conditions. Another potential of CES, as the data is collected in a standardized way along years, is to reveal potential shifts in migratory routes and/or places.

Some species are difficult to sex, and most of the juveniles are caught before the first moult, leading to large amounts of undetermined sex individuals during ringing sessions. We were able to identify biometric measures that are significantly different between sexes and can be used in juveniles and adults to help with sexing. The variable wing length was the most important in detecting these differences.

Birds with sexual dimorphism in the wing length present the same dimorphism in the 8th primary feather 58.8% of the time. The 8th primary is almost equivalent to the wing length and there are evidences that it is a better measure since it's easier to take and has a higher repeatability (Jenni & Winkler, 1989). As always, other studies argue that there were no differences in repeatability between measurements taken by experienced ringers (Gosler et al., 1995). Our results show that wing length is much better at detecting morphological differences between sexes than just the primary. Therefore the wing length should be favored over the length of the 8th primary.

The recapture rates are not homogeneous between species, apparently without relation with the number of individuals captured. Two strong billed finches have extremely low recapture rates even though they both have more than 75 captures, the Greenfinch (*Chloris chloris*) and the Hawfinch (*Coccothraustes coccothraustes*) have 4% and 0% recapture rates respectively. The Short-toed Treecreeper has a similar number of captures (n=79) but a recapture rate of 39%. Although this type of information is somehow neglected in studies, several studies (Young, 1941; Calvo & Furness, 1992; Marion & Shamis, 1977; Laskey, 1944; Lovell, 1948) in North America with the Red cardinal (*Cardinalis cardinalis*), which can be an equivalent in terms of diet and bill structure, to the finches mentioned, showed that they can remove the aluminum rings, so this species is now ringed with steel bands. This could explain the low recaptures of these particular species, and perhaps the 5% rate on 279 House sparrows as well. As suggested by (Smith et al., 1997) these species can also compress the aluminum rings, leading to leg injuries or in the worst cases to amputation. This phenomenon should be deeply investigated.

A CES can be vital in providing valuable data to researchers as they can offer decades of standardized data, allowing for comparisons to be made across several years and between different CES, as most will have similar capturing techniques, ringing effort and skilled technicians. That data, one CES obtains, can also be used for a multitude of purposes and is not limited to just one type of study. Most ringing studies are focused on one particular species or problem but collect similar data to a CES. Investing in better CES programs would eliminate the need of implementing new ringing studies in order to study something specific, scientists could just use data collected in several CES instead.

In order to enhance the value of Constant Effort Sites to bird and habitat conservation, CES should be encouraged instead of temporary ringing sites. Particular attention should be paid to the new locations, to assure a representativeness of the most important habitats in the country, instead of the actual unbalance to the coast and wetland habitats we see today. If these places remain unchanged through time, the species trends can be used as reliable indicators and as biodiversity assessments.

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Attachments

Table 1 - Capture and Recapture numbers and Recapture rates (in percentage) for every species with more than 10 captures

Species	Capture	Recapture	Recapture rates
Cettia cetti	22	10	45%
Certhia brachydactyla	76	30	39%
Sitta europaea	41	16	39%
Troglodytes troglodytes	45	17	38%
Luscinia megarhynchos	94	33	35%
Dendrocopos major	18	6	33%
Passer montanus	12	4	33%
Parus major	141	39	28%
Turdus merula	229	63	28%
Sylvia melanocephala	154	42	27%
Erithacus rubecula	140	37	26%
Sturnus unicolor	24	6	25%
Alcedo atthis	39	9	23%
Emberiza cirlus	26	6	23%
Lophophanes cristatus	26	6	23%
Prunella modularis	13	3	23%
Cisticola juncidis	10	2	20%
Phylloscopus ibericus	44	8	18%
Aegithalos caudatus	49	7	14%
Cyanistes caeruleus	365	52	14%
Sylvia atricapilla	535	75	14%
Delichon urbica	395	55	14%
Serinus serinus	117	16	14%
Fringilla coelebs	111	13	12%
Phylloscopus collybita	97	9	9%
Estrilda astrild	50	4	8%
Passer domesticus	279	14	5%
Chloris chloris	79	3	4%
Carduelis carduelis	40	1	3%
Coccothraustes coccothraustes	74	0	0%
Anthus pratensis	16	0	0%
Cyanopica cooki	34	0	0%
Hippolais polyglotta	14	0	0%
Hirundo rustica	19	0	0%
Turdus philomelos	22	0	0%
Total	**3450**	**586**	**17%**

Table 2 - Total Capture and Recapture numbers and Recapture rates (in percentage) for every year

Year	Capture	Recapture	Recapture %	Total
2010	537	84	15,64%	621
2011	485	80	16,49%	565
2012	416	140	33,65%	556
2013	448	132	29,46%	580
2014	665	163	24,51%	828
2015	283	110	38,87%	393
2016	263	68	25,86%	331
2017	400	114	28,50%	514
2018	52	16	30,77%	68
Total	**3549**	**907**	**25,56%**	**4456**

Table 3 - Total number of captures (with recaptures included) for every species and all years (2010-2018)

Species	Captures
Sylvia atricapilla	635
Delichon urbica	453
Cyanistes caeruleus	438
Turdus merula	338
Passer domesticus	297
Sylvia melanocephala	223
Parus major	202
Erithacus rubecula	194
Luscinia megarhynchos	169
Fringilla coelebs	136
Serinus serinus	135
Certhia brachydactyla	133
Phylloscopus collybita	107
Chloris chloris	83
Coccothraustes coccothraustes	74
Troglodytes troglodytes	72
Sitta europaea	60
Aegithalus caudatus	58
Phylloscopus ibericus	58
Alcedo atthis	57
Estrilda astrild	54
Cettia cetti	44
Carduelis carduelis	41
Emberiza cirlus	36
Cyanopica cooki	34
Lophophanes cristatus	33
Sturnus unicolor	32
Dendrocopos major	30
Turdus philomelos	22
Hirundo rustica	20
Passer montanus	17
Anthus pratensis	16
Prunella modularis	16
Hippolais polyglotta	14
Cisticola juncidis	13
Phoenicurus ochruros	9
Saxicola rubicola	9
Garrulus glandarius	8
Pyrrhula pyrrhula	9
Cecropis daurica	7
Ficedula hypoleuca	6
Passer hispaniolensis	6
Picus viridis	6
Sylvia borin	6
Motacilla cinerea	5
Phoenicurus phoenicurus	5
Spinus spinus	5
Acrocephalus scirpaceus	3
Passer sp.	3
Phylloscopus trochilus	3
Regulus ignicapillus	3
Streptopelia decaocto	3
Accipiter nisus	2
Emberiza calandra	2
Lanius meridionalis	2
Lanius senator	2
Apus pallidus	1
Athene noctua	1
Cuculus canorus	1
Dendrocopos minor	1
Falco tinnunculus	1
Oriolus oriolus	1
Strix aluco	1
Sylvia communis	1
Total	**4456**

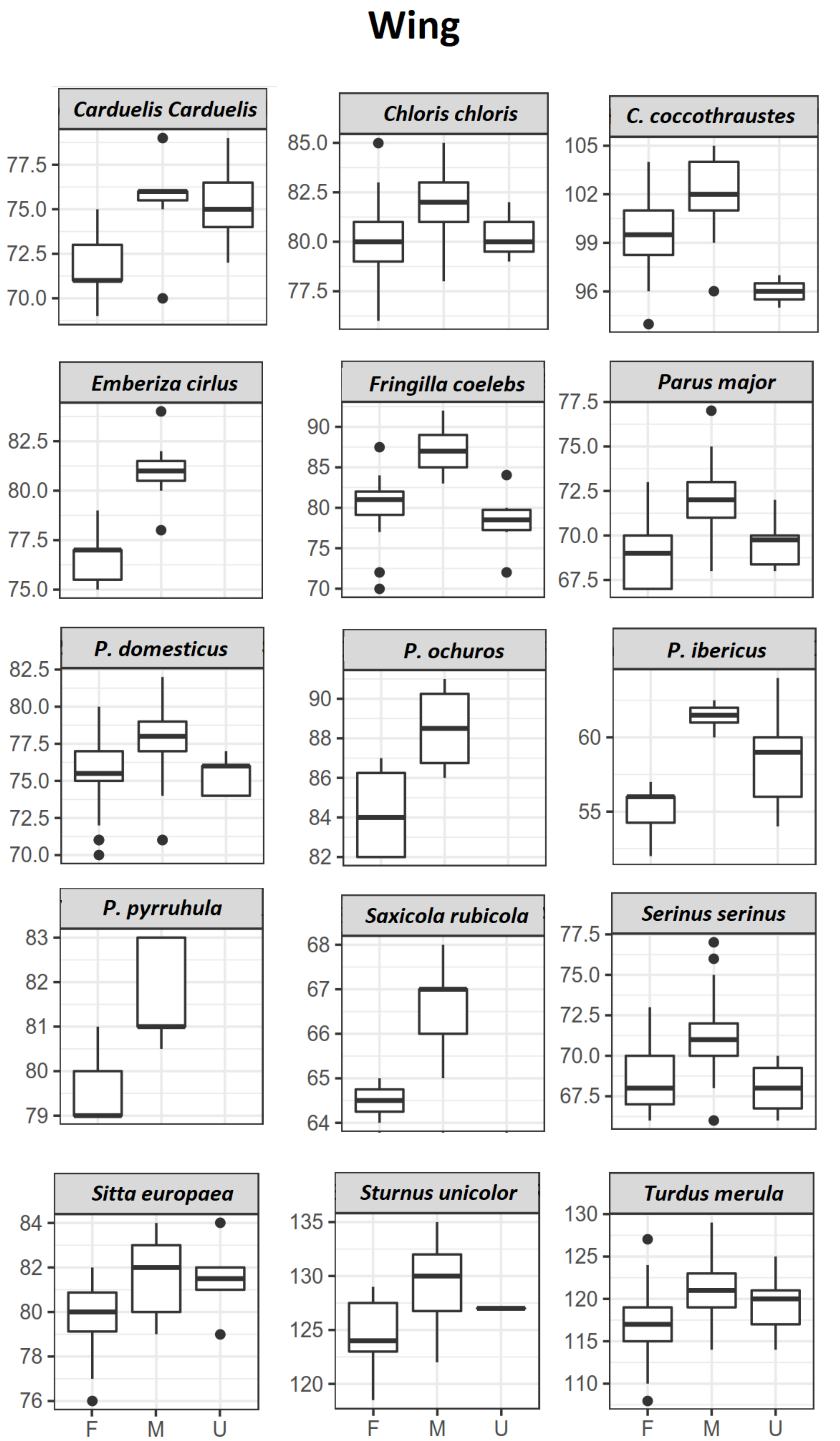

Figure 1 - Boxplots for every species with significant (p-value < 0.05) sexual dimorphism in Wing length size

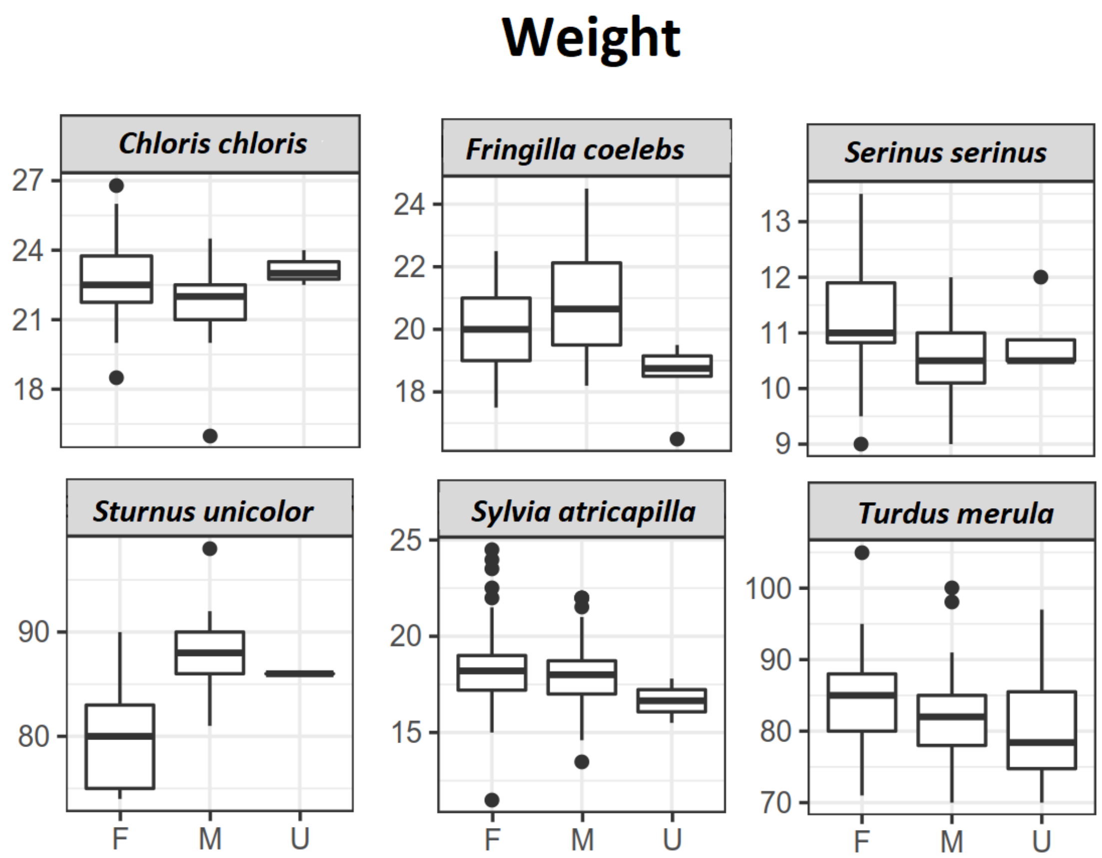

Figure 2 - Boxplots for every species with significant (p-value < 0.05) sexual dimorphism in Weight

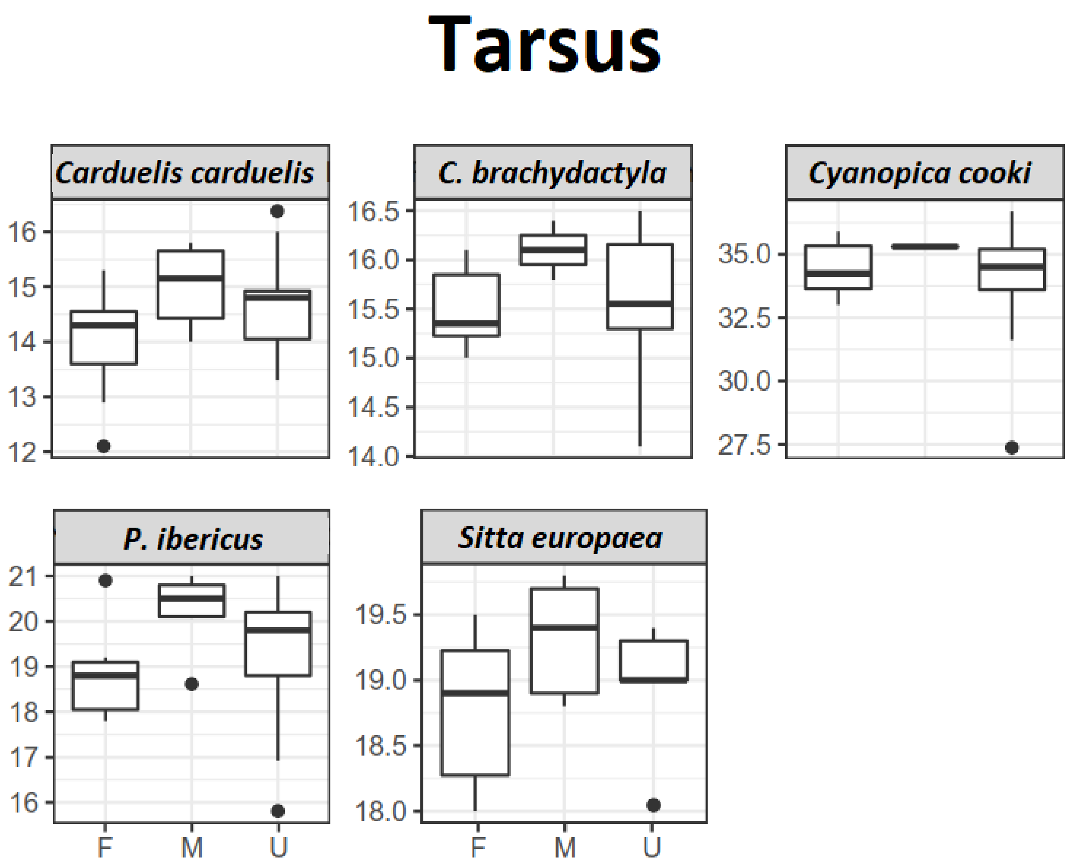

Figure 3 - Boxplots for every species with significant (p-value < 0.05) sexual dimorphism in Tarsus length

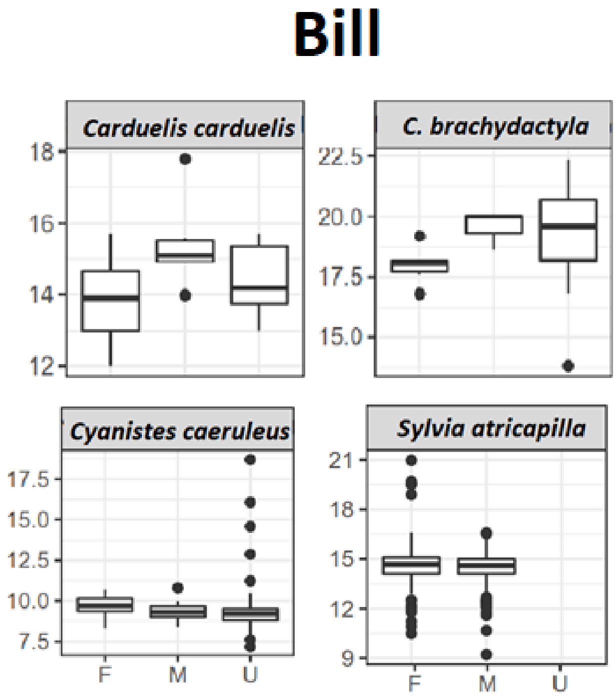

Figure 4 - Boxplots for every species with significant (p-value < 0.05) sexual dimorphism for Bill Length

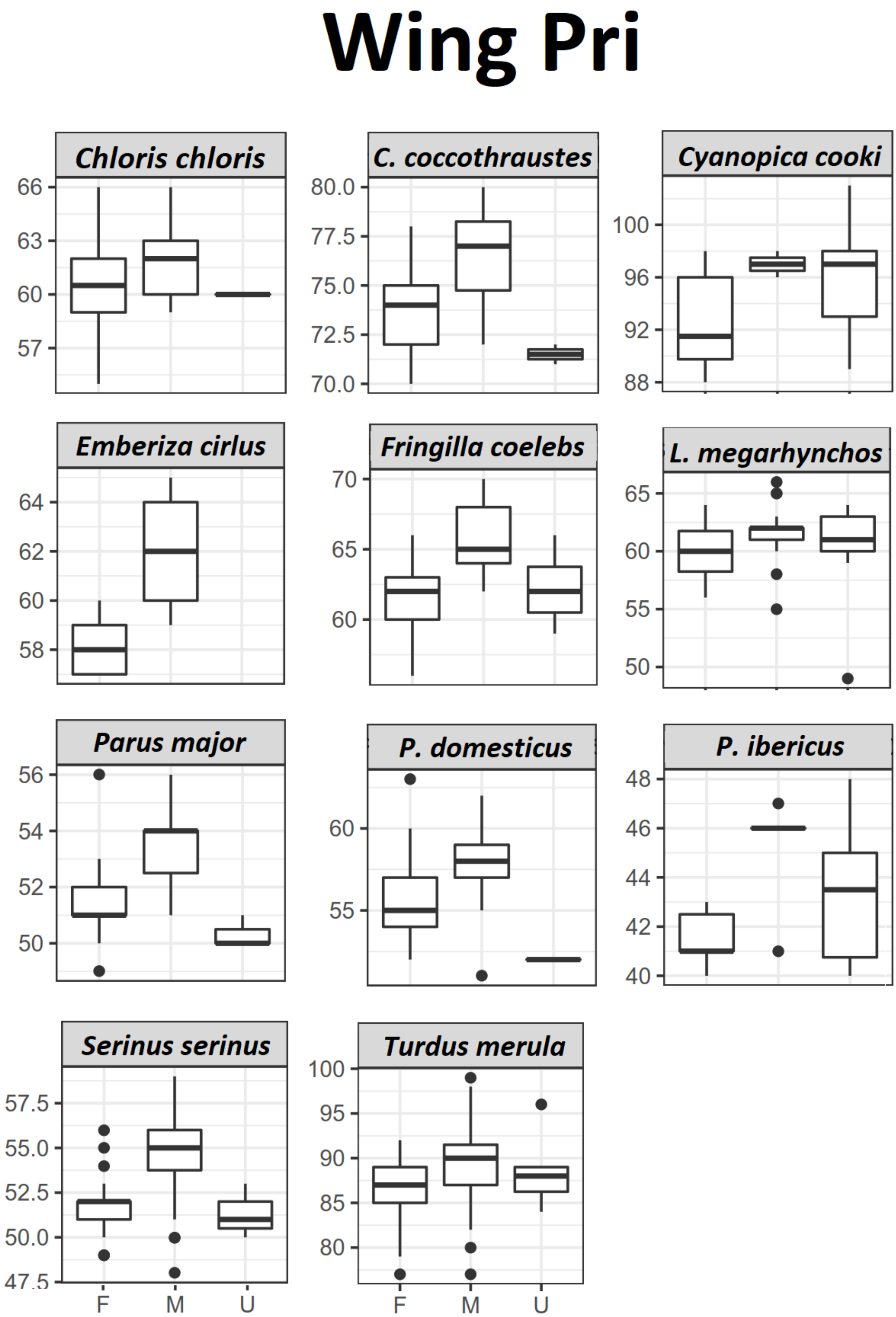

Figure 5 - Boxplots for every species with significant (p-value < 0.05) sexual dimorphism for P8 (primary feather 8)