



*International Ornithologists' Union*

*Working Group on Bird Marking*

# **Bird-marking Programs: Standards Guidance**

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## **Executive Summary**

This guidance document provides recommendations to assist developing and established bird-marking programs to achieve high ethical, scientific and data-management standards, while promoting collaboration and coordination among programs to advance bird research and conservation. The term ‘program’ is used to refer to coordinated efforts, often at a national level, related to capturing and marking birds, using numbered metal rings (also called bands) and other types of markers. We hope this document will be useful to any program that supports or permits activities involving the capture and marking of wild birds using any type of marker ranging from uniquely numbered metal rings to visual markers to radio or satellite tags or data loggers.

### **Why mark birds?**

Bird-marking is a fundamental tool used to undertake many types of scientific research to understand the ecology and conservation of birds, allowing individual birds to be followed through space and time. Marking birds is essential for tracking migration movements, studying demography and population dynamics, as well as behavioural studies. Traditionally, based on uniquely numbered metal rings placed on the legs of birds, increasingly many studies are supplementing those with auxiliary markers, including various types of visual markers (e.g., colour rings, wing tags, neck collars, etc.) and or electronic markers (radio tags, satellite tags, data loggers). Such novel markers can greatly increase the amount, type and quality of data gathered on each bird.

### **Types of bird-marking projects**

Effective bird-marking projects can vary along a spectrum from local, targeted research projects, to large-scale collaborative projects that may span multiple countries. Local projects are most effective if undertaken by trained researchers (e.g., academic or government scientists, graduate students) with specific research goals and objectives and the capacity to analyse and publish the results. Large-scale collaborative projects, such as monitoring migration or constant-effort capture-recapture projects are most effective if participants follow standardized approaches and ensure that the data are well managed, well documented and publicly available so that anybody can access and analyse them.

## **Ethical considerations**

High ethical and scientific standards are required to support bird welfare and to ensure the scientific integrity of the results. Birds that are unduly stressed or harmed during capture and marking are unlikely to behave naturally after release, compromising the scientific value of any data gathered on the marked birds. Programs should develop and promote ethical guidelines for ringers. Ringers should be familiar with the guidelines and have appropriate experience and training to safely handle and mark birds using their proposed trapping or marking techniques.

## **Permitting**

Permits that are personalised to the ringer's expertise and proposed project can facilitate managing skill level and compliance. Permit applications should be evaluated based on demonstrated competence of the ringer in capture, handling, and marking methods relevant to their project; bird identification including ageing and sexing; and accurate and timely data collection, management and reporting. Bird-marking programs should have clear guidelines for the level of training required to achieve these standards while protecting bird safety. Qualifications may be assessed by information supplied in an application form, certifications or standardised exams, and/or testimonial letters from expert ringers attesting to the skill level of the applicant. Permits linked to a specific project with a limited duration (e.g., 1-3 years) are recommended so that the success of the project and the compliance of the ringer can be assessed prior to renewal. Permits should clearly articulate what is, and is not, authorized by the permit, by including specific authorizations, terms and conditions.

## **Project evaluation**

Proposed projects should be reviewed for scientific merit to justify capturing and marking birds. Reviews should consider the scientific and ethical merit of projects based on whether they have well-defined objectives / study hypotheses with clear scientific and conservation relevance, and whether the study design, methods and approach are necessary and sufficient to meet those objectives. Reviews may be undertaken by program staff or independent bodies such as granting agencies. Review by animal ethics / care committees may be required, particularly for projects that involve more complex or novel marking techniques. If novel approaches are being proposed, a pilot study is recommended to ensure that they will be appropriate for study species and objective.

## **Managing rings**

Programs must ensure that the numbering system used for metal rings is flexible to allow for program expansion and does not duplicate numbers within the scheme or with other nearby schemes. Rings must be available in a range of sizes to accommodate the various species being studied in the region. Programs should provide a list of recommended ring sizes and types for use on each species in their jurisdiction. Programs may purchase and disseminate rings, either free or with a cost to ringers. Alternatively, ringers may be required to purchase their own rings based on sequence numbers issued by the program. Programs should have an efficient system to track the inventory held by ringers to ensure that data are reported in a timely manner.

## **Managing auxiliary markers**

Most programs require ringers to source and purchase their own auxiliary markers. Efficient coordination of visual markers and codes (e.g., colour rings, wing tags, neck collars) within species or similar looking species is required to avoid duplication of markers which can jeopardize all projects. For studies of resident birds, local coordination may be sufficient while for long-distance migrants, international coordination is required. Coordination may be led by the program or may be delegated to international collaborative research groups. Coordination of electronic markers is required both within and among species, to avoid duplication of codes. In some systems, such as Motus or satellite tracking, tags must be registered upon deployment, which allows for tracking, but care is still needed to ensure that different tags with the same codes are not active at the same time on different species.

## **Data management**

Marking programs must have robust, secure databases to manage original ringing data as well as all subsequent recaptures by ringers and encounters by the general public. For the original ringing event, databases must include, as a minimum, data on the permit number, ring number, species, age, sex, date, location, auxiliary markers and any treatments applied to the bird. For subsequent encounters, the same fields are required as well as information on the current condition of the bird, how the bird was encountered, any changes to the markers, and the identity of the person reporting the encounter. Whenever possible, central databases should also manage additional information collected by ringers such as standardised biometrics or moult. Metadata associated with projects, such as information on capture effort and methods, can also be valuable for

collaborative analysis of data, though few marking schemes currently have standardized databases to manage those data.

### **Managing tracking data**

Programs should also develop guidance for management of data collected using electronic markers such as radio-tags or geologgers. In most cases, these can most efficiently be managed using existing platforms such as Movebank or Motus. Marking programs should provide clear guidelines on the type of permissions and access that should be associated with the data, to ensure that the schemes themselves have access, and that data will be published openly either immediately or after a reasonable time delay to allow for analysis and publication.

### **Encounter reporting**

Marking programs should develop a web data platform where members of the public can report data on marked birds they encounter. This website can provide information on the program and should solicit all of required information including ring or marker numbers / codes, location, date, species, and the name and contact information of the person reporting. Pictures of different marker types and drop-down menus can be used to minimise reporting errors. An option should be available to upload photos of the bird or the markers so they can be verified. If possible, the platform should link directly to the ringing database, so that immediate feedback can be provided on the original ringing and past history of the bird. The web platform should be made available in multiple languages relevant to the region to encourage reporting from throughout the flyway. Multiple programs within a flyway may benefit from developing a collaborative reporting platform.

### **Data dissemination and publication**

Programs should aim to make all marking and encounter data publicly and openly available, either immediately or after an appropriate time lag, to maximize the value of the data for science and conservation. To achieve this, programs should develop clear guidance for ringers related to data ownership, data dissemination and rights to publication. Programs may consider data to belong to the program or to the ringer. In the latter case, the program should be granted an appropriate licence to use and disseminate the data in perpetuity. While ringers should have a prior right to publish scientific results from their studies, this should have a time limit and should allow immediate use of the data for other purposes, particularly related to conservation and management. Programs should develop guidelines for researchers accessing data from other ringers on how to

ethically use the data for scientific publication, including guidelines for collaboration with the original ringers. In many cases, the original ringer can provide valuable insight to the research project, particular through providing context on study methods and design.

## Preface

The International Ornithologists' Union Working Group on Bird Marking, previously known as the International Ornithological Congress Standing Committee on Bird Ringing, was established in 2006 to enhance international collaboration and standardisation related to bird marking and associated data management issues of mutual concern. The committee aims to achieve this mission by promoting communication, coordination, and sharing of data, tools, and best practices among bird-marking programs to enhance scientific and conservation value, while incorporating high ethical and scientific standards.

This Bird Markings Programs Standards Guidance was created to share information among developing and established bird-marking programs to enhance ethical, scientific and data management standards, while promoting collaboration and coordination of programs. Throughout this document, we use UK spelling and terms. Please note that among English speaking countries, the terms ring, ringing, and ringer are generally used in the UK, South Africa and some other African countries, while band, banding and bander are used in the USA, Canada, Australia and New Zealand. When referring to a particular program, such as the U.S. Bird Banding Laboratory or the BTO Bird Ringing Office, we use their official terms. In this document, we use the term 'bird marking program' to refer to the whole program or scheme (including all the people who participate in it by collecting or analysing data) and may or may not have a central program administration office. When we use 'ringing centre, program administration or administrators' we refer to the office (administrators) of the program that manages data, issues permits, sets program policy, etc. Not all programs have administrators, in which case ringers must take on some of those responsibilities. Bird ringing refers to the attachment of metal rings to birds, while bird-marking is an umbrella term, including the application of rings (metal and colour), as well as other auxiliary markers (visual and electronic).

The writers of this document wish to recognise and acknowledge the importance of respecting and incorporating Indigenous values into scientific research that take place on their lands. Indigenous peoples have knowledge systems that guide their worldview, and they often have an intimate knowledge of local plant and animal communities. We encourage researchers to engage with communities before research begins to understand the local perspective and plan to integrate community questions into your research. Answering community questions and sharing your findings will help to develop a relationship based on trust and respect. For more information, see [Towards reconciliation: 10 Calls to Action to natural scientists working in Canada](#).

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### Working Group Co-chairs

2006 – 2014: Fernando Spina (Italian Bird Ringing Scheme) and Charles M. Francis (Environment and Climate Change Canada)

2014 – 2022: Charles M. Francis (Environment and Climate Change Canada) and Judit K. Szabo (Charles Darwin University, Australia)

2022 – present: Judit K. Szabo (Charles Darwin University, Australia) and Gudrun Hilgerloh (Nature and Biodiversity Conservation Union, Wilhelmshaven, Germany)

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# 1. Bird-marking programs

## 1.1. Why mark birds?

Historically used to understand and describe migratory routes, bird marking continues to be a critical tool for many aspects of scientific research, monitoring, and conservation of avian populations. In addition to traditional metal bird rings, there are numerous other markers and tags that allow identification and tracking of birds in the field, without the need for recapture. Field readable visual markers such as colour rings, wing tags or neck collars allow easy identification of birds from a distance for behavioural or movement studies. Novel technologies, such as radio and satellite transmitters, global positioning systems, and data loggers are being used more and more to gather vital data about avian movements, demographic parameters, game bird management, ecological factors, and population dynamics.

Understanding bird movements and the impacts of various threats, such as climate change and emergent diseases on birds, requires collaboration among bird-marking programs on a global scale to coordinate ringing efforts and exchange information worldwide. Communication and coordination within a collaborative network of international bird-marking programs promotes best practices in bird-marking and high standards of data quality worldwide by:

- allowing for the sharing of tools (data management systems, training material, etc.) and data to maximise the impact of individual marking efforts on global avian conservation;
- providing training standards (about bird-marking, study design, reporting methods, etc.) to ensure the scientific integrity of the results;
- fostering international participation in collaborative studies to address avian conservation; and
- informing conservation and management decisions and actions.

All data gathered from bird-marking activities are potentially valuable, if they are collected following standard scientific and ethical field protocols prescribed for the capture, handling and marking of wild birds. However, data are most valuable to avian research and conservation efforts when they are:

- part of a well-designed research project;
- accurate and standardised;

- stored centrally and made readily available for further analysis and research; and
- analysed with the results made publicly available.

### **Box 1. Glossary**

*Bird ringing* or its synonym *bird banding*: placing a unique metal *ring* (or *band*) on the leg of a bird

*Ring* or *band*: a round piece of metal with a unique numbered sequence appropriately sized to fit on the leg of a bird

*Bird marking*: besides *bird ringing* it also includes other use of auxiliary markers (colour rings or other visual tags, and electronic markers such as data loggers or radio transmitters)

*Encounter*: Subsequent encounters of marked birds, including live recaptures (i.e., the bird is captured by ringers alive), dead recoveries (usually by hunters or other members of the public), resightings of a marked individual bird and electronic data points in case of an individual tagged with an electronic marker

*Ringling centre*: The central office from which a ringing program is coordinated

*Ringling program*: a collective term used to cover the coordinated program of capturing and marking birds and managing the resultant data, that includes the ringing centre and all of the participating ringers. A program may encompass many individual projects.

*Ringer (bander)*: professional scientists or amateur (avocational) birders with the appropriate skills and permits to safely capture and mark birds

*Wildlife permit*: the exact definition will depend on the regulations of the country. Wildlife permits include all permits, including hunting, damage and danger, taxidermy, rehabilitation, etc. These will vary with country but include a diverse range of permit types

*Wildlife research/scientific permit*: includes any specific wildlife permits required for scientific and education activities, such as collections, capture and banding or marking, collection of biological samples (blood and feathers), taking into captivity for research purposes, etc.

## 1.2. What is a bird-marking program?

Bird-marking programs across the globe play an essential role in avian research and conservation by managing bird-marking activities within their region. We use the term ‘program’ to refer to coordinated efforts, often at a national level, related to capturing and marking birds, using numbered metal rings (bands) and other types of markers. They are most often administered through a national or centralised office, but in some places may be run by an individual research team. Their main goal is to ensure that high-quality data are gathered by professional and amateur ringers from scientifically sound bird-marking projects; that data are appropriately stored and managed to reduce risk of loss; and that data are available for use by the ringers themselves, researchers or others with an interest in birds to understand the ecology, conservation and management of birds. The hundreds of active bird-marking programs around the world involve the capture and handling of millions of wild birds. Given the large number of people that participate in these projects, bird-marking programs also have a role to ensure that all involved activities are fully justified from an ethical standpoint and that standardised field protocols are followed to minimise the risk to the birds’ welfare and facilitate data sharing. Bird-marking programs need to work with professional and amateur ringers, volunteers, program administrators, governmental authorities and partners to promote high ethical and scientific standards in the capture, handling, and marking of birds for scientific research.

### Types of bird-marking programs

Bird-marking programs can have different levels of management:

**Centralised marking programs:** in most countries, the administration of bird marking programs is managed by institutions or organisations that have secured long-term funding and have technically trained staff in ornithology, data analysis, database management and policy. They may be managed within the government, by non-governmental organisations, or jointly by both. These programs are also usually responsible for providing permits. In all cases, centralised ringing programs rely on collaboration between the central management and the individual researchers and biologists who participate in the marking activities.

**Independent programs:** individuals or a small group of independent researchers may participate in bird-marking projects in countries where centralised marking programs do not exist. The ringers themselves manage markers, as well as ringing and recovery data. Data are generally not held centrally and may be vulnerable to loss. Independent programs are encouraged to reach out to national ringing programs of other countries

and flyway networks in their geographical area to ensure that rings and other markers remain unique within the network and there is international collaboration on relevant projects.

### **Coordination among programs**

Coordination among programs in different jurisdictions is important to support sharing of data and information, especially given that many birds travel across international boundaries and conservation and management requires international coordination. This can happen informally or through more formal structures.

**Flyway networks:** bird marking programs may participate in flyway networks over a broader geographic region. Such networks may help to coordinate projects, coordinate the use of auxiliary markers, develop and share guidelines, promote standards, and facilitate data exchange, although the roles vary among networks. They are mostly managed by well-established non-governmental organisations or institutions and focus on coordinating projects, provide guidelines, and promote standards. Current international networks include [EURING](#), [AFRING](#), Western Hemisphere Bird Banding Network (WHBBN), and the East Asian-Australasian Flyway Partnership ([EAAFP](#)).

**International Ornithologists' Union Working Group on Bird Marking:** the IOU [WGBM](#) was established to share information among programs, including providing guidance on managing bird-marking programs, training, ethics, data use, management and analysis. The committee is led by managers of national ringing centres and flyway networks.



**Figure 1.** Bird-marking programs need to ensure that all bird rings used in the program have a unique combination of number and address so that they can be distinguished from rings from any other program that may be encountered on birds in their region. © Judit Szabo

### **Roles of a bird-marking program**

At the core, bird-marking programs are responsible for:

- ensuring that bird capture and marking are performed by trained individuals using best practices;
- managing data gathered from marking activities;
- managing encounter and recovery data; and
- managing the inventory of unique rings.

While independent programs can operate by satisfying these four core functions, centralised ringing programs generally have additional responsibilities related to administration, permitting, and data management (Table 1).

**Table 1.** Roles and responsibilities of different levels of entities involved in bird-marking programs. Flyway networks and the IOU Working Group on Bird Marking have different roles, focussing instead on enhancing international communication and collaboration in standardisation of training, ethical conduct, and data management.

	Ringer	Ringing Program	Ringing Network	IOU RCC on Bird Marking
Training	Acquire practical ringing skills and academic research skills	Provide training to ringers or point them towards existing opportunities; Assess qualifications of ringers	Set standards for required bird-marking skills	Enhance international collaboration and communication on training standards
Ethics	Acquire knowledge of avian welfare and scientific standards	Adopt, adapt or set code of ethics; Provide guidelines for ethical conduct in bird marking activities	Promote the need for standards of scientific research and avian welfare in bird marking	Promote communication, coordination and sharing of best practices

Data Management	Gather, computerize, and verify required data; Submit to secure central repository	Centrally manage database of all ringing and recovery data; set standards for collection, QA/QC and submission of data	Support platforms for reporting of encounter data; Facilitate sharing of data through open platforms	Enhance international collaboration and standardisation on data issues
Auxiliary Markers	Select appropriate markers for study species; ensure all markers are approved and registered prior to use. Report on effectiveness of novel marker types.	Maintain registry of markers in use by ringers; Allocate codes to ringers as required.	Coordinate allocation of markers among programs along the flyway; Encourage collaboration on large-scale projects	Share information on types and effectiveness of markers
Rings	Acquire and manage inventory of rings appropriate for study species.	Acquire and manage inventory of rings; sell or distribute to ringers; or direct ringers to suppliers.	Help coordinate ring supply for small programs, as required.	

To achieve the goal of supporting scientifically and ethically justified research projects that produce high-quality data for use in avian conservation and management, centralised bird-marking programs provide a service to ringers and other data users (researchers, program administrators, government officials, etc.) that may include:

- Administering the program:
  - evaluating ringer qualifications;
  - evaluating the scientific validity of ringing projects;
  - issuing, amending or renewing permits to eligible ringers;
  - promoting compliance with permit conditions;
  - coordinating the use of bird markers (rings and/or auxiliary markers);
  - managing the inventory of bird markers (rings and/or auxiliary markers);
  - managing a central data repository of ringing and encounter data;
  - coordinating requests for data (ringing, recaptures and resightings);
  - coordinating ringing activities between regions or internationally;
- Setting and promoting high standards:
  - developing standard training materials to improve qualifications of ringers and the quality of the data collected;
  - encouraging ringers to participate in well-designed scientific research projects;
  - facilitating communication among ringers and data users to promote best practices in capture, handling, marking, data use and analysis;
  - supporting research aimed at improving criteria for identification, ageing and sexing;
  - promoting the publication of peer-reviewed results from these studies; and
  - supporting research and development in producing new materials and technologies for bird markers to ensure better longevity and legibility, while minimising risks to bird welfare.
- Developing program policies, procedures, codes of practice:
  - banders codes of ethics;
  - data-use policies for use of data gathered from bird-marking projects.
- Public outreach, analysis and data dissemination:
  - promoting the reporting of recaptures, resightings and recoveries by other researchers and the public;

- publishing annual reports of operations and/or ensuring that data are available to others to develop such reports;
- conducting selected analyses (e.g., trends in encounter reporting or publishing ringing atlases)
- developing online data exploration tools.

Efficient operation of a centrally managed bird-marking program generally requires staff with technical expertise in ornithology, database management, and administration, as well as adequate infrastructure to manage the program effectively. Certain key aspects to be taken into account when establishing a new bird-marking program are highlighted in Box 2.

## **Box 2. Checklist for setting up a new ringing program**

### **1. Engage appropriate personnel:**

- a) To communicate with ringers, manage permits, assign unique ring numbers, manage ringing data and collaborate with other established schemes

### **2. Set up permitting infrastructure:**

- a) Develop and maintain an electronic filing system for managing permit information (applications, permits, etc.)

### **3. Building and maintain a database or marking data:**

- a) For managing assignments of rings and auxiliary markers
- b) For collating all ringing, recapture and resighting data submitted by ringers

### **4. Maintain contact with ringers:**

- a) Develop an efficient approach for regular communication with the ringing community (electronic and/or postal)

**5. Provide resources for ringers:** For finding ringing equipment, training material, and other researchers

### **6. If feasible:**

- a) Maintain an inventory of rings and auxiliary markers to distribute to ringers
- b) Collect and manage other data variables collected during ringing projects (e.g., biometric data, environmental conditions, etc.)
- c) Coordinate research projects with other regions, flyways or groups
- d) Coordinate auxiliary markers with other schemes

## 2. Ethical and Scientific Standards

### 2.1. Promoting high ethical and scientific standards

Bird-marking programs should aim to support justified scientific research that requires the capture, handling, and marking of wild birds, while maintaining high scientific and ethical standards. These studies are expected to contribute to our understanding of avian species and populations, while supporting long-term conservation objectives.

Although different cultures may have different specific values and ethics, standards must ensure bird safety and the scientific integrity of the results. Birds that are unduly stressed or harmed during capture and marking are unlikely to behave naturally after release, compromising the scientific value of any data gathered on the marked birds. High standards will promote credibility of the project, program or network; provide confidence in the scientific results gathered from the project and any resultant conservation management decisions and actions; and increase acceptance by animal welfare groups and the public. See the [Resources](#) section for further information on ethics and the use of animals in research.

### 2.2. Bird safety

Bird safety and the careful treatment of individual birds under study are of utmost importance to maintain the scientific integrity of research results and the credibility of bird-marking projects and programs. Ringers are expected to be familiar with the best practices and standards involved in capturing and handling birds. They must maintain appropriate standards and ensure that the studied birds are free from harassment and excessive or unnecessary discomfort and pain. Field staff training and ethical reviews of the research project also support bird safety. Program administrators should review proposals to ensure that birds will be handled in a safe and appropriate manner, while maximising data collection.

### 2.3. Animal ethics / animal care committees

Animal ethics or animal care committees are generally established by organisations to ensure that animal-based research is conducted in a humane fashion and adheres to international standards of animal use in research. This includes the concepts of the 3Rs, which are Replacement, Reduction and Refinement (Russell and Burch, 1959).

Replacement means that if other options are available, no animals are used. In the case of bird marking, this would imply not capturing and marking birds if other options, such as observational studies can provide the same information. For most of the objectives of bird-marking, such as following behaviour of individual birds, tracking migration or studying demographics, capturing and marking birds is usually the only available option. Reducing the number of individuals implies using as few individuals as possible to obtain the desired information. For many bird-marking studies, such as those studying survival rates or tracking migration, large numbers of individuals need to be marked to obtain statistically meaningful results, particularly if recapture or recovery rates are low. However, using appropriate technologies, such as satellite or radio tags to achieve particular objectives, for instance tracking migration, can lead to improved results using fewer individuals. Refinement means continually improving techniques and technologies to minimise harm or stress to the birds. This implies using the best possible capture and handling methods, and the least invasive methods possible for the objectives. In some cases, there may be a trade-off between invasiveness and sample size. For example, satellite tags or colour marks may have a greater impact on the birds, but provide much more data for a given sample size. Ultimately, the projects should always be justified as reasonable and providing valuable and defensible scientific information.

While the process for working with animal ethics committees differs by country, many bird capture, handling, marking and sampling techniques are standard with well-designed protocols and refinements. Providing a committee with standard protocols can facilitate reviews. Novel and invasive techniques or applying a technique to a new species may require greater attention during a review process.

Bird-marking programs may require an animal ethics review before a permit is issued or applied as a condition of the permit. In many countries, researchers working at a university or government institution will be required to obtain animal ethics approval before conducting their research. Other programs may conduct their own reviews to ensure appropriate techniques and that ringers are well trained.

## 2.4. Scientific integrity

Professional and amateur ringers should both strive to maintain high ethical standards during the different steps of the research, including hypothesis formulation, study design, and literature review, as well as the collection, analysis, interpretation and publication of the data. To achieve this, they should:

- have clear objectives;
- ensure the study design and methods are suitable to achieve the project's objectives;
- conduct a literature review to assess the relevance of the study and to learn about previously used methods and existing protocols;
- determine whether capture and marking are justified for the study and use the least invasive practical procedures;
- consider a pilot study to evaluate methods and ensure that they are appropriate to meeting the project's objectives, especially if testing novel techniques;
- avoid procedures that could have lasting negative effects on a population;
- maximize the quantity and quality of information obtained during handling, while reducing the impacts on the individual bird;
- minimize disturbance to avoid bias in results; and
- treat study animals with care and respect, knowing that data obtained from a compromised subject may not provide scientifically reliable results.

## 2.5. Credibility

Researchers have an ethical responsibility to the animals involved in their research, the public and the research community. Openness is a key principle in research ethics and an important point to build credibility and maintain support from the public by demonstrating honesty and integrity. Sharing and publishing the data builds trust and collaboration among researchers and allows constructive criticism, feedback, and replication.

To build credibility within a conservation context, researchers should consider the following concepts:

- projects should have intended use of data; it may be considered unethical to collect data with no intention of using them;
- high ethical standards in handling birds are required to ensure data integrity. Unreliable results may lead to misguided management actions, policies and a misuse of resources;
- protocols should provide sufficient information to reproduce or replicate the study; and

- if study subjects are harmed during the process, marking is not an appropriate conservation tool.

### 3. Program Operations: Project Review and Permitting

Most bird-marking programs are responsible for issuing permits or licences for ringers to capture and mark birds. In many cases, these **permits and licences** are administered under wildlife legislation, which prohibits harming, disturbing, capturing or marking birds without a permit. In other countries, there may be requirements for a research permit. Many programs require ringers to specify the projects they are proposing to undertake, though others provide permits solely on the basis of ringer qualifications. Bird-marking programs may thus be responsible for evaluating both the scientific merit of the projects and the qualifications of the ringers.

#### 3.1. Evaluating bird-marking projects

Bird-marking projects should be reviewed to assess their scientific merit; the researchers' qualifications to achieve the results; the procedures used to capture, handle and mark wild birds, and potential positive or negative impacts on avian populations. Generally, a well-designed project should have:

- clear objectives, hypotheses and intended use of data; and
- clear scientific or conservation benefits, such as monitoring demography or population change to assess conservation status; understanding migratory patterns and connectivity, or contributing to species-specific management or sustainable gamebird management.

While particular research projects can help answer specific study questions, general activities, such as monitoring migration or gamebird management, tend to involve large datasets collected over extended time frames. If appropriately designed, these can be particularly valuable to manage hunting limits or to understand the impacts of long-term and large-scale events on avian populations, such as climate change and emergent diseases. Bird-marking programs may wish to encourage researchers to participate in such projects (independently or jointly), given that these projects help foster cooperation and partnerships in global conservation efforts.

## Review by independent bodies

If possible, to promote and maintain high ethical and scientific standards, projects that require the use of wild birds should be evaluated by independent bodies to ensure they are scientifically valid, have minimal impact on avian populations, follow standardised field protocols to capture, handle and mark wild birds, and are undertaken by qualified individuals. The scientific validity and merit of a proposed study is best assessed by peer review undertaken by researchers who are experts in the field, funding agencies (for instance research councils), or animal welfare committees. Bird-marking programs can either accept their recommendations or conduct an assessment themselves.

Peer review generally evaluates projects based on the following criteria:

- significance of the proposed research and its contribution to a better understanding of the issues being studied;
- justification for undertaking the proposed research;
- quality of the proposed research, including clarity and scope of the stated objectives, as appropriate and reasonable;
- evidence of a good understanding of the relevant scientific literature and the current state of knowledge of the issue;
- suitability of the study design to meet the stated objectives considering the proposed methodologies, as well as laboratory (when relevant) and statistical analyses; and
- appropriateness of proposed time frame for meeting the stated objectives.

## Review by bird-marking programs

Bird-marking programs may wish to assess projects based on additional specific criteria to ensure compliance with high scientific and ethical standards, as well as with their own policies and guidelines. Assessment may include:

- researcher qualifications in relation to their proposed project;
- purpose and value of the research, in terms of contribution to scientific understanding, avian conservation, and environmental health;
- justification to use free-living birds to meet study objectives;
- duration and location of the study;
- level of invasiveness;

- measures to mitigate potential negative effects; and
- intended use of data and results.

When necessary, program administrators can suggest technical training material and guidance documents to researchers that provide current standards and best practices for capture, handling, marking, and sampling of birds. See the [Resources](#) section for further details.

### **Guiding principles for project evaluation**

1. Pilot studies that use few individuals of non-threatened species should be encouraged when new approaches, methods or techniques are being tried, before large-scale protocols are approved. This will ensure that the technique is appropriate and strengthen the results of the project by reducing error and attrition.
2. Projects that involve the use of birds should use the least invasive practical procedures required to achieve the study objectives, considering the biology and behaviour of the species of interest. Every effort must be made to minimise distress and ensure post-handling survival and normal behaviour of each individual bird.
3. Projects that apply invasive techniques to collect data are only appropriate, when the scientific benefits offset potential impacts. Potential negative effects of project activities on bird populations should be predictable, possible to mitigate and temporary.
4. Procedures with likely lasting negative effects on a population or that place a population at risk should not be undertaken, except under extraordinary circumstances. When such impacts are expected, the researcher must demonstrate why the procedure is necessary. Procedures for sample collection and manipulation of migratory birds should be species-specific and meet high scientific and ethical standards. Researchers must be trained in the methods and techniques proposed to ensure the safety of individual birds and the scientific integrity of the data.

### **3.2. Ringer qualification**

It is fundamental to ensure that high technical and ethical standards are being followed during bird-marking activities. Well-trained ringers are essential for bird safety, as well as

for ensuring that the design and execution of studies will lead to high-quality data. Bird-marking programs should have clear guidelines for the level of training required in relation to capturing, handling, and marking wild birds. This will assist bird-marking programs to evaluate the competence of individual ringers, their level of expertise and capability to perform a project resulting in high-quality data. This also helps prospective applicants to understand expectations and training requirements.

Those wishing to undertake bird-marking activities should clearly demonstrate in their application that they have the knowledge, skills and training to carry out the specific field techniques proposed, including ability to safely capture, handle and mark birds and to collect biological samples, as appropriate. Expertise and competence can be demonstrated in terms of academic and technical qualification:

- **Academic expertise** includes having the ability and resources to develop a well-designed study, carry out research, accurately record and manage data, conduct laboratory and statistical analyses, and interpret, write up and publish the results. This may be demonstrated by providing the researchers' educational background, publication history within this area of expertise, association with a research institution, committed funding for the project, membership in scientific organisations, etc.
- **Technical expertise** includes, but is not limited to, understanding the ethics of working with wildlife; ability to safely capture, handle, and mark birds; ability to collect biological materials if required; and accuracy in data recording. This may be demonstrated by providing exam results, certifications, proof of field experience, participation in training workshops, list of trainers, letters of reference from those who are aware of the ringer's field skills, etc.

Bird-marking programs may request reports from expert ringers and/or trainers who can directly attest to the expertise of an applicant in practical aspects, such as setting and operating nets/traps, handling and marking birds, and accurately collecting biological measurements and other relevant data. These testimonials can assist bird-marking programs in evaluating the technical expertise acquired by new applicants, who wish to obtain a permit to conduct bird-marking activities, as well as experienced ringers, who wish to obtain permits to undertake different activities.

Regardless of the evaluation method used or whether bird-marking programs choose to accept the recommendation of others, the skills and competence of ringers in relation to

their proposed project should be assessed before permits are issued to mark birds for scientific and/or educational purposes.

## Ringer Training

Some larger bird-marking programs may choose to run their own training programs, which enables them to evaluate the expertise level of ringers in a standardised manner by administering formal exams. Standard exams can be a useful tool for bird-marking programs to certify that ringers comply with current, updated standards and protocols, and are familiar with relevant acts and regulations. This can also be relevant for experienced ringers who would like to resume bird-marking after being inactive for a number of years.

Every ringer should be familiar with the following basic set of ringing skills before undertaking activities involving the capture, handling and marking of wild birds:

- the ethics of bird marking;
- the role of marking in research and monitoring;
- life histories, energetics, moult and plumages of target species;
- operation of mist nets and other trapping equipment and the safe removal of birds from them;
- bird handling skills (including grips and carrying techniques);
- in-hand identification, ageing and sexing of target species; and
- collecting standard measurements (e.g., wing chord, tarsus, culmen, fat score, muscle score, body mass).

A complete checklist of basic ringing skills recommended for ringing passerines and other landbirds can be downloaded from the [Banders Resources](#) page of the North American Banding Council website.

If bird-marking programs lack the capacity to run their own training program, this function can be delegated to other organisations. Some schemes rely on peer-to-peer learning and accreditation, where a more experienced ringer is responsible for a less experienced ringer until the knowledge and skills of the latter are sufficient for independent work.

### 3.3. Permits

#### What are permits, what role do they play and why are they important?

Permits are legal documents that authorise individuals to conduct activities that are otherwise prohibited legislation. For bird marking, the relevant legislation usually relates to protection of birds or other wildlife or control of scientific research.

As a regulatory tool, permits enable authorities to limit and control activities to ensure that the work is being carried out by qualified individuals, according to established standards, and following specific terms and conditions. Consequently, they play an important role in helping authorities uphold standards of practice and codes of conduct. They also can be used to limit the amount and type of disturbance to wildlife, and thus can play an important conservation role.

#### Regulatory authorities

There are large differences in wildlife regulations and permitting among countries, and hence variation in the regulatory authorities. In most cases, permits are issued by government authorities. In many cases, ringing programs have the authority to issue permits required to capture and mark birds, but in others they are granted by other responsible authorities.

In some cases, the authority to issue bird-ringing permits has been delegated to a non-governmental organisation (NGO) or institution with a vested interest in avian conservation. These organisations and institutions may be involved in some or all aspects of managing the program including evaluating projects; setting terms and conditions; issuing, renewing and revoking permits; enforcing permit conditions; managing ring inventories; and managing ringing and recovery data. They may maintain formal contacts with national and regional government authorities to ensure that ringing permits are managed in accordance with existing legislative frameworks and policies.

In other cases, the permitting responsibility is shared between government authorities and NGOs. For example, one authority may issue wildlife research permits to authorise research on certain birds in specific areas, while the other may issue ringing permits and administer the bird-marking program. Different types of permits might be required in different jurisdictions. In some cases, this may even vary among regions within a country.

In Austria, for instance, depending on the province, ringing permits are delivered by different authorities.

## **Types of permits**

### ***Research permits***

Some countries or jurisdictions require anybody conducting scientific research of any sort to have a Research permit. Research permits grant qualified individuals the permission to undertake certain types of scientific or research activities. Such permits may be in addition to, and separate from, permits to capture and mark birds, and may be administered under different legislation or regulations.

### ***Permits to capture/disturb birds***

In many jurisdictions, wildlife legislation provides protection to birds, and a permit is required to capture or otherwise disturb birds. In many cases, these permits may be the same as a ringing permit, but in some jurisdictions, permits to capture birds may be separate from ringing permits. In some areas, multiple permits may be required, for example, if birds are protected under both federal and provincial/territorial or state legislation. These permits allow authorities to regulate scientific or educational projects that include the capture, handling, marking or taking of birds, nests or eggs, generally as part of avian conservation and management efforts. Such permits usually have specific terms and conditions to be followed by individuals for the duration of their permitted project with regard to location, level of disturbance, target species, activities, methods to be used, possession limits, reporting requirements, code of conduct, etc.

### ***Ringing permits***

Most ringing programs require all ringers to have a specific ringing permit to capture and mark birds. Usually, these are issued under the authority of regulations used to protect birds or other wildlife. Depending on the jurisdiction, regulations may provide for a specific ringing permit, or they may include ringing activities under a broader category, such as a scientific permit. Some countries (e.g., Chile) that do not have comprehensive wildlife research permits have used laws regulating wildlife hunting to create and manage a bird-ringing program. Pursuit and capture of birds for ringing has been defined as hunting in these cases.

In general, ringing permits should only be issued to highly trained individuals who have the necessary skills and demonstrated competency to follow ethical and standard protocols. However, some countries require everybody who handles a bird, even beginners, to have a permit. In this case, there are typically different types of permits, with inexperienced ringers receiving a special training permit that authorizes them to capture and mark birds only under the supervision of an experienced ringer (Box 3).

### **Box 3. Case study: British Trust of Ornithology (BTO)**

The BTO issues ringing permits based on a graduated licensing system to ensure that only highly skilled and trained individuals conduct bird ringing activities. The level of technical expertise of ringers is evaluated using a standard method. Field skills are acquired through training under experienced ringers and progress is assessed by independent ringers. This system for issuing permits based on acquired expertise helps the bird marking program to maintain high scientific and ethical standards in bird ringing by controlling and managing skill level and compliance.

The four most important levels are:

T - Trainee, must ring with and be answerable to a Trainer

C - Can ring alone, but still answerable to a Trainer

A - Independent ringer

S - Trainer

The system has recently been revised to have specific endorsements for particular species groups / catching methods based on relative risk within these broad levels.

In jurisdictions that do not have specific regulations related to capturing and marking birds, we recommend that the bird marking program issue documents equivalent to a permit that clearly indicate the terms and conditions under which ringers can participate in the program.

## Applying for a permit

There should be an application process for ringers to apply for a permit. Application forms should allow the applicant to describe their training and experience and enable the applicants to attest that they are aware of applicable laws and policies and will follow them (see Box 4 for an example). Applications should be signed by the applicant or use an appropriate electronic equivalent if the application process is online.

Application materials should clearly indicate expectations with respect to the amount of training and experience required to obtain a permit; codes of scientific and ethical conduct that need to be followed; and the data reporting requirements.

Applicants should be made aware that the ringing permit may be only one of many authorisations required for a project. For example, they may also require a separate research permit or wildlife permit as described above. They may require special permits to work with particular species (e.g., species at risk), as well as permits to work in particular areas such as parks or other protected areas. They may also require separate permits to collect biological material (e.g., feathers or blood samples) if those are not authorised through the ringing permit. Although not a permit, they should also ensure that they have permission to work on private land.

#### **Box 4. Case study of the Canadian Bird Banding Office (BBO)**

When a researcher applies for a permit to capture and ring birds in Canada, they are required to fill in a permit application form. The application form and supplementary materials need to provide sufficient details to allow a permit decision to be made. The BBO evaluates the level of technical expertise of the applicant by considering:

- Two reports on applicant qualifications provided by a trainer who has worked and assessed the applicant's skill level and abilities to safely capture and ring birds.
- Specific details about the ringing qualifications of the applicant provided in the application form, including:
  - Current or previous permits and authorisations held (Canadian, US or other countries);
  - Ringing courses taken;
  - Names of the trainers who trained them;
  - Level and year of certification obtained;
  - List of observatories or research projects where the applicant gained experience
  - Hours of ringing experience;
  - Experience with various capture methods (trap types), handling and marking birds (standard rings and/or other markers);
  - Numbers of target species and individuals ringed to date by the applicant
  - Number of birds extracted from mist nets or other relevant trap types;
  - Seasons in which they have ringed;
  - Experience with other activities applied for, such as biological sample collection, attaching tracking devices, etc.;
- Animal Care Approval from an animal welfare and ethics committee for the proposed project (if applicable).

## Criteria for evaluating applications for permits

- 1) **Core criteria** evaluate the ringers' qualifications through demonstrated competence in and knowledge about:
  - a) bird identification;
  - b) standard capture, handling, and marking methods (e.g., extraction from nets and traps, applying or removing rings, using appropriate physical restraints, etc.);
  - c) appropriate euthanasia techniques in case of an emergency; and
  - d) accurate data collection (e.g., age, sex, wing length, moult, fat scores, etc.).

Qualifications may be assessed via:

- application form with specific questions related to education, training and experience;
- standardised exams (administered by the bird-marking program or another group); or
- testimonials or letters of reference from permitted ringers/trainers attesting to the skill level of the applicant.

- 2) **Optional criteria** evaluate the scientific integrity of specific projects, in particular they:
  - a) justify the need to mark birds to obtain sound scientific results;
  - b) identify target and non-target species that may be captured;
  - c) use the least invasive practical procedures possible, while maximising the data obtained;
  - d) minimise disturbance to animals and their habitat; and
  - e) minimize impacts on individuals and prevent detrimental effects on the population.

Scientific and ethical integrity of projects may also be demonstrated by having:

- clear objectives and clear hypotheses to be tested;
- study design and methods suitable to achieve the objectives;
- thorough literature review to assess the relevance of the study and acknowledge previously used methods and existing protocols; and
- ethical review of project protocols by an animal care committee.

## Permit authorisations

Permits can generally include a variety of different authorisations, terms and conditions. As a minimum, these should include:

- authorisations indicating which species, capture methods and types of markers may be used on each species;
- an indication of any restrictions in geographic areas where the permit is valid;
- conditions related to codes of scientific and ethical conduct;
- conditions related to data reporting requirements; and
- expiry dates and renewal requirements.

In general, permit conditions personalised to the ringer's expertise and project are most effective in terms of managing skill level and compliance.

Some ringing permits can authorise biological collections, such as blood sampling, collection of feathers, nails, etc. In some countries these activities may require a separate wildlife research permit. Whether or not they are authorised through separate permits, we strongly recommend that the ringing database track any additional activities associated with the bird, as these could affect the subsequent behaviour and capture probabilities of the bird. Tracking such information can also be used to evaluate the safety of these activities.

Some permits also allow for the collection of birds found dead or that die as a result of ringing operations. These specimens should be donated to persons or organisations with a permit to use dead birds in a scientific capacity or educational capacity e.g., maintain a collection, educational training, use for genetic, contaminant or other tissue analysis.

### *Examples of authorisations for ringing permits*

Permits typically specify exactly what species, activities and techniques are being authorised by the permit. For example, a permit may specify:

- particular species or species groups (e.g., passerines, waders, or waterfowl), which may include species at risk (some of which may require a separate permit depending on the relevant legislation);

- capture methods (traps, mist nets, cannon, rocket or pneumatic nets and net guns, hand capture, ringing nestlings, etc.). These would normally be limited based on the experience and requirements of the ringer;
- auxiliary markers (colour rings, neck collars, patagial tags, paint/dye, nasal saddles, nape tags, radio, satellite transmitters, PIT tags, geolocators and other data loggers, etc.). These normally would only be authorised for the particular species the ringer wants to study, and with particular codes or combinations, all of which should be specified on the permit;
- location of activities;
- types of biological materials that can be collected (blood, feathers, nails, etc.); other authorisations (e.g., working in colonies).

### **Permit conditions**

Whereas ringing permits authorise individuals to conduct specific bird-marking activities that are otherwise prohibited, permit conditions impose limits or restrictions on them. Whether they are standard to all ringing projects or specific to certain activities, conditions on ringing permits should be in place to ensure that the authorised activities do not adversely affect avian populations or individuals to a significant degree.

### ***Examples of general conditions that may be relevant to a ringing permit***

- Unless otherwise authorized, permit is not valid in protected areas.
- Unless otherwise stated, permit does not authorize activities involving threatened species.
- Permit is not transferable and only valid for the person to whom it was issued.
- Permit may be cancelled at any time if the permit holder has failed to comply with any of the conditions set out in the permit.
- Permit holder must abide by all relevant regulations (federal, regional, municipal, etc.) that apply to the study area and the study species;
- Permit holder must carry a copy of their permit at all times while conducting authorised activities or while in possession of samples;
- Permit holders must show a copy of their permit on request to regulating authorities;

- Permit holders must keep a detailed written record of all activities conducted under their permit; and
- Permit holders must submit a written report of all activities conducted under their permit, as directed by the permit-issuing authority (e.g., submission of all ringing and encounter data).

*Examples of types of specific conditions that could be included if relevant*

- Permit holder may collect blood volume of less than 1% of body weight per bird;
- Permit holder may collect no more than 2 tail feathers per bird;

Scientific journals play a role in ensuring that data are collected under permits and these permits should be listed in the acknowledgements of the published articles. This can help to ensure that data are collected and used to a high scientific standard.

## 4. Program Operations: Markers

### 4.1. Issuing and management of markers

#### Ring design and materials

In most situations, each bird should be marked with a uniquely numbered metal ring placed on the leg, even if additional auxiliary markers are proposed, such as radio- or satellite tags, or field readable colour leg, wing or neck tags. This is particularly important if the auxiliary marker is designed to detach from the bird after a period of time or is not uniquely identified, to ensure that the individual bird can be recognised again. Exceptions are species for which leg bands are not suitable. In this case, an alternative permanent uniquely numbered tag should be used.

Rings of particular bird-marking programs are generally made of metal, though there are some exceptions (e.g., black octagonal [ELSA](#) rings for white storks). Rings come in various shapes, sizes, and types and provide a unique and ideally, permanent identification for each marked individual. They are generally around 0.01% of a bird's body weight and therefore do not significantly affect the behaviour or survival of the bird, provided they are fitted correctly. Critical information on bird rings are 1) a unique code and 2) an address to report.

#### *Unique coding system*

There are many ring coding systems in use throughout the world. The North American program uses a system of a three-to-four digit prefix followed by a five-digit suffix, providing a unique number for each ring. All rings with the same prefix are the same size, with the final digit giving an indication of the ring size. Similarly, the Australian Bird and Bat Banding Scheme ([ABBBS](#)) rings have a three-digit prefix, which indicates ring size and series followed by a five-digit sequential number. The use of a prefix in the ring number allows for identification of the ring size and maximises the number of rings produced within a series. On the smallest rings, the prefix can be stamped above the suffix to allow for more space. Maximising the number of code combinations is more important for larger programs compared to smaller programs. Rings from some programs use a combination of letters and numbers, increasing the possible number of rings for a given number of characters. Schemes should avoid the use of letters that could be confused with numbers (e.g., I and 1 or O and 0).

It is beneficial for emerging programs to develop a coding system that allows for program expansion, does not duplicate numbers, and is compatible with other programs within a network or flyway. This will facilitate data sharing for encounters and recoveries throughout species ranges. When deciding on a coding system, keep in mind that there are limits to the amount of information and characters that can be put on the bird ring, in particular for small sizes, as the characters need to be large enough to read. Some bird-marking programs provide additional information, instructions or multiple reporting methods on larger rings. It is best to consult with the manufacturer to ensure that there is room on the ring for the necessary information. Even on the smallest ring sizes there is generally enough room for two lines of text. In North America, additional information, such as the reporting address, is stamped on the inside of the ring. However, this may reduce public reporting rates, as people who find a ring may not open it.

### *Reporting address*

Besides the ring number, the other critical information required on the ring is a (web) address or agency to report the recovery. Inscriptions on rings are very important, as they can influence ring reporting rates from members of the public. The inscription is also important to identify which scheme produced the ring. For simplicity and clarity, it is advisable to limit information and keep the reporting address as simple as possible, while making sure that the report will reach the right address.

Historically, bird-marking programs would include a mailing address or agency name on the ring. In most cases, the mailing address was highly abbreviated which may sometimes affect delivery of letters. Some rings contain only the name of the agency, for instance, some Australian rings were inscribed: "Write Wildlife CSIRO Canberra Australia." In North America, some rings included a toll-free telephone number. However, that required having adequate personnel to either answer the calls or respond to messages, as many finders left incomplete information on the message.

We recommend that all schemes aim to include a concise website address for ring reporting. Not only are web addresses recognised throughout the world, but also the finder can access the website to report anywhere in the world and rings can often be reported as soon as they are found, using a smart phone. Providing a web address that is instructive clues the finder to report the ring and can increase the chances that rings are reported by members of the public. Examples of this are [www.reportband.gov](http://www.reportband.gov) (North American Bird Banding Program), [www.ring.ac](http://www.ring.ac) (Europe). A well-designed webpage will

direct the finder to report all of the required information related to the date, location and circumstances of finding the ring as well as the contact information of the finder. If the reporting page is linked to the underlying database, in many cases immediate and direct feedback can be provided to the reporting person regarding the history of the particular bird they found, and highlighting the importance of their report for contributing to bird conservation and science. Whenever possible, the reporting page should be made available in multiple languages to match those most widely used in the countries where most rings are expected to be reported. Smaller schemes with limited resources to develop their own reporting page could explore collaborating with other schemes in the same flyway.

### Ring types

Bird rings may be manufactured in a variety of metals for use on different bird species with different behaviours that occupy a variety of habitat types. The most common types of metals used are: aluminium (spelled aluminum in North America), stainless steel, monel (nickel-copper alloy), incoloy (nickel-chromium alloy), and magnesium-aluminium alloy. Aluminium and magnesium-aluminium alloy rings are softer metal rings, easy to apply and cost less to produce. They are most appropriate to use on smaller species that do not necessarily have a long lifespan and where there is limited ring wear from contact with the body of the bird or the environment. Corrosion of aluminium rings has been considered a factor in ring loss and this occurs faster in saltwater compared to freshwater. Harder metal rings are incoloy, monel or stainless steel and these are more resistant to wear, abrasion, discolouration and thus last longer, although monel rings are somewhat prone to corrosion due to faecal excretions. Ideally, the bands should endure for the maximum expected lifetime of the bird. As a result, hard metal rings are generally recommended for longer-lived species, species that frequent marine or other potentially corrosive or abrasive environments and any species that have a particular behaviour, such as biting that may damage aluminium rings. Although these rings are more expensive to produce and more difficult to apply, their use reduces ring loss in many species (which can severely bias demographic studies) and are more cost-efficient for generating recoveries and critical long-term datasets.

A ringing centre should consider that changing ring design or type or even the reporting address could influence long-term recovery data for that species. The potential benefits (e.g., greater longevity of the ring or increased reporting rates) must be considered in

relation to impacts on long-term studies. Researchers using ringing data should ensure that any changes in ring type are dealt with statistically in analyses.

Depending on the manufacturer, rings can be supplied pre-opened on plastic tubing or closed and needing to be opened before attachment to the bird. The most common type of ring is butt-ended. This is a standard design, where the ring can be gently pulled open (if not pre-opened) and then closed using ringing pliers, so that the two sides come together snugly forming a seam (Figure 2). Butt-end rings are generally available in all metal compositions. Various other ring types have been developed over time to accommodate specific needs. The most common of these are [lock-on](#) rings and [rivet](#) rings. These ring types are available in aluminium alloys for use on larger bird species, such as raptors. Lock-on rings have a small flange that sticks out from the ring and must be crimped into place with pliers, whereas rivet rings require a rivet to secure the ring closed using a pop-rivet tool. Both of these ring types provide extra assurance that rings are not removed by the bird wearing it. Some programs do not offer lock-on or rivet rings and recommend the use of harder stainless steel or incoloy rings instead. For examples of closed butt-end federal bird rings, see [here](#) and for split ring sizes, [here](#).

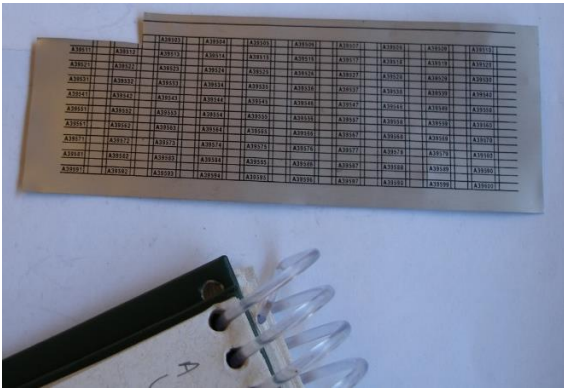


**Figure 2.** Butt-end rings often come closed and the ringer has to open them before placing them on a bird's leg © Judit Szabo

### *Specialty rings*

Specialty rings have been developed for specific species. Hummingbird legs are very short and narrow, requiring extremely small rings. In North America, these come on sheets that have to be cut and shaped by the ringer (Figure 3A). Triangular rings have been developed for use on murre species that have a triangular-shaped tarsus (Figure 3B). Their behaviour of sitting on their legs on rocky ledges causes the information to get scratched off a round ring in a short time. The design of the triangular ring has the added advantage of being readable in the field with binoculars or a spotting scope. Cormorants, grebes and other waterbirds and seabirds may require a more oval-shaped ring to accommodate tarsus shape and minimise risk of injury and also to reduce wear to the ring. Oval rings can be formed from a standard butt-end ring (skill and additional handling

time is required) or can be specially ordered. Other taxa, such as kingfishers and some owls have very short tarsi and so require narrower rings to reduce the risk of injury. Parrots usually require hard stainless-steel rings.



**A.**



**B.**

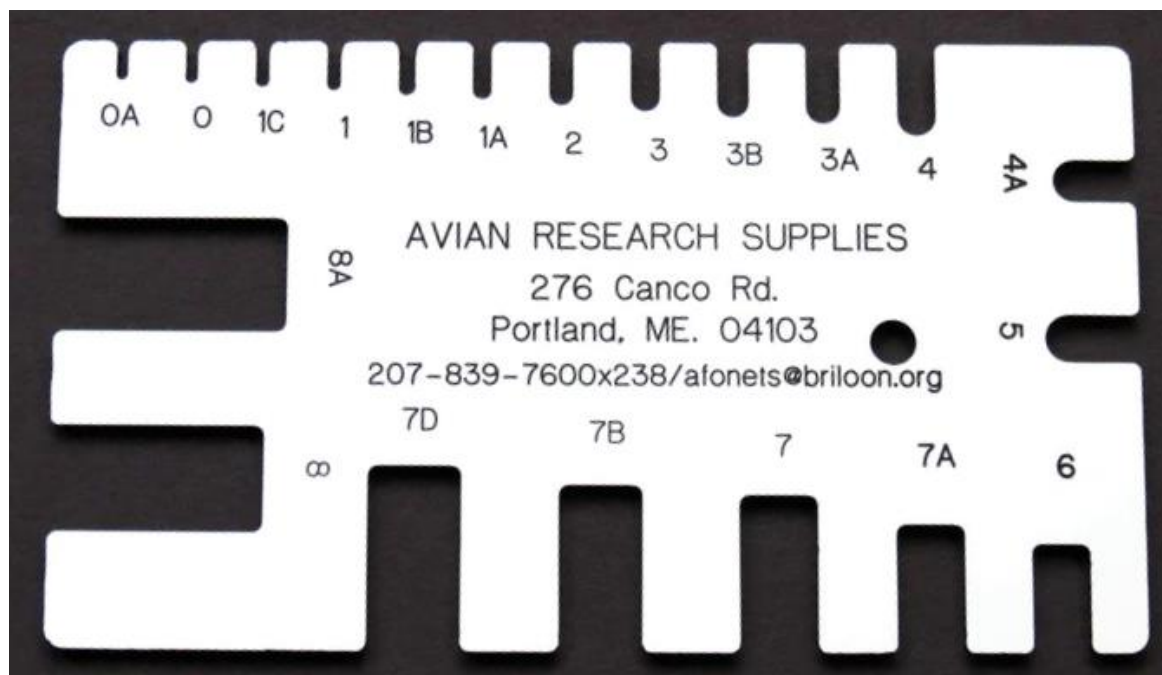
**Figure 3A.** Hummingbird rings sometimes are provided flat and uncut as part of an aluminium sheet. The ringer must carefully cut out each tiny ring using precision tools and form it into shape using pliers. Note that these rings are so small that there is no other information provided besides the ring number © Judit Szabo. **B.** Triangular rings are for use on murre species that have a triangular-shaped tarsus. The design allows these bands to be read from a distance usually when the birds are in the colony © Chantal Marier.

Rings designed to be placed on ducklings are filled with clay that wears away as the young bird ages, allowing ducklings to be ringed at an early age with the adult size ring, when they are too small for the ring to stay on their foot. Proper training and precautions are required to ensure that the clay used will erode slowly so that the ring does not fall off while the bird is small, but also so it does not solidify and injure the bird when it grows.

### Ring sizes

Bird rings come in a variety of internal diameters (from approximately 1.27 mm to over 28.0 mm) and heights to accommodate the various species in the bird-marking program. While some ring sizes may need to be especially developed to accommodate certain species, many bird ring manufacturers produce several standard sizes that are suitable

for use on a wide variety of species. Emerging bird-marking programs may consult with manufacturers or other network programs and adopt standard ring sizes. Bird-marking programs should provide a list of recommended ring sizes and types for use on each species, even if acknowledging uncertainty around the most appropriate size for a few rarely caught species. The list of recommended ring sizes and types should be developed based on the size and shape of the tarsus (or for some species the tibia), as well as the habitat and behaviour of the bird. It is important to understand that there is a certain amount of individual and population-level variation in the size of the birds. Ringers should fit the most appropriate ring size to the individual, even if it is not the recommended size for the species. This will reduce the risk of injury to the bird and help to modify recommendations as appropriate. For well-established bird banding schemes this should be very rare and would require written justification. Ringers working in areas or with species that have not been frequently studied should use a leg gauge to verify the required size (Figure 4).



**Figure 4.** A leg gauge can be used to measure the diameter of the tarsus of birds to decide which size ring fits best. © Avian Research Supplies

## *Obtaining rings*

There are several potential models for providing rings to ringers:

1. rings are provided to ringers free of charge by the bird-marking program;
2. ringers pay the bird-marking program for the rings they order and use;
3. ringers purchase rings from the manufacturer for their own use, based on series numbers approved by the ringing scheme; and
4. mixed system.

## *Program-supplied rings*

This model is most often run by governments that have mandated responsibilities for managing bird populations. Program funds are used to purchase rings generally with bulk order discounts.

Programs should:

- carefully manage the ring numbering system to ensure that there is no duplication of numbers;
- have one or more suppliers that can meet all ring needs (sizes and types);
- maintain an in-stock inventory of all ring sizes and types available to ringers and avoid shortages that could negatively affect ongoing ringing projects;
- manage a database of ring inventory including in-house inventory, rings sent to ringers, but not yet put on birds, rings on birds, and rings lost or destroyed;
- maintain relatively tight control on ring inventories kept by ringers to ensure that rings are properly managed and not lost, hoarded or wasted by ringers. This can be linked to the permit renewal process; and
- balance ring quality with the available funding.

Ringers submit their requests for rings to the program administrator, who will verify that the ringer is authorised to ring the species and ensure that appropriate ring sizes and types will be used. Programs will want to ensure that ringers order only the number of rings they intend to use for their projects and that ring numbers are produced and used in an efficient way that is economical to the program. Once verified, the order is processed and shipped to the ringer at the expense of the program or ringers themselves.

### *Rings purchased from program administrators*

The structure of this model is similar to the program-purchased model in that ring inventories are developed and managed by the program administrators. The two models differ in that here, unlike in the previous model, ringers pay the program for the rings they receive. Because rings are purchased by the program, high ring quality is maintained, while bulk ordering allows for discounted pricing. Some bird-marking programs may include a contribution towards the costs of administration, inventory maintenance and general operational costs of the program in their ring prices.

### *Rings purchased from the manufacturer*

In countries where bird-marking programs are not well established or have limited capacity, it may be up to the ringer to purchase the rings that are required for a project directly from the manufacturer. While this is less than ideal, in some cases it may be the only option. In some cases, it may be possible for ringers to purchase or otherwise obtain rings through an existing scheme in another country using that country's numbering system. Otherwise, the major challenge is ensuring that the numbering system does not result in duplicate ring numbers for different ringers within a region or with other schemes that may have birds migrating through the region. The best way to manage this is to have a central ringing office that issues the ring numbers to the ringer before they order rings, along with other specification criteria such as the appropriate contact information (e.g., web reporting address). It would also be possible for ringers to develop their own numbering system and include their own contact information on the ring. The limits of this model are that ring numbering is generally not coordinated with others, the longevity and sustainability of the project or program may be limited, and data are not shared or archived in a central database, which increases potential data loss. Costs are the responsibility of the ringer who may not qualify for discounts of bulk orders. It can be challenging for individuals working with a diverse community of bird species to maintain adequate inventories of all required ring sizes and types.

### *Mixed system*

The British Trust for Ornithology and other large bird-marking programs offer a mixed system, where rings issued for specific monitoring programs or coordinated projects are offered to ringers at no cost, while rings required for independent projects run by the ringers themselves need to be purchased from the program. Also, some schemes may

provide ringers with standard rings free of charge, but ringers may be responsible for ordering their own specialty rings.

## Quality control

The quality of the rings can affect whether the ring lasts for the lifespan of the bird, and whether the numbers are readable to anybody encountering the bird, which can affect reporting probability and accuracy. The quality of the ring will depend on the metal used and the inscription method. Numbers and contact information need to be clear and legible using appropriate fonts that can still be read even if slightly worn. Stamping numbers and contact information into the metal increases the chances that, if there is surface wear, the information can still be read. For example, if one or more digits have been worn off the outside of a band, the number can often be read if the band is removed from the bird and etched using acid to highlight the areas that had been compressed during stamping. In contrast, if numbers are etched into the band using a laser they cannot be retrieved once they are worn off. Numbers must not be repeated between rings, and rings should be packed in sequential order to minimize risks of errors in recording. Rings need to be inspected before issuance (by the manufacturer and the ringing scheme) and before putting on the bird (by the ringer) to ensure that the number is correct, that there are no sharp edges, faults in the material of the ring that would make it prone to breaking off, or other anomalies that could injure the bird. In particular, when used on long-lived species, rings should outlast the bird and remain readable sometimes for decades in saltwater or other harsh habitats.

## 4.2. Use and coordination of auxiliary markers

### Overview

Metal rings used in bird-marking programs are generally considered to be the unique identifier for a marked bird and the basis for tracking all data associated with the bird. However, many researchers also use additional “auxiliary” markers to facilitate identification and/or additional data collection in the field, in most cases without the need to recapture the bird. There are many considerations for choosing an appropriate type of marker for a particular study species and project. These may include:

- study design and objectives;
- invasiveness of the technique and safety of the birds;

- species biology, ecology and behaviour;
- the length of research and the need for temporary or more permanent marking; and
- the need to coordinate with other studies regionally, nationally or internationally.

While not all bird-marking programs consider the administration and coordination of auxiliary markers a core function, it is highly recommended that this important aspect of bird-marking is managed and coordinated by the program. This will help to ensure that markers are used appropriately and conservatively, i.e., minimising the effects to individual birds and ensuring that the number of colours and codes available for use by others is maximised. Many types of visual markers also require regional, national or, in the case of long-distance migrants, international coordination to ensure that marker codes assigned to new projects do not overlap with those used by existing projects. If individuals within a species are marked with the same or similar markers by different studies, it can be difficult or impossible to distinguish them in the field, compromising the results of both studies. Being part of a ringing network of programs can facilitate the coordination responsibility (see section on the [Importance of coordination](#)).

Program administrators should assess projects and evaluate if auxiliary markers are required to meet the objectives of the study. If visual markers are being used, it is particularly important to ensure that there is a good plan for resighting the birds that is sufficient to meet study objectives. For some types of studies (e.g., demographic or behavioural studies) this may require dedicated effort by the research team at or near the study site, while for long-distance movements this may involve outreach to the birding public. If there is minimal chance that birds will be seen again, then use of auxiliary markers may not be justified.

For selection of the most appropriate marker for the study, the purpose of the study must be clear, and the selected marker should persist for the duration of the study. Markers must not impede movement, hinder or irritate the bird. They should also have a negligible impact on reproductive success, social interactions, longevity, migration, and vulnerability to predation (e.g., not compromise the bird's camouflage). Marker use must consider seasonal changes in the bird's plumage or behaviour and growth of the bird, if applied to young birds before they are fully grown. Markers should not cause pain and should minimise the risk of infection and tissue damage. Markers must not interfere with social signals or compromise waterproofing and must be non-toxic. Any marking codes (digits

or colours) should be readily visible and distinguishable and persist until the research objectives have been fulfilled.

To ensure that markers are used appropriately and are placed on birds in a safe and ethical manner, markers should only be applied by highly skilled and experienced ringers and in studies that are scientifically justified. Pilot studies are recommended if marking techniques are being used for the first time on a species to ensure that the marker is appropriate for use on that particular species. Markers can be designed to fall off after a limited time, if they are only needed for a short-term study, or they can persist for the lifetime of the bird. Investigators should be encouraged to report back to the program coordinators and publish their results showing the effectiveness of the marker type or design, including any negative impacts, so that this can be taken into account for future applications.

It is important that researchers do not add, remove or exchange existing markers on recaptured birds from other projects without prior agreement, unless a marker is causing injury to the bird. Tampering with existing markers can cause interference with other studies, affecting the data, results, and efforts of other researchers.

Markers may require regional, national or international coordination to prevent overlap of use. The level of coordination to make markers unique will depend on the species and the project. Investigating social interactions on the breeding territory of a resident species may only require local coordination. In this case, the same marker combinations can be used for different projects, provided the birds will not move among the study areas. If the project is studying a migratory species, particularly if the aim of the project is to determine stopover, moulting or wintering sites of long-distance migrants, international coordination is necessary. Internet tools can facilitate coordination of marker use and encounter reporting (e.g., <https://www.eaaflyway.net/coordination-of-colour-marking>). Species-appropriate markers and attachment methods are very important, considering the risk of injury and wellbeing of the individual, as well as marker loss. A guidance document should be developed for marker use, including international standards.

## Types of auxiliary markers

The two types of auxiliary markers are:

1. visual markers including colour rings, flags, patagial (wing) tags, nasal markers, paint or dye etc. and
2. electronic markers, such as radio tags, satellite transmitters, PIT tags, data loggers, etc.

### *Visual Markers*

Visual markers provide a specialised, cost-effective scientific tool, useful for many types of behavioural or connectivity studies. They allow the identification of individuals or cohorts with minimal disturbance and without the need to recapture birds. Visual markers may be coded through combinations of different colour markers or may be engraved with unique field readable numbers. In many cases, every individual in a study is uniquely marked, but in some cases age or location cohorts are identified with the same code. Generally, markers should be designed to be readable in the field with binoculars or a spotting scope, though increasingly, researchers and public are using digital cameras with a telephoto lens to document birds with markers. Photographs have the advantage that combinations can be verified after the fact, reducing the risk of errors, though care must be taken to use an appropriate white balance to avoid mixing up colours. Visual auxiliary markers include engraved (coded) or plain coloured rings, flags (Figure 5A), neck collars (Figure 5B), patagial markers, nasal saddles, paint or dye. It is advisable to limit the use of characters that may be easily confused with other letters or numbers.

Temporary markers, such as paint and dye are among the least invasive marker types. They may fade over time or disappear as feathers are replaced during moult. Mass-marking of birds in roosting or nesting colonies using aerial and ground spraying with fluorescent markers has been done. Examples of temporary paint or dye markers include felt-tip markers, lacquers, commercial hair bleaches, colouring dyes, tattoo inks, Rhodamine B, and Malachite Green. Picric Acid has been used extensively in the past as a cohort marker, however it does pose an explosion risk, so instructions for use should be followed carefully.

Applying colour rings is one of the most common methods of individually marking birds. Unique colour combinations of rings applied to birds' legs can identify individuals without

the need to recapture. While several colour rings can be put on the legs of most bird species, the maximum number of rings is limited by the length and thickness of the tarsus (and in some species, the tibia). Thus, colour rings are not appropriate for all species or all studies. For example, birds with short tarsi may only take one ring per leg and birds that have feathered tarsi (some raptors), that sit on their legs (e.g., swallows) or have their legs in the water much of the time (e.g., phalaropes) may not display the colour rings for easy identification. Some species have very thin and delicate tarsi and should not be fitted with additional rings/flags.

While most colour rings are made of UV resistant materials in a variety of colours, they can break, get lost, fade or get discolouration from water/mud over time. Depending on the duration of the study, fading or discoloration can make colours unrecognisable or confused with others. In some species, certain colours, especially those similar to plumage or soft parts involved in social signalling, may affect mate attractiveness, dominance status, or aggression, so knowledge of the study species is critical.

Coded markers can be applied to the neck, legs or wings depending on the species and availability of marker types. In all cases, colours and codes must be easy to read from a distance with binoculars or a spotting scope or a digital camera. It is critical that a clear font is used for the code. Program administrators and ringers should be mindful that some letters and numbers are difficult to distinguish in the field. Avoiding characters and digits that can be confused from a distance by using a set of 25 sans-serif characters (15 letters **(A C E H J K L M N P T U V X Y)** and 10 numbers **(1 2 3 4 5 6 7 8 9 0)** increases the reliability of resightings by minimising the risk of confusing digits in the field. Some ringers may also decide to use optional symbols such as: **+ = @ %**. The selected characters should be unlikely to be confused with any of the 29 standard characters but may confuse members of the public reporting markers if they are not expecting the additional codes.

The US Geological Survey Bird Banding Laboratory (BBL) [website](#) provides some additional recommendations for the use of coded markers:

- Always use unique code combinations for individuals of a given species, e.g., by not using the same code for males and females and not using the same code on opposite legs to differentiate between two individuals.
- Always use a consistent number of characters. For example, if you need two hundred unique combinations, use three-digit codes for all combinations, 000-199, not 0-199.

- When choosing codes, it is helpful to have sets of 100 that start with the number 0 and end with 9, for example using 00-99 for a hundred combinations rather than 001-100.
- When using only alpha codes, to add more combinations change the first letter in the combination and keep the same codes in the 2nd, 3rd etc. positions, for example use AAA, BAA, CAA, as opposed to AAA, AAB, AAC.

Projects should also consider the level of effort required for resighting and a protocol for resighting should be in place. If insufficient effort is put into resighting, the use of colour markers may not be justified.



A.



B.

**Figure 5A.** Western Sandpiper (*Calidris mauri*) with yellow leg flag © Eveling Tavera Fernández **B.** Canada Goose (*Branta canadensis*) with a neck collar © Guy Marcotte

### *Electronic markers*

The use of VHF radio, cellular network, satellite and data loggers (i.e., devices programmed to record and store data) (Figure 6) for tracking bird movements has gained popularity in recent years. Program administrators should have a role in reviewing and approving the use of electronic markers and other novel technologies to ensure they are

appropriate for the species being studied and that an appropriate data management plan is in place. The size and weight of the markers and the attachment mechanisms must be appropriate for the size of the bird and its ecology. For example, tags placed on species that spend a lot of time flying (e.g., aerial insectivores) must be sufficiently streamlined within the feathers to avoid causing drag and affecting their survival. A plan must also be in place to ensure that radio transmitters used in the same geographic area do not overlap in frequency or code set with those used by other researchers (including researchers who may be tagging taxa other than birds). In some cases, companies selling devices may be able to share information on other projects in the same geographic area using similar tags. In other cases, such as the Motus Wildlife Tracking Network, or satellite transmitters, tags must be registered with the network before use, allowing for coordination.

Many data loggers collect and store data but must be retrieved to obtain the information. Their use should only be approved if there is a good plan to recapture the birds at an appropriate time after tagging (which may vary from a few days to the following year, depending on the type of tag and study objectives). If using a new technology on a species that has not been previously studied, it is advisable to also ring a control sample without auxiliary tags to evaluate potential impacts of the technology on return or recapture probabilities.

Studies using novel technologies potentially provide much more data than traditional ringing programs. These should be stored in collaborative databases where they can be made available for use and analysis by other researchers, in a similar manner to the original ringing and recovery data. However, storing and managing data from automated tracking systems requires specialized data structures that most marking programs do not have the capacity or resources to develop. As an alternative, schemes should encourage or require ringers to submit their data to established international data repositories such as [Movebank](#). Ringers should be given guidance on the appropriate permissions they should assign the data. For example, within Movebank, ringers could be required to make the data fully openly available within a certain time period (e.g., 2 or 5 years) or as soon as they have published a paper on their results. It is also recommended that the administrator of the ringing program be given full access to all data contributed by participants in the program, so that they can help ensure the data eventually be made public.



**A.**



**B.**

**Figure 6A.** Snowy Owl (*Bubo scandiacus*) with a satellite tag © Charlotte England. **B.** American Tree Sparrow (*Spizelloides arborea*) with a nanotag as part of the MOTUS network. © Lesley Howes

### The importance of coordination

Program administrators should approve use of any auxiliary markers on ringing permits, and ensure that their use is well coordinated and the data well managed, as described above. This may require regional, national, or international coordination to prevent overlap of use. Investigating social interactions on breeding territory may only require local coordination and the same marker combinations can be used on the same species for projects in different areas, whereas movement studies of long-distance migrants require international coordination with unique markers on each individual.

Collaboration among large international networks, such as [EURING](#) (Europe), the now inactive WHBBN (Americas), [AFRING](#) (Africa), and [EAAFP](#) (East Asia-Australasia) can play an important role by developing efficient data management and analysis tools to help with coordinating the use of auxiliary markers. This can help to avoid overlap at the international scale, while providing a platform for regions to work together in analysing data collected across very large geographic areas. Coordination may be arranged

separately for different species groups; in some cases, coordination may be delegated to researchers or volunteers working with particular species groups.

Coordination of auxiliary markers has many benefits:

- promoting best practices in marking to minimise risks to birds;
- standardising marking protocols for long distance migrants that may be marked or resighted by public or other research teams (e.g., shorebirds, geese, cranes and other large migratory birds);
- facilitating coordination and reporting of field resighting to ensure data are stored and reported back to the researcher;
- promoting high standards of data quality, including enhancing reliability of resighting data throughout a species range;
- elevating the scientific integrity of results;
- promoting collaboration;
- ensuring uniqueness of individual markers;
- maximising the use of marker colours and codes, while allowing room for new researchers to participate; and
- adding credibility to projects and associated conservation activities.

### **Capture equipment and other ringing tools**

Ringing programs should provide information to ringers on the types of equipment required to safely capture and ring birds and collect the necessary information. While some bird-marking programs give or lend ringing equipment or kits to ringers or program participants, in most schemes, individual ringers or teams of ringers are responsible for acquiring their own ringing equipment or kit. Ringing kits and equipment required will vary depending on the species being studied and the types of markers being applied (Figure 7). Equipment required may include nets, traps, holding bags or boxes, pliers, wing rules, scales, and optical equipment for reading bands.

Some bird-marking programs sell ringing equipment to program participants. Pliers and other equipment may be specific for use on ring sizes or designs supplied by the program. Selling equipment may provide bird-marking programs with additional revenues to help

offset the costs of running the program and can help ensure ringers have appropriate equipment. There are several suppliers of ringing equipment throughout the world. Many require proof of permits, licences or a demonstration that the ringer can use the equipment safely.



**Figure 7.** A field ringing station in operation. Here the ringer is weighing a hummingbird on an electric scale. Near the hand of the ringer are a ringing plier with red handles, two black ring openers, and a dial calliper. The four plastic containers in front of the ringer contain different sized rings each on a string. © Judit Szabo

## 5. Program Operations: Data Management

### 5.1. Data collection and data quality

The three main types of data that ringing centres should be prepared to manage are:

1. first-capture data by ringers (including biometrics);
2. recaptures by ringers (of their own birds or of birds ringed by others); and
3. encounters from the public.

When catching and handling a bird, ringers have the opportunity to collect different types of data associated with the bird:

- trapping information (e.g., net or trap number or location);
- sex and age;
- morphometrics (size and structure of the individual bird);
- details of plumage and morphology (e.g., plumage colour and features, wing shape);
- moult patterns;
- breeding condition;
- physical condition (e.g., fat and muscle scores).

This information can potentially be used to analyse a variety of topics related to the initial capture, such as:

- movement phenology (e.g., timing of migration) and how it varies over time;
- habitat selection and use (e.g., through analysing location of capture in relation to the location of other traps or nets);
- habitat suitability (e.g., by analysing the physical condition of birds in different habitats);
- breeding phenology (e.g., by looking at seasonality of brood patch and cloacal protuberance and appearance of young birds);
- moult phenology (timing and duration of moult within and among species).

Such information can also be valuable for analysing data associated with subsequent recaptures or recoveries, such as analysing whether birds in different body condition have different migration patterns or survival probabilities.

Marking programs should ask ringers to submit as a minimum, the following information associated with each individual capture for storage in a central database:

- ring number;
- date (and optionally time of capture);
- species;
- age and sex;
- precise location (latitude and longitude);
- permit number of the ringer, which is associated with the ringer's contact information.
- Relevant auxiliary marker information which could include:
  - type (e.g., flag, colour ring, geocator, radio-tag, etc.);
  - colour combinations (flags and rings);
  - alpha-numeric code (on flag or ring).

Additional information that could also be stored and managed centrally include:

- standard biometrics (wing chord, body mass, etc.);
- additional biometrics (tarsus, culmen, tail, etc.);
- fat scores or muscle scores;
- moult information.

To improve the potential for data to be analysed from a large number of observers and geographical areas, program administrators should promote data standardisation, implement approaches to assure the quality of the data and validate that the measurements collected by ringers are:

- accurate;
- precise;
- repeatable; and
- standardised.

Whenever possible, program administrators should work with ringers to promote high data quality and reduce errors. Ensuring high data quality is essential to scientific integrity and to have confidence in the resulting conservation or management decisions or activities. High data quality requires both **error prevention** and **error correction**, both of which are crucial to maintain the integrity of the ringing database.

Error prevention is always more efficient than error correction. It requires that ringers be appropriately trained to collect data following the standards and transcribe data correctly into the database. Data should be as accurate and precise as can be determined. For example, the age should not be recorded as unknown, if the bird was known to be a breeding adult of at least one year old (even if the exact age is not known).

Data quality control checks should be implemented into data entry programs, so that potential errors or unusual codes are flagged immediately to the ringer. This increases their ability to detect and correct errors before they enter the database. Checks should include ensuring that the codes used are valid, as well as checking for inconsistencies among codes. For example, if a bird was sexed using CP/BP then the age should be coded as an adult (using the appropriate coding scheme). Similarly, geographic coordinates can be checked against the province or state where the ringing took place. Species codes can also be checked against the time of year and geographic location to determine if the species is expected at that time of year and location. Whenever possible, ringers should document cases when data fall outside of the accepted norms by photographing the individual or annotating data in the comments field.

Error correction includes the need to check data to catch and correct any errors made during data collection and verify any data that fall outside the accepted range. Once data have been submitted to the appropriate ringing program, program administrators may need to verify unusual data or correct apparent errors. This protects the integrity of data and provides confidence in the database.

### **Electronic data submission**

Although data gathered from bird-marking activities were historically submitted on paper schedules, and some schemes still have substantial amounts of historic data that have not been digitized, moving forward all data must be submitted in an electronic form that can be readily integrated into the central database. This includes all of the original ringing data, as well as subsequent encounter information.

Having fully digitized data is essential for all aspects of data management from running quality control checks to providing efficient responses to public reporting encounters to running statistical analyses. Even analyses based mainly on ring recoveries (e.g., to study movement or survival), also need information on the individuals that were not recovered. Survival models can also benefit from information on covariates, such as body size or body condition at the time of ringing.

Most modern bird-marking programs require ringers to submit all of their data in a standardised electronic format that can be directly imported into the central database. To help reduce the risks of errors and improve quality control, program administrators may want to develop specific software for ringers to submit their data electronically and in a standardised way, which includes various automatic data quality control checks. Some programs are now moving towards web-based data submission.

### Data coding

Being collected by a large number of people, the different variables gathered during ringing activities need to be categorised using common codes that ringers can refer to when collecting and submitting their data electronically. This is also important for the ringing centre, to maximise standardisation in data collection and management within the community of ringers and minimise errors. Given that birds cross national and international boundaries and an individual may be captured, recaptured, and resighted at sites located in different countries that often use different languages, common coding systems shared across countries are worth considering. A shared coding system can be an efficient tool to exchange information related to the movement of marked birds throughout their range. It can also provide analysts with large datasets in a standard format that were gathered across multiple countries.

### Existing systems

There are many systems existing in many countries. For instance, [EURING](#), the coordinating organisation for European bird ringing schemes, maintains a system that allows ringers to use common codes for all possible variables related to ringing and to the subsequent encounters of marked individuals. The same codes are used across countries and are translated into the language of each country, thereby allowing full comprehension of the information exchanged between colleagues working at different national programs across Europe. For details on the different versions see [EURING exchange-code 2000](#).

The North American Bird Banding Program uses a standard set of codes that differs from the EURING scheme, but can generally be easily cross-walked. For many years, they provided standard software to run on the computer of ringers that was used to manage and submit data. Recently these have been replaced with a new web-based [Bander Portal](#) that ringers must use to manage their ringing and encounter data. This tool provides options for ringers to submit data as well as correct errors, manage lookup tables (e.g., locations) as well as search and query their data for analysis.

Newly established ringing programs wishing to set up their own database could benefit from looking into these existing systems, as they can serve as a source of definitions of important categories of variables, e.g., conditions and circumstances of recovery of marked birds. Currently both the North American and European schemes are using ageing systems based on calendar year (i.e., a bird moves into the next age class on January 1 each year). However, the moult-based ageing system recently published by Pyle et al. (2022) may be more appropriate for many schemes, particularly outside of the northern hemisphere, where birds breeding seasons may overlap the end of the calendar year.

## 5.2. Coordination of recoveries and reporting

### Reporting options

Encounters of marked birds may be reported to the ringing centre by phone, mail or online. Submitting data directly into an online database is the most efficient and effective approach, as it automates the process and allows for more efficient use of ringing centre personnel, while minimising possible transcription errors. Online entry of data can also ensure data are entered in a standard format and helps to make sure the data are complete (e.g., by reminding the reporter if some fields are missing). Online mapping tools can be used to improve the accuracy of location information. Drop-down menus can be used to ensure only valid codes are used for fields such as reporting circumstances (how the bird was encountered) or the present condition of the bird (dead or alive, etc.). Pictures or photographs can also be used to show different types of markers to ensure they are being accurately reported.

Not only are web addresses more or less ubiquitously recognised, but also the finder can access the website to report anywhere in the world, including from a smartphone as soon as they encounter the bird. Reporting websites can be provided in multiple languages to

support reporting from different countries. Some schemes now provide only a web address on the rings, for instance [www.reportband.gov](http://www.reportband.gov) (North American Bird Banding Program) and [www.ring.ac](http://www.ring.ac) (Europe). Other examples of websites for ring reporting are [How to report a bird or bat band to the ABBBS](#) (Australia) and [www.ibama.gov.br/sna/recuperacao.php](http://www.ibama.gov.br/sna/recuperacao.php) (Brazil). There are also several webpages to report auxiliary markers, such as leg flags or neck bands (e.g., [BirdMark portal](#) and <https://cms.geese.org/content/how-report-rings-and-neckbands>). If these portals are linked to the banding databases, direct feedback can also be provided to the reporting person regarding the importance of their contribution to bird conservation and the history of the particular bird they found.

In order to produce an encounter report that supports the research efforts, the person should capture at least the following information:

- marker type (flag, colour/metal ring, geolocator);
- ring number or alpha-numeric code on visual marker;
- colour combinations for visual markers (e.g., flags, rings, neck collars);
- date and time of the encounter;
- the species;
- precise location (latitude and longitude, if possible);
- condition of the bird (live/dead/unknown);
- method of encounter (capture, sighting, shot, etc.); and
- the contact information of the reporter.

Programs that are not able to sustain websites for reporting should consider collaborating with other programs or networks to share website maintenance costs and ensure that important data are not lost. Using one common URL that offers web reporting forms in different languages facilitates reporting, maximises the data collected and reduces the likelihood of error in reporting. Reports can be sent automatically to the relevant program administrators that issued the rings reported or directly to the ringer to whom the rings were issued.

In some cases, members of the public may be reporting sightings or recoveries in Facebook groups or on other social media platforms. Unless transcribed to the central database, such data are not available for scientific analysis and hence are not supporting

scientific studies nor bird conservation. It is therefore strongly recommended that someone from the program should be monitoring these reports, entering the data into the system or encouraging the person with the sighting to do so. Ringers should be encouraged to refrain from responding to social media requests for information until after the encounter has been reported in the official system.

### Options for data management systems

Data for a ringing program should be managed in a proper database, with a secure backup system. While some small programs may use simple systems, such as Excel spreadsheets, these are not appropriate for managing large datasets. Spreadsheets can be useful for data input or data export, but lack many features required for an effective data management system. Such a system needs to support multiple linked tables (tables of location information, ringer information, codes, including species codes, for each of the fields, original ringing data, recapture data, reencounter data, etc.). The system also needs to have automatic checks and data-type settings to ensure that only valid data are entered into each field, that records are not duplicated (e.g., only one original ringing record for each ring number or the same recovery is not reported twice), etc. The system also needs to have mechanisms for effective backup, as well as an ability to roll-back changes or revert to earlier versions in case of errors. All of these features are best implemented with an appropriate database. Small databases can be managed with desktop programs, such as MS Access although that lacks integrated backup features. Larger databases require more secure server-based systems, such as SQL server, Oracle or cloud-based alternatives.

Developing effective data management systems requires dedicated information-technology specialists and carries significant set-up and maintenance costs but is necessary to ensure that data are secure and not lost. Smaller or new bird-marking programs could consider connecting with existing programs to determine whether they can share some of their database structure and code or even work through a shared database.

Some data can be managed through existing multinational online databases. For example, [Movebank](#) allows users to manage, share, protect, analyse, and archive data gathered from movement studies. Through these online platforms it is possible to manage effectively all data variables that were acquired from auxiliary markers, including satellite transmitters, light-level geolocators, GPS tags, radio tags, and even standard ring-

recapture-recovery data. In the case of satellite tags, encounter data can sometimes be downloaded directly into Movebank. Researchers also have the option to make their data available for others. [Seatrack](#) is a similar database used specifically for managing data on movements of seabirds.

### **Coordination among countries in reporting**

The sharing of software and databases among ringing centres can provide an efficient way to distribute resources and promote collaboration across regions, while maintaining high data quality and integrity. Online databases, such as those currently provided by [EURING](#) in Europe, the [BBO](#) and [BBL](#) in North America, [AFRING](#) in Africa and [Aves Argentinas](#) in South America, can facilitate the exchange of data across countries. Shared online reporting tools can help members of the public, as well as ringers, to report recaptures and resightings from anywhere in the world.

### **5.3. Data use, analysis, and ownership**

There is a global open-science and open-government movement to broaden access to data and information to enhance transparency and accountability and to maximize the value of the data. Ringing data, ancillary data, and electronic tracking data are important for bird conservation now and will remain so in the future. To support data preservation and accessibility, these data should be centrally managed and made openly accessible to support analysis by others. This benefits the ringer, the scientific community, the public, and the species under study. In the future, novel algorithms could make it possible to reanalyse data refining our understanding of the birds and the environmental conditions under which the data were collected. Making data accessible as soon as possible can stimulate research interest and encourage collaborations, including meta-analyses across studies to examine broader trends and address more complex questions. Ringing programs need to develop clear guidelines for ringers on how their data may be used that balances the need for researchers to have first priority to analyse and publish their results, with the need to make data openly available within a reasonable timeframe to support conservation and collaboration.

Open data increases transparency in decision-making by allowing others to validate conclusions. It can also improve understanding amongst the public and policymakers on the importance of studies involving marked birds. Some funding agencies and scientific journals require data associated with research to be published in an online data repository

when a study is published. Clear metadata describing the purpose of the project and methods used should always accompany datasets.

## Managing data

Long-term management of core data (ringing and encounter data) in a secure database is crucial for every program to protect against data loss and to support scientific analyses, including for studying changes over time and trends. Whenever possible, auxiliary data (such as measurements or body condition indices) should be stored with the original ringing data. If the ringing scheme is unable to accept these auxiliary data, they can also be published in various online repositories. However, if they are not tied to the ringing database, they can be harder for future researchers to discover and integrate into their analyses.

Electronic tracking data and other biologging data should also be submitted to and managed in a suitable data repository. Some collaborative research networks already require that metadata for every tagged bird and all detection data be uploaded to a central data management system. Some tag types collect data that are automatically uploaded to a central data management system, such as radiotelemetry by the [Motus](#) Wildlife Tracking System. Researchers can only receive information on tag detections if the original tag deployment was registered in the Motus system. For others the owner must upload all associated data themselves (e.g., [Seabird Tracking Database](#)). [Movebank](#) is a flexible repository that can archive and manage many types of ringing, tracking and biologging data. Movebank is a free online database hosted by the Max Planck Institute of Animal Behaviour that was especially designed for managing and analysing animal tracking data from automated trackers such as GPS, Argos, radio telemetry, and solar geolocators. Movebank has features to enter, edit, manage, analyse, and archive data. The researcher who collected the data can set different levels of [access](#), from keeping the data fully private to making them openly available immediately. Ringing programs should encourage researchers to make their data openly available; if there are sensitivities, they can often be alleviated by making the data open after a time delay, which may range from a few months to a couple of years (e.g., to allow time for publication of associated research). Ringing programs could require ringers to provide administrative access for their projects to staff in the ringing office, to ensure that data can be accessed in case they are needed for management purposes, or if the ringer retires without publishing the data.

Most repositories designed for tracking data have their own accepted formats or required data fields. These include at least the following fields:

- ring number on the bird at time of device deployment;
- species of the bird;
- sex of the bird;
- age of the bird when device was deployed;
- type of device deployed (e.g., Lotek NTQB-2 nanotag, Lotek PinPoint-10 GPS tag);
- unique device ID;
- location (i.e., latitude and longitude), where the bird was released with the deployed device;
- date and time when the bird was released with the deployed device;
- unique identification for this tracking event (one track ID is associated to each time the device was detected while deployed, i.e., there may be many Track IDs for one bird);
- date of the tracking event;
- time of the tracking event;
- location of the tracking event (i.e., latitude and longitude); and
- metadata.

Researchers should always include metadata, such as the name and contact information of the owner of the data, the name and purpose of the project for which it was collected, etc. This includes creating a legend for the data that includes descriptors for all possible values of each field, as well how the data was formatted, where applicable (e.g., Sex: M = male, F = female, U = unknown).

### **Data ownership**

Programs should develop clear criteria to determine whether data are owned by the program or by the ringer or by a combination of both. If data ownership is considered to rest with the ringer, then a data sharing licence should be developed that must be accepted by all ringers to allow the program to manage and disseminate the resultant data to anybody encountering a marked bird, as well as to third party researchers wishing to use and access the data.

In either case, it is important to acknowledge and respect the rights of researchers to prior analysis and publication of data resulting from their efforts, within reasonable time limits. However, it should also be acknowledged that in most cases, a permit to capture and mark birds is a privilege that carries moral and ethical obligations to make the data available to support science and conservation. Ringers should be encouraged to share their data, including data that are not managed within the ringing centre, to permit raw data to be analysed, particularly in conjunction with other data sets. In many cases, the value of marking data is greatly enhanced by combining data from many different studies.

Access to data (both core and additional) need to be discussed and agreed on. The pros and cons of making data freely available to anyone should be evaluated. Advantages of making data about migratory birds available include clear links to conservation actions, which facilitate decision-making by managers. Nevertheless, in some cases (e.g., nesting sites of sensitive raptors, or species that may otherwise be at risk of persecution or harm), there may be conservation reasons for some restrictions. In these cases, providing a less precise location (e.g., the centre of a 10 min latitude / longitude block) or delaying a few months (e.g., until after the breeding season) may be sufficient to remove the sensitivity.

Many repositories allow the data owner to specify the level of access that others can have to their data (e.g., Movebank). In other cases, database managers may set limitations on access to data (e.g., restricting downloading data to approved users with a justified research purpose, as in the example of [shorebird banding and resighting data](#) in the Americas). Ringing programs should encourage, or require, ringers depositing data in third party sites to choose an option that makes the data fully public, if not immediately, then after a reasonable time delay while the researchers who collected the data publish the initial results.

### **Analysing the data**

The primary responsibility for analysing marking data generally rests with the researchers who collected the data, although a research team or non-governmental organization may lead analyses of large-scale collaborative projects involving many different ringers. National or regional ringing centres can help ringers by providing links to data analysis methods and tools (e.g., Vogelwarte's site: [Analysis tools: Ring re-encounter analysis](#) or the EURING [Migration Mapping Tool](#)) or by providing lists of potentially relevant scientific articles (e.g., papers such as [Harnos et al. 2015](#) or [Amrhein et al. 2012](#)), although it is not possible to capture methods for all possible research questions.

In some regions, ringing offices may have capacity and expertise to analyse data themselves, either for specific research projects, or for broader overview analyses. Many countries have published ringing atlases summarising movements of birds ringed or recovered in that county, which are often coordinated or led by the ringing office.

Online publication of data and free access encourages better and more timely data analysis and better uptake in conservation, especially using online tools such as the [USGS Request Data site](#). Providing online mapping and data exploration tools, such as the EURING site mentioned above, allows a broad range of people to access the data.

Whether data are freely available online, or only available upon request, programs should develop guidelines for best practices related to use of the data for scientific publications. As a minimum, this should include guidance for appropriate citation and acknowledgement of the efforts of the ringers involved in collecting the data and, in some cases, offering the option of co-authorship on publications. In many cases, there can be advantages to contacting and collaborating with the original ringers in developing publications, as they can provide valuable insights into the methods and circumstances of data collection that can influence interpretation of the results.

## 6. Managing a bird-marking Program

### 6.1. Options for program models

Bird-marking programs can be operated by:

- local authorities (e.g., regional or national governments);
- independent institutions (e.g., non-governmental organisations - NGOs); or
- independent institutions in partnership with local authorities.

The most appropriate option depends on the regional circumstances, existing resource capacities, and legislative requirements. They each have their strengths and challenges.

#### Programs managed by government authorities

##### *Strengths:*

- long-term funding is more likely to be secure;
- personnel may have a range of expertise from general ornithology and ringing methods to data analysis and data management;
- job security and career progression opportunities can help retain personnel with high levels of experience and competence, who can train new staff as required to maintain efficient program operations;
- may be possible to obtain resources from elsewhere in the institution (e.g., database developers) to support development of a database management and ring reporting system;
- permitting can be linked with legislative requirements if the agency has the relevant mandate.

##### *Challenges:*

- program support may be influenced by politics and changes in government;
- the program may shut down when governments are not operational (e.g., personnel are on strike);
- In a large country, it may be difficult to coordinate marker assignment, licensing, and data management between government and other institutions;

- there may be significant administrative delays and inefficiencies imposed by internal policies; and
- may have political or legal restrictions that affect the efficiency of program operations.

### **Programs managed by independent institutions**

#### Strengths:

- community-based organisations can better engage and relate with local ringing groups;
- personnel may be more likely to include researchers and/or ringers that are active and are known in their region, with a passion for avian science or conservation;
- can operate directly in response to local needs and situations, with less restrictions than a government-run program;
- can develop innovative and integrated approaches to address local needs; and
- can facilitate communication between local ringing groups and local authorities.

#### Challenges:

- may have difficulty securing adequate long-term funding, thus limiting ability to retain personnel and operate effectively;
- ringing schemes and data management may be difficult for a smaller organisation to coordinate across the entire region or country;
- may have to work collaboratively with government agencies to issue permits that are valid under relevant legislation.

### **Jointly managed programs**

A jointly managed system has the potential to combine the strengths of the previous two models, where the challenges for one model are balanced by the strengths of the other. This could be a feasible model to follow when establishing a new bird-marking program.

## 6.2. Components of a program

### Setting up a scheme

Setting up a new scheme works should be established through collaboration with any researchers or volunteers in the country interested in ringing, the local government and the international community. Consultation with potential ringers is essential to ensure that the scheme will meet their needs. It is essential to gain endorsement and support by the government of the country the ringing activities are conducted in, particularly any agencies that may be involved in permitting ringing activities.

A new ringing program needs to have a plan to cover all of the core functions including:

- Managing permits and authorizations
- Managing and issuing rings and optionally auxiliary markers
- Managing all data associated with ringing
- Receiving and managing encounter data (recaptures and recoveries)
- Disseminating data to support analyses
- Communicating and working with ringers
- Providing training materials or information and setting standards

Although a few highly organised individuals could possibly set up a new scheme by themselves, generally an approach is required that will provide long-term stability. Participating in a pre-existing scheme can help a ringing centre perform these administrative tasks in a coordinated manner that fosters collaboration in avian conservation efforts.

### Resources required to run a bird-marking program

#### *Core Requirements and Functions*

- **Personnel:** to communicate with ringers, issue permits, manage rings, manage data, etc.
- **Infrastructure:** office space with room for ring inventory and access to databases.
- **Information management system:** secure databases and information management system for managing banding and encounter data.

- **Permit Management:** a system is needed for issuing permits and managing permit information, potentially in conjunction with local authorities.
- **Contact with ringers:** to ensure frequent and regular delivery of ringing and encounter data, compliance promotion, policy development, etc. via emails, distribution lists, online fora, newsletters or meetings.

### *Additional requirements*

- **Purchasing and distributing rings:** Costs can be covered by the program or passed to individual ringers. Alternatively, the program could manage ring numbers and allow individual ringers to purchase rings.
- **Managing auxiliary markers:** Ideally this would be done centrally by the program, but it could alternatively be delegated to research teams working on individual bird groups. Requires an efficient database management system as well as close communication with national and international teams using markers.
- **Developing a web reporting platform:** A web-reporting platform is essential to gather information from encounters by the public. If the program does not develop their own platform, the alternative is to make use of a scheme developed and managed by another program in the same flyway.
- **Auxiliary banding data:** Ideally, the program would store any auxiliary data (such as biometrics, body condition indices, moult, etc.) collected in a standardised way as part of the standard database, incorporating appropriate checking and quality control. Alternatively, this information can be left for individual ringers to manage for their own use, but not made available for collaborative studies.
- **Reviewing proposed bird ringing projects:** Ideally, the program would have the expertise to review and approve individual bird-ringing projects. Alternatively, the program could review only ringer qualifications, and rely on other approaches to review projects (e.g., reviews by funding agencies).
- **Providing training for ringers:** via reference material (online or print), workshops, field training, bulletins, etc. Alternatively, the program could point to existing material developed by other programs.

Ultimately, anybody contemplating development of a new ringing program should consult with as many existing programs as possible to understand the advantages and disadvantages of each model before proceeding.

## 7. Resources

### Links of publications and resources by different ringing schemes

- Australian Bird and Bat Banding Scheme (ABBBS) [Forms and Publications](#)
- British Trust for Ornithology (BTO) [Ringing Publications](#)
- Canadian Bird Banding Program [Resources](#)
- North American Banding Council (NABC) [Bander Resources](#)
- East Asian-Australasian Flyway Partnership (EAAFP) [Resources](#)
- South African Bird Ringing Unit (SAFRING) [Species Guides](#)
- USGS Eastern Ecological Science Center's Bird Banding Laboratory's [references](#) and data analysis [tools](#)

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**Figure 8.** Bird ringing can contribute to scientific knowledge, bird and habitat conservation and education and public relations. Band-tailed manakin (*Pipra fascicauda*) caught during a training workshop for future bird ringers © Judit Szabo