# DAWN CHORUS

A project report on the scientific aspects of the "arts and citizen-science project Dawn Chorus"

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# INTRODUCTION

In early 2020, the lockdown situation in response to the worldwide outbreak of the novel coronavirus SARS-CoV2 brought about a sudden and extreme reduction in human activity. While this crisis affected the lives, and physical, psychological and financial wellbeing of billions of people, it also posed a once-in-a-lifetime chance to study the effects of human activities on wildlife. A number of scientific studies as well as lay programs seized this extraordinary time of silence to collect data on animal behaviour and biodiversity – the perfect time to quickly join forces and kick off project Dawn Chorus, the "first worldwide art and citizen science project" aiming to explore bird biodiversity from early morning bird song with the help of citizen scientists and their everyday smartphones. Next to many other important supporters, the official parties involved in the project were the arts and nature foundation Nantesbuch and Munich's new natural history museum BIOTOPIA, with the support of the Max-Planck-Society through its Institute for Ornithology (funding for scientific support).

The following report reviews the scientific background and progress of project Dawn Chorus 2020, and aims to provide a basis for discussing its future development.

# SCIENTIFIC BACKGROUND

## Dawn chorus, biodiversity and noise

Before sunrise, many bird species simultaneously engage in an intense display of song, the "dawn chorus" (Dabelsteen and Mathevon, 2002). This beautiful phenomenon has fascinated humans for centuries. Next to its aesthetic value, the dawn chorus also contains a lot of scientifically relevant information, and has been a part of scientific research for decades now, with new findings still coming to light – not least because of novel approaches and technological advances in recording and analysing sound. Ornithological topics dealing with the dawn chorus are highly diverse, with studies focusing on hormones, trade-offs in song versus foraging behaviour, or the impacts of human-made noise (Gil and Llusia, 2020). The scientific backbone of these studies lies in the fact that avian vocalisations (sounds produced in the bird vocal tract) play an important role for the survival and reproduction of many species, and are quantifiable traits that can be investigated in an evolutionary context – from the evolution of bird song features, such as dialects, up to universal patterns in language and learning (Catchpole and Slater, 1995). Since bird vocalisations (especially the song) are largely characteristic of different bird species, they may also function as useful bioindicators, which means that the presence of a species may be detected through its song.

Species detection is key to mapping the current and future "health state" of a given habitat. A growing number of studies confirm that animal and plant species abundance is plummeting all across the globe (Ceballos et al., 2017; Humphreys et al., 2019; Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, IPBES, 2019). In order to take steps towards halting the loss of species, we must quantify biodiversity over time and in different habitats, and seek out the reasons behind its decline. Birds are often considered important indicators of habitat changes (Morrison, 1986). Many bird species themselves are endangered, or face growing challenges such as declining food sources, diverse types of human-caused pollution, or the loss of suitable habitats due to land development and urbanisation (Gamero et al., 2017; Rosenberg et al., 2019). Such changes in the environment are often coupled, and appear at rates faster than most species can adapt, leaving the field to few, generalist species (IPBES, 2019).

Anthropogenic (human-made) noise causes harmful elevations in stress levels, and has been shown to negatively affect humans and animals. In birds, it may also hinder acoustic signals that facilitate foraging (searching for food), mating or predator-defence (Halfwerk et al., 2018). Apart from direct effects on the survival and reproduction of birds, anthropogenic noise may also bear indirect costs. For instance, birds close to airports have been shown to shift their dawn song earlier to avoid interference from airplane noise (Gil et al., 2015). Such shifts in diurnal patterns are considered costly due to loss of sleep and potentially increased predation risks. Studying the types and levels of anthropogenic noise is thus an important point in keeping track of habitat quality over time.

In the first half of 2020, human activity was suddenly brought to a drastic halt through travel bans and stay-at-home policies (lockdown) in many countries of the world, to fight the rapid, worldwide spread of a serious, novel coronavirus-induced disease (CoViD-19). While the beginning of a time of hardship for millions of humans, this stage of the crisis was also associated with a profound quietness experienced in cities, airports and industrial areas, and a number of anecdotal reports of wildlife reclaiming territory otherwise occupied by humans. One of our major objectives was thus to use this sudden time of relative human silence and heightened human awareness to nature, specifically to nature's sounds, to launch project Dawn Chorus, aiming to provide a basis for documenting and exploring biodiversity and anthropogenic noise through early-morning sound recordings, together with participants from all around the globe.

## Methodology

Soundscapes are the acoustic representations of entire biospheres or scenes which may be captured via sound recordings. While they have great potential to reflect the acoustic biodiversity of habitats, these relatively unspecific sound recordings have only the recently become tools for answering concrete biodiversity questions, due to the advances in sound recording, storage and analysis (Buxton et al., 2018; Celis-Murillo et al., 2009; Farina et al., 2011; Gibb et al., 2019; McKenna et al., 2017). High-quality sound recordings required for bioacoustic analysis of bird song have inherently high energy and storage demands, and their audio analysis often requires a lot of time and heavy computation. Therefore, in the study of bird song, vocalisations are usually recorded in a highly specific manner, focusing on exact time-points or on specific individuals. Yet an increasing number of studies seems to bring these two approaches closer together, for instance, acoustic recording stations have been placed in specific locations along bird migration routes to provide information on the bird species passing by (Blumstein et al., 2011; Sanders and Mennill, 2014). One main drawback of this technique obviously lies in the fact that species can only be detected when they actually vocalise. Therefore, periods of reliable, high vocal activity across species must be selected when assessing biodiversity based on vocal signals – making the dawn chorus a suitable time window for bioacoustic recordings. It should be mentioned here that as a consequence of multiple species singing simultaneously, vocalisations are very likely to overlap, hence becoming more difficult to analyse, even with modern computational tools. However, the analysis of such complex sound recordings is an active field of research, and scientists keep presenting novel algorithms to extract information of increasing detail and depth (Brooker et al., 2020; Nanni et al., 2020).

The standard approach to recording bird song for bioacoustic analysis is to collect specific, high-quality sound recordings, in few long or multiple short time periods, under different conditions necessary to answer the scientific question (e.g. song characteristics in a forest versus in a city). Designing a study under these premises to provide a wide distribution of dawn chorus data points from different habitats, during the lockdown period of 2020 and over the following years, would entail repeatedly placing and operating costly recording devices in various locations. Project Dawn Chorus aims to obtain early

morning audio recordings from various locations with the help of citizen scientists and their everyday smartphones. Using smartphones instead of professional recording equipment of course strongly lowers the sound quality compared to state-of-the-art recordings that scientists usually work with. However, by recruiting a large number of participants, it is possible that the benefits of a large and diverse dataset could outweigh the costs, and provide valuable results otherwise difficult to obtain.

One of the challenges of this project was thus to find a balance between high-quality, standardised sound recordings, and maximising participation, including from people without any technical background or affinity. Due to the speed at which this project was to be brought about, an app could not be developed for the round of 2020, but will hopefully be part of the project's future development. Therefore, our aim was to provide scientific background (Text 1) and precise instructions for participants of all levels of expertise and available equipment, along with recommendations for suitable apps, to allow audio recordings of sufficient quality from as many participants as possible (Text 2).

## Expected data and potential scientific questions

During the conception of project Dawn Chorus, the details of the bioacoustic analysis were still a song of the future, with the goal of getting bird song identification and machine learning experts involved to build a human-annotated library of dawn chorus bird song from our dataset and other bird song repositories, and eventually develop suitable algorithms for species detection. In our estimation, such a diverse acoustic dataset of largely limited audio quality is challenging to analyse in a machine-learning framework, but could potentially yield scientific bird song parameters for further analysis (the timing of bird song relative to sunrise, the vocalising species, and potentially a crude categorisation of song type).

The acoustic dataset itself was not expected to allow an analysis of detailed acoustic parameters, such as song amplitude, song frequency, or background noise. Therefore, we designed a questionnaire (Table 1) aimed to yield important information about each dawn chorus sound recording, and to provide contexts of biodiversity, urbanisation and human-made noise for any future scientific evaluation of the song parameters. In addition, this set of simple questions was intended to raise awareness towards the biodiversity and acoustic features of one's environment, including anthropogenic noise, and to encourage participants to take part more actively in the scientific project.

Another idea on how to obtain scientifically valuable information and engaging the public was through explicitly encouraging participants to make multiple recordings, across different timepoints on the same morning, as well as on different days of the week, ideally a working day and a holiday, not too far apart. Recording from the same location on days of different noise levels (working day versus holiday) is an elegant approach to separating noise from other effects of urbanisation or habitat fragmentation, which is not necessarily possible when taking only urban-rural gradients into account. It should be noted that the difference in noise levels between working days and holidays was expected to be less pronounced during lockdown than during "normal" years, due to the overall decrease in human activity and noise – but which could be highly interesting for an inter-annual comparison.

For the questionnaire, some of the multiple-choice options were purposely adopted from other projects to make the obtained data more comparable. For example, the habitat included options used in "Die Stunde der Gartenvögel" (an established bird censoring project from NaBu/LBV, German bird protection NGOs), and we also asked participants to indicate recognised species. Further, next to local time, date and weather conditions of each recording, the participants would be asked to note down whether the recording was made on a local holiday or working day, and to estimate the levels and sources of human-made noise they perceived during each recording session. Apart from its scientific value, this was also

intended as a technique to raise the participants' awareness towards biodiversity through the change of tune within each dawn chorus or in different locations, and towards human-made noise on different days. Meanwhile, the repeated-measures design would also allow for some standardisation of the data, which could be useful given the expected amount of variability of the recordings, and the successive changes in dawn-chorus species composition during the course of every morning.

In the following, we list information and scientific questions that could potentially be derived from the bioacoustic data, the answered questionnaire and file metadata of each dawn chorus recording.

1. Questionnaire (and/or file metadata):
    A. As part of the pilot project, to estimate coverage and explore future strategies:
        1. Participation (within Germany and other countries)
        2. Distribution of sound recordings across different habitats
        3. Distribution of sound recordings over the course of the week and on holidays
        4. How many participants would be willing to participate again next year, and give consent to be contacted?
        5. What is the percentage of multiple recordings (on one or multiple days)?
    B. Scientific questions:
        1. How does the experienced human-made noise differ in terms of source and intensity (especially interesting across years), with respect to:
            - Lockdown, or as lockdown eases (potentially difficult; requires estimate of current lockdown strictness for each date and location)
            - Habitat (further GIS-based analysis possible)
            - Working days, weekends or holidays
            - Different times of the day
        2. To what degree do the recognised bird species coincide with those recorded by other citizen science projects? Are there any striking differences, and how can they be explained?
2. Scientific questions from combined bioacoustic and questionnaire dataset
    A. How does the presence or frequency of species (% of locations) change depending on
        1. Time of day
        2. Source and intensity of human-made noise (especially interesting across years)
        3. Lockdown or as lockdown eases (potentially difficult; requires estimate of current lockdown strictness for each date and location)
        4. Habitat (further GIS-based analysis possible)
        5. Weather conditions (control)
    B. Time of day of song onset with respect to (note: this depends on good temporal and spatial data coverage)
        1. Bird species
        2. Type, amount and intensity of human-made noise
        3. Habitat (further GIS-based analysis possible)
        4. Weather conditions (control)

Text 1: Lay summary of the project's scientific background

# The Science behind Project Dawn Chorus

## What does "dawn chorus" mean, and what is interesting about it?

Dawn chorus – the early morning bird concert – is fascinating to nature lovers, artists and dreamers alike. But it is also highly interesting for scientists.

Today we know that bird song fulfils many important functions, especially during the breeding season, for example to attract females or to defend territories against rivals. For bird researchers (ornithologists), the early morning is a very interesting time of the day because this is the time when most (song)birds are especially active. Although birds may keep singing throughout the day, their song behaviour is never as intense as during the early morning hours. Interestingly, each bird species begins their song at a specific time with respect to sunrise. This means that the sound of the bird concert will change its tune every morning when different species enter the stage. The sound also differs between regions, depending on which species are around to sing along – just like a concert sounds quite different if gentle flutes or electric guitars set the tone.

Not only time and place, but a number of other factors may also influence the dawn chorus, such as weather conditions (e.g. storm) or human-made noise (e.g. from air traffic). Hence, the dawn chorus of the Himalayan foothills will likely sound completely different from the one down at Piccadilly Circus in London (see noise maps, e.g.: http://noise.eea.europa.eu/) – and the latter will probably sound rather different on a busy Tuesday morning compared to on a rainy Sunday when a lot of people are allowed to sleep in.

We find this flexibility in bird behaviour absolutely exciting and would like to understand it better. In this special year of 2020, lockdown restricts a lot of human activity, thereby also tuning down a lot of human-made sounds, and leaving the centre stage to the bird dawn chorus – and we are here to listen very closely!

## What are soundscapes, and how are they useful for science?

Soundscapes (from sound + landscape) reflect a lot of properties of a given habitat through their sound alone. Using the words of Bernie Krause (https://www.biotopia.net/en/event/past-events/36bernie krause?date=2020-04-22-17-00): „While a picture may be worth a thousand words, a soundscape is worth a thousand pictures" (*www.researchgate.net/profile/Bernie_Krause/publication/257943543_The_Sound_of_a_Damaged_Habitat/links/00b7d5266932cf3dad000000.pdf).

Sometimes, soundscapes change suddenly and drastically. A painful experience that Bernie witnessed when recording sound before and after logging activity in a Californian forest: despite reforestation efforts, the majority of birds had become silent, even years after the logging event*. Other changes may occur more gradually, for example due to the increase in road-traffic induced noise.

Thus, sound recordings or soundscapes may help scientists to become aware of long-term changes in a habitat's species composition, and to indicate where species disappear and biodiversity decreases. Further, they may also help investigate the influence of human-made noise on the song behaviour of birds.

## The scientific goals of Dawn Chorus

The scientific goal of Dawn Chorus is to document the early morning song of birds at different locations, and across multiple years. Based on the collected data we hope to verify the occurrence of different

(singing) species, and follow its development across years. This could help investigating species decline or disappearance in different habitats (including in cities), and to find explanations. Further, we hope to shed some light on the present types and intensities of human-made noise sources (e.g. traffic noise), and how they may influence bird song.

## What is the role of "citizen science" for Dawn Chorus?

Citizen science is based on the help of volunteers, for example for data collection or analysis during a scientific project. With volunteer support, scientists are able to collect much more data than they could ever achieve on their own. Even if the data are not always of professional quality, they still produce exciting and important results. Last but not least, citizen science has an educational aspect in that it transfers knowledge, and provides food for thought.

In our project Dawn Chorus, we rely on citizen science to obtain sound recordings of the early morning bird song from a multitude of locations simultaneously. These data are complemented with information on time, date and location of the recording, and a few simple questions about the current weather conditions and human-made background noise. From this, scientists will be able to document the current state of soundscapes, to compare it to the ones in the years to come, and to gain important insight into human influence on biodiversity.

Many people have heard about bird species decline on the news, but they may not be aware that this phenomenon is happening right now, literally in their own backyard. The dawn chorus is a wonderful nature spectacle, and it is a useful indicator of species diversity which we would like to make accessible. So, join us in experiencing this beautiful spectacle of nature, and engage – take a conscious listen! Especially in these challenging times of the 2020 lockdown in which human activities but also human sounds are toned down.

## What kind of data will you collect, and why?

As explained above, the dawn chorus sounds different, depending on where you are and what time (with respect to sunrise) it is. To disentangle the effect of human activities, e.g. noise, we need to control for other factors such as the time of day or the current weather conditions, because these factors may also strongly influence the dawn chorus.

This is why we require a LOT of recordings, preferably collected under the same recording conditions, from many different locations. Ideally, each volunteer would collect multiple recordings from the same location (1) over the course of the same morning (before, during and after dawn), or (2) made at the same time, but distributed across multiple days (ideally on a normal working day and a holiday). You will find instructions on how to make an ideal recording here (https://dawn-chorus.org/en).

Based on the collected data, we hope to identify the species and timing (with respect to sunrise) of bird song. A short questionnaire in the upload section aims to collect additional data on location, time, current weather conditions, the exact temperature (if available), the type of habitat (e.g. city balcony or country garden), as well as the amount of human-made noise experienced during the recording.

## Who "we" are

The Citizen Science Platform Dawn Chorus is a project by BIOTOPIA (Bavaria's new museum of life sciences and environment) and the Nantesbuch Foundation. Scientific support is provided by the Max Planck Society, via the Max Planck Institute for Ornithology in Seewiesen, Germany.

Table 1: Recommended scientific questionnaire for each Dawn Chorus recording

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Date*** | [select] | | | | | | |
| **Time*** | [select] | | | | | | |
| **Holiday/Working day*** | Holiday | Working day | | | | | |
| **Location** | [GPS location or address] | | | | | | |
| **Habitat*** | City | Suburban | Village | Solitary building/estate | Field | Forest | Other: [Text] |
| **Device*** | Smartphone | Advanced recording equipment | | | | | |
| **App** | [Text] | | | | | | |
| **Quality (Bit rate, Sampling rate)** | [Text] | | | | | | |
| **Weather conditions*** | Sun | Clouds | Rain | Storm | | | |
| **Temperature (if available)** | [Text] | | | | | | |
| **Human-made noise*** | Low | Medium | High | | | | |
| **Source of human-made noise*** | Street traffic | Air traffic | Industry | Other: [Text] | | | |
| **May we contact you for further questions?*** | Yes | No | | | | | |
| **Are you willing to participate again next year?*** | Yes | No | Maybe | | | | |

*mandatory fields

Text 2: Recommended Recording Protocol and Apps

## Which app should I use?

a) **Android:**
Some Android phones have good built-in sound recording Apps, such as Samsung's Voice Recorder. But for our purposes, it would be better if you could download and install apps that allow high-quality sound recordings. Their default settings are a good start, but if you would like to support us with a high-quality recording, please set the bitrate to 320 kbps. Sampling rate should be 44100 Hz (sometimes called 44kHz). For highest quality recordings, change the format to "wav". Please note that file size will increase with increasing audio quality. Here are some app suggestions:

- **Hi-Q MP3 Voice Recorder (Free**) by "Audiophile". You will find your recording in a folder called "Recordings". Make sure that "stereo" is switched off (default), and under "microphone", please select "unprocessed (raw)".
- **MP3 recorder** by "Smart Mobile Tools". You will find your recording in a folder called "com.fragileheart.recorder". Please disable "noise suppressor"
- **Voice Recorder** by "quality apps (recorder, weather, music)". You will find your recording in a folder called: "Recorders"

b) **iPhone**:
As a simple option, you may use the inbuilt Voice Memos app with the Lossless setting (show screenshot). But for our purposes, it would be better if you could download and install apps that allow high-quality sound recordings. Their default settings are a good start, but if you would like to support us with a high-quality recording, please set the bitrate to 320 kbps. Sampling rate should be 44100 Hz (sometimes called 44kHz). For highest quality recordings, change the format to "wav". Please note that file size will increase with increasing audio quality. Here are some app suggestions:

- **Hokusai 2**
- **AVR (Awesome Voice Recorder)**

c) Or if you are really serious about recording you may use an external stereo microphone (such as Zoom iQ6 or iQ7 for iPhone) or even a solid state audio recorder (for which you just need to make sure that it is set to output WAV files at 44.100 Hz sampling rate, bit depth of 32) and keep file size under 20MB.

## What do I do?

Please make sure once more that your phone's date and time are correct.

1. **Check the time of sunrise**
   Once you have chosen your App, the next thing to do, the night before, is to check the time of sunrise in your area for the date you will record, for example by using the Weather app on your phone or else by checking https://www.sunrise-and-sunset.com/en. As different birds begin singing at different times, you will hear different species depending on exactly when you record. A good time is from about 30 minutes before sunrise until after dawn (for Germany, see NABU clock).
2. **Choose a location**
   You can make a recording from a garden or park near your home, or if you are unable to go outside your house/apartment due to Covid-19 restrictions, then you can record from a balcony or even an open window.
3. **Make your recording**
   Place your phone or other recording device in a safe and stable position protected from wind and rain with the microphone (usually at the bottom of the phone) facing towards the birdsong (on a table or tripod or leaning against a stable surface). Once the device is in place, press record, and

walk away. If it is not possible for you to put the device down, hold it in your hand without moving, using as few fingers as possible. Make sure you don't touch the microphone during the recording. **Now, be very quiet**: no talking, sneezing, walking, shuffling feet, scratching etc. Record at least **30 seconds to 2 minutes** of sound and retrieve device. Stop the recording.

**Optional:** you may wish to use the app to trim off the beginning and end of the recording to remove any noises you made (e.g. doors, footsteps etc). **Do not use any filters to make the recording sound "nice" or to reduce any noise.**

If you have time, make two or three recordings at 15-minute intervals. And also, please make more recordings on different days at the same time (ideally on a holiday and on a normal working day).

4. Upload your recording to [www.dawn-chorus.org](http://www.dawn-chorus.org)

# DATA COLLECTION PHASE

As mentioned above, project Dawn Chorus was the result of a few highly motivated people quickly joining forces to seize an unexpected moment of human silence to engage the public and to collect bird song recordings from all over the world. Hence, only a few weeks passed between the conception of the project, and its launch on May 1st 2020. Due to this time constraint, not all functions were fully implemented when the website went online (e.g. multiple uploads, user-friendly location input, dawn chorus world map), and some of the content and design of the website, including the upload page (containing the scientific questionnaire, **Table 1**) were not finally defined. Therefore, during the early data collection phase, all partners (and even some participants) engaged in various tests, pointing out issues in the website content and its technical functions, and providing bug fixes and suggestions to resolve problems. With the initial focus lying on website functionality, especially the development of the world map and image upload, some of the changes will have to be implemented in the next round of Dawn Chorus in 2021.

Due to the great response to project Dawn Chorus, the data collection period was extended by 10 days, and ended on May 31st.

# RESULTS

By the end of the data collection period, more than 3500 recordings had been uploaded, which helped answer some of the proposed questions, and yielded useful information for estimating participation numbers, for seeking improvements to the format and the website, and for exploring potential future directions and developments of the project.

As explained above, the bioacoustic analysis of bird song is a research topic in itself, and not part of the present evaluation, but a main objective for the future of project Dawn Chorus. Based on audio-visual inspection of a number of sound recordings, it appears that a large subset of the uploaded data is likely of sufficient quality that would allow more complex sound analyses. At present, it remains to be determined what effects the extremely variable sound recording parameters and quality loss (due to low-quality microphones, compression and background sounds) may have on the potential complexity of analyses and on the validity of results.

## Number of participants

3481 data points were included in the analysis of the upload form contextual data (after e.g. correcting GPS locations, deleting test entries). Almost 1000 participants provided an email address for future correspondence (ca. 80% of the recordings). Around 25% of the recordings came from the English, and 75% from the German upload form. The recordings were made at 2128 different GPS locations ($n_{Germany}$=1673), with an average of 1.6 recordings per location (min: 1, max: 33, SD (standard deviation): 2.03). For the future of this project, we seek to implement a means of participant identification which will allow an unequivocal allocation of repeated recordings, even if participants may wish to maintain their location and identity private.

## Uploads

Most uploads were made on Sundays, with the largest proportion on the last day of the data collection phase (May 31st, **Fig. 1**). The uploads were spread out more evenly across the week than the audio recordings themselves (**Figs. 1** and **2**).

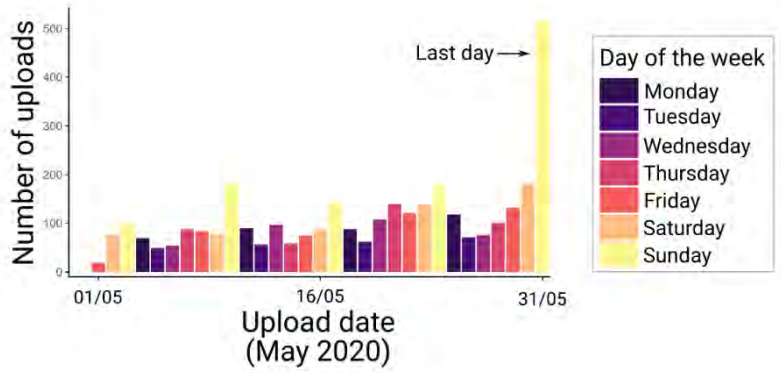
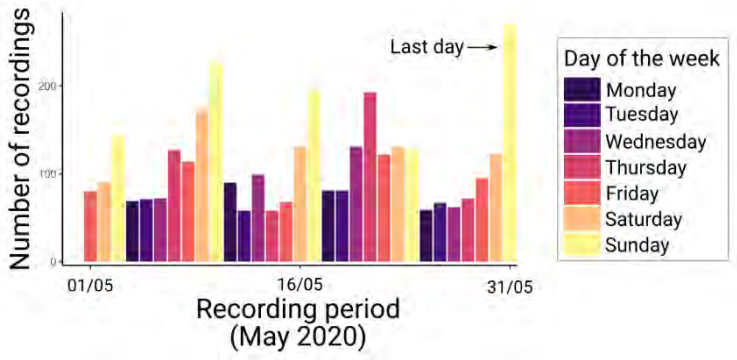



**Figure 1: Distribution of uploads over the course of the recording period (May 2020)**

## Outcome of the scientific questionnaire

### Date of the recording:




The number of recordings fluctuated over the course of the data collection period (May 2020, **Fig. 2**), and over the different days of the week (**Figs. 5a**, **b**). Most recordings were made on the last day of the data collection period (**Fig. 2**).

**Figure 2: Number of recordings across the recording period**

We are hoping to make a dedicated Dawn Chorus app available for the upcoming rounds of the project (see below for further discussion). Among other useful features, this app would automatically save the local date and time along with each audio recording.

### Holiday/Working day:

This question was dropped from the questionnaire in 2020. Since it cannot be easily answered post-hoc in a worldwide setting, it is excluded from the present report. **Fig. 5** shows that the number of recordings (and uploads) increased during the course of the week, and peaked on Sundays.

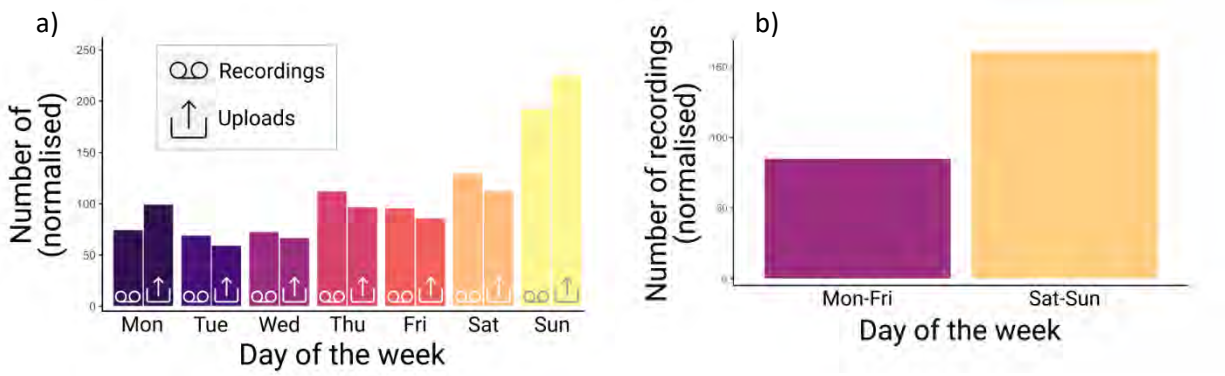



Figure 3: Number of recordings a) at different days of the week, b) on weekends versus weekdays

## Time of the recording:

The local time at which the participants had made their recordings appeared to be rather widespread (Figs. **3a**, **3b**). This might be explained by the wide international participation, but also by typing errors and recordings outside of the actual dawn chorus. For the future analysis of biodiversity and song data, it will be necessary to focus on a specific dawn chorus time-window, and to discard recordings made outside of this period.

Therefore, the time zone and UTC-offset (R-package *lutz*), as well as the time of dawn (end of nautical twilight and beginning of civil twilight) and the end of sunrise (bottom edge of the sun touching the horizon) were calculated for each location and date (R-package *suncalc*). Selecting a time window from one hour before dawn until one hour after sunrise left 3219 of recordings, most of which were in fact made at local times distributed around sunrise (**Fig. 4a, b**). Eight recordings were excluded because they came from two locations too far North to allow an exact calculation of dawn onset.

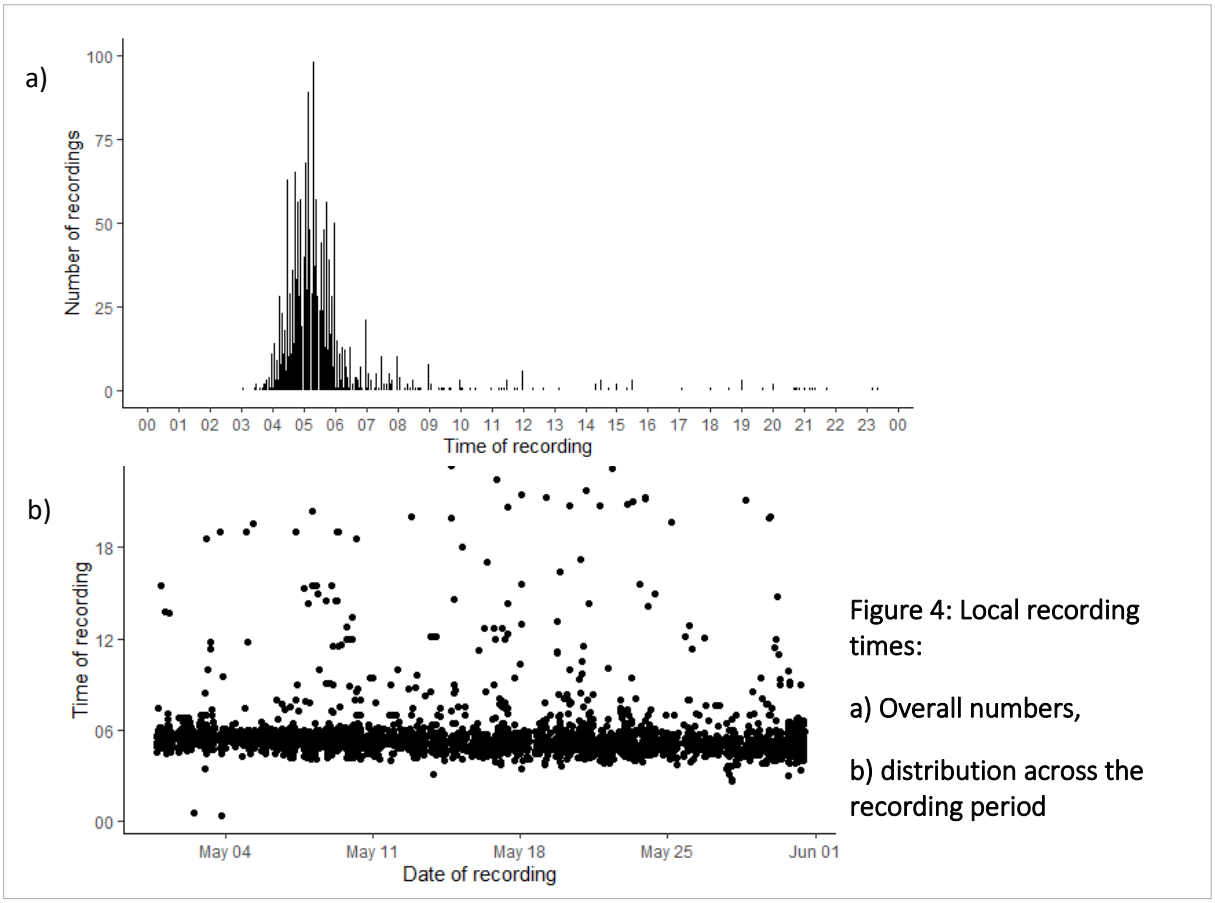
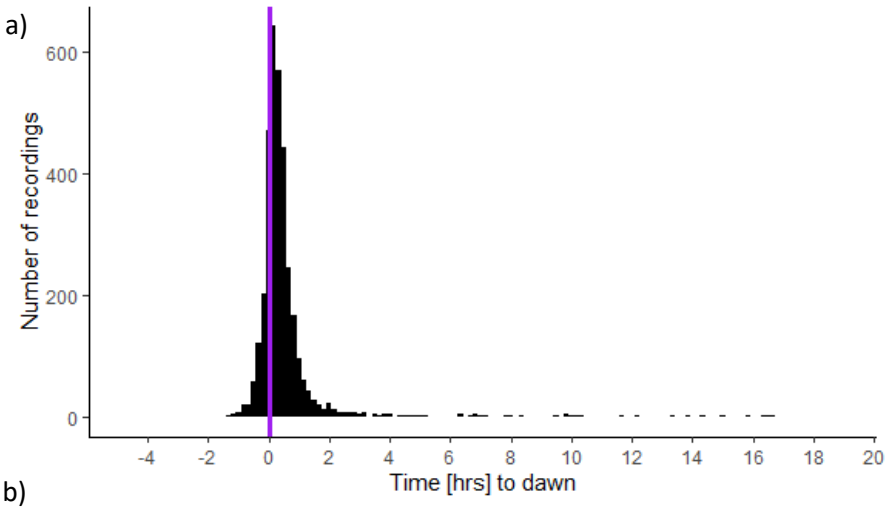



Figure 4: Local recording times:

a) Overall numbers,

b) distribution across the recording period



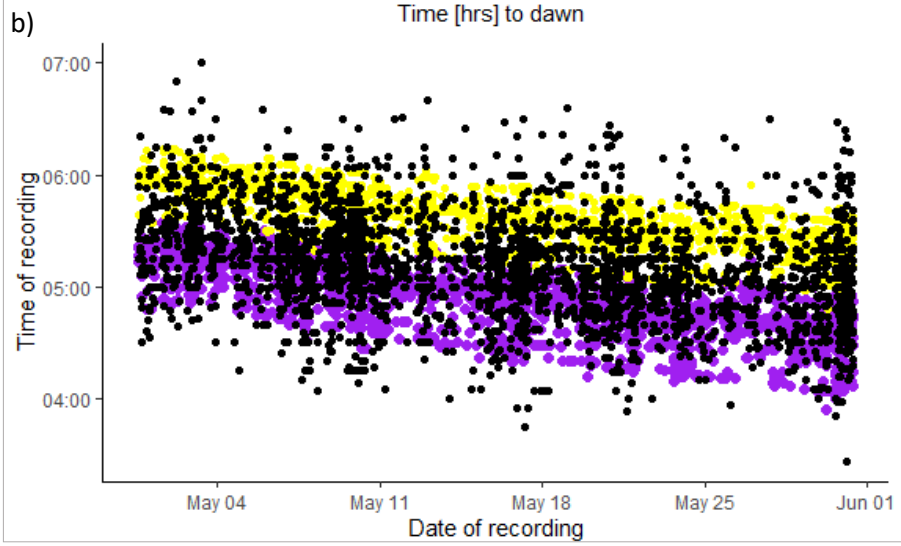




Figure 5: Local recording time with respect to dawn

a) Time from dawn (purple vertical line) for all recordings (black bars)

b) Local time of each recording (black), and of the corresponding dawn (purple) and sunrise (yellow); data from Germany, Austria and Switzerland, within one hour before dawn until one hour after sunrise

## Location and habitat

Worldwide location data were analysed using R-package *rworldmap*. Table 2 shows the number of recordings (n=3481) from 50 different countries. 80% of the recordings came from Germany, about 5% from the USA and 3.4% from the UK.

Table 2: Number of recordings from different countries

| Country | Uploads | | | | | | |
|---|---|---|---|---|---|---|---|
| Germany | 2777 | Italy | 13 | Taiwan | 3 | Indonesia | 1 |
| USA | 164 | Portugal | 12 | Fiji | 2 | Israel | 1 |
| UK | 119 | Czech Rep. | 11 | Greece | 2 | Kazakhstan | 1 |
| Switzerl. | 73 | Belgium | 9 | Mexico | 2 | Latvia | 1 |
| India | 35 | Malaysia | 8 | New Zeal. | 2 | Malta | 1 |
| Austria | 33 | NL | 7 | Qatar | 2 | Nicaragua | 1 |
| Canada | 30 | Australia | 6 | Turkey | 2 | Poland | 1 |
| Japan | 25 | Brazil | 5 | Costa Rica | 1 | South Afr. | 1 |
| Spain | 23 | Chile | 4 | Egypt | 1 | Sri Lanka | 1 |
| France | 21 | Sweden | 4 | Estonia | 1 | Trinidad & | |
| Ireland | 15 | Bhutan | 3 | Ghana | 1 | Tobago | 1 |
| Thailand | 15 | Morocco | 3 | Guatemala | 1 | Venezuela | 1 |
| Finland | 14 | Norway | 3 | Honduras | 1 | NA | 17 |

Note that there were initial difficulties with the website's GPS entry mask which may have led to some false location data. It was possible to correct some of the obvious errors (e.g. blackbirds singing at the equator in the middle of the ocean), and the number of obviously false locations decreased once an improved input mask was online. 17 GPS data points were excluded. It may also be that some participants consciously entered false or random GPS values because it was not possible to leave the location blank. We are currently working on finding a solution for this, one of which being a dedicated Dawn Chorus app.

Defining a specific habitat from GPS points alone can be difficult: it may differ drastically with small changes in location (e.g. a cliff), and GPS data may be incorrect or not accurate enough (e.g. inside or next to buildings). Hence, the participants were asked to provide information about the habitat (similar to "Die Stunde der Gartenvögel") in which they had made their Dawn Chorus recording, in addition to providing GPS coordinates. **Fig. 6** shows that most recordings were made in habitats specified as "suburban" (41%), "city" (24%) or "village" (11%) by the participants (sum: 76%).

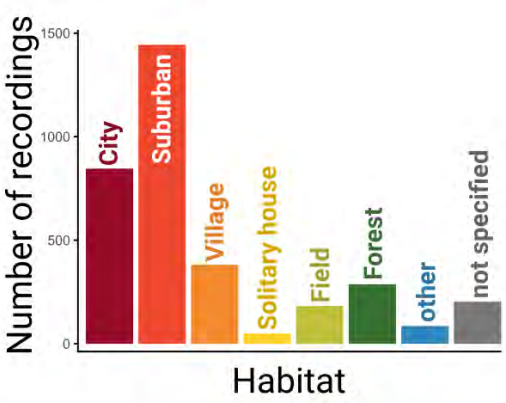



Figure 6: Number of recordings made in different habitats (specified by participants)

For 2604 recordings (made in Germany and within one hour before until one hour after sunrise) we further analysed the location in a GIS (geographic information system) approach, using QGIS (3.14). For each recording location, we determined the federal state (Bundesland) it was made in, as well as the respective land cover class, as established by the European CORINE land cover project (CLC 2018, 5ha; data from *Bundesamt für Kartographie und Geodäsie*). **Fig. 7** depicts the distribution of Dawn Chorus recordings, per land cover class (CLC) and per federal state, with almost half of the recordings coming from Bavaria. According to the CORINE land cover classification, the vast majority of recordings (82%) were made "built-up" areas, i.e. in cities, along roads or industrial areas etc. (note the resolution of 5 ha). Similarly, the same data subset consisted of 79% built-up ("suburban" (43%), "city" (24%) and "village" (12%)) habitats, as specified by the participants.

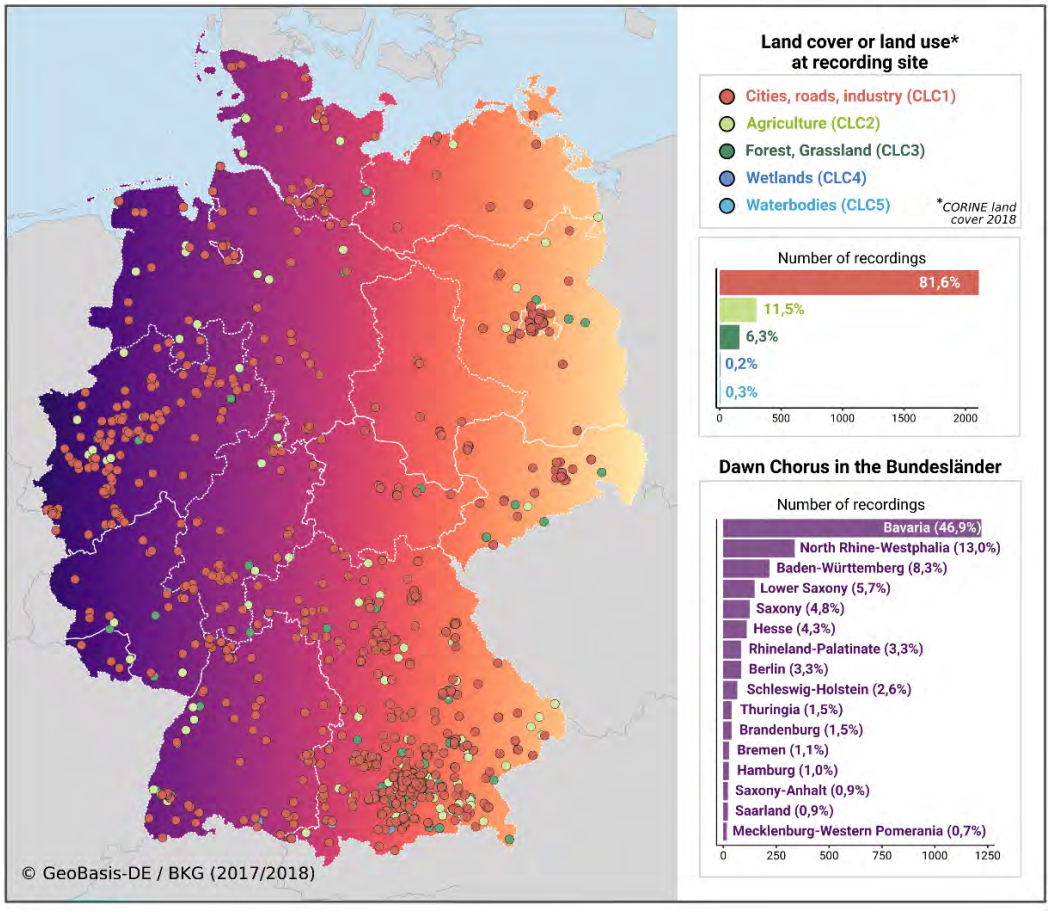



Figure 7: Distribution of recordings within Germany

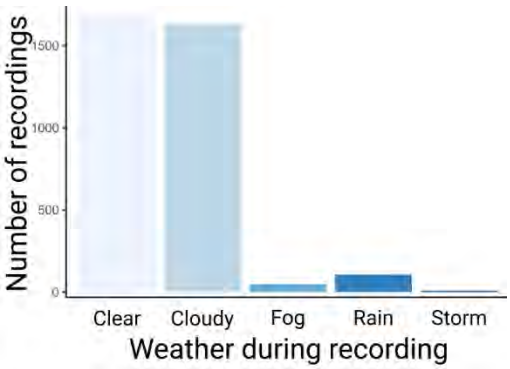
**Recording device:**

2790 participants (ca. 80%) used a smartphone, while 691 (ca. 20%) used "advanced" recording devices to make their recording.

**App used, Quality (sampling rate, bit rate)**:

These text fields were introduced to pre-sort the audio recording by quality, in case of insufficient metadata. For a next run, we hope to automatically obtain correct metadata instead of text fields.

**Weather conditions**:




This question was introduced for the purpose of statistical control, and will come into effect when the bioacoustic results are available for statistical analysis. A new category "foggy" was introduced after the beginning of the data collection period. **Figure 8** depicts the distribution of recordings made under different weather conditions.

**Figure 8Figure 1: Distribution of uploads over the course of *the recording period (May 2020)***

**Temperature:**

This text field was introduced as a statistical control, and will only become relevant once the bioacoustics analysis is complete and available for statistical analysis.

**Intensity and sources of anthropogenic noise:**

Unfortunately, this part of the scientific questionnaire was somehow lost in translation. Instead of asking participants about "human-made noise" experienced during the dawn chorus recording, the questionnaire enquired about the levels of "interference" in the sound recordings (in German: Störgeräusche). We have to assume that many participants thus answered the questions about intensity and source of noise differently than intended. For instance, we found apologies about "rustling rain jackets", "footsteps" or "wind" in the open text fields open for general comments. These are of course valid and important points for dealing with the sound recordings, but not quite what we had in mind here. In combination with noise type, we "salvaged" some of the categories ("street" and "airplane" noise), but the results should be interpreted with some caution. **Figure 9** depicts the intensity of noise/interference in different habitats (% of recordings).

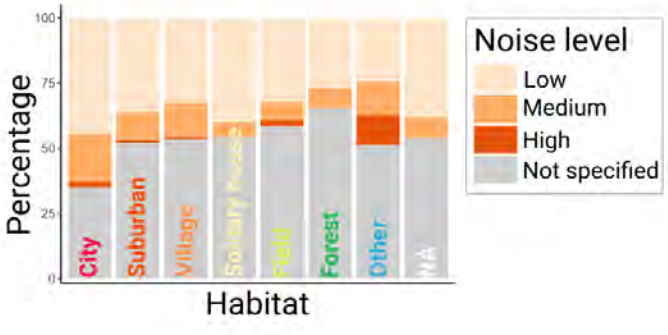



**Figure 9: Intensity of noise/interference in different habitats**

**In terms of anthropogenic noise sources**, the "type of human-made noise" was renamed to "type of interference", and contained "street", "airplane", "construction-work", "humans" and "other". **Figure 10a** shows that most recordings did not contain any information about noise.

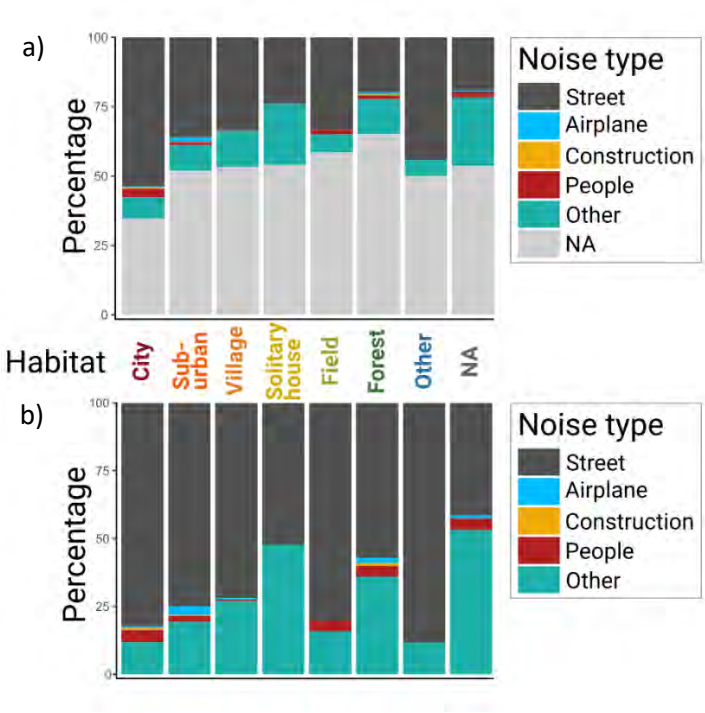



**Figure 10b** indicates that "street" was the most mentioned source of noise. Only very few participants mentioned "airplane" noise. Further analysis is necessary, in a multi-year comparison, to figure out whether this could be due to the lockdown situation of 2020, or rather an effect of the early time of the day (or a by-product of the questionnaire error). Living within a 25km radius from a busy airport myself, I can subjectively confirm that airplane noise became almost absent at the beginning of the lockdown in early 2020, and remained low even when street noise started to re-increase. Next year, we may start to analyse this in more detail by comparing the official traffic numbers.

**Figure 10: Percentage of different noise types in different habitats;**
**a) all data (including NA), b) without missing data points**

### Permission to contact you?

For 2785 recordings (80%), an email address was provided. For 2688 of these, participants also consented to being contacted via email (77%).

### Would you consider participating again next year?

This question was also dropped from the questionnaire in 2020. Since a large proportion of participants gave us their consent to be contacted, we will send out an email early on to encourage participation for next year which is important for a multi-year comparison of the collected data. In this way we could also recruit potential participants for using advanced recording equipment (see Future development section below for details).

## Recognised bird species

Another point which should not be underestimated is participant species recognition. Recognising bird species via their song alone is a challenging task for many people. Hence, the species recognised by the participants should not be viewed as absolute species frequencies for a biodiversity index. However, they do allow drawing some interesting conclusions, especially when comparing the data with the results of other citizen science projects.

The word cloud in Figure 11, created as social media content (using R-packages *wordcloud* and *RColorBrewer*), illustrates the relative frequencies of all non-scientific species names mentioned by the participants (from open text field; including unspecific common names such as "tit" or "crow"; data from Germany, n= 1197 recordings).


Figure 111: Word cloud of the bird species recognised by the participants

"Die Stunde der Gartenvögel" (The hour of the garden birds) of the German environmental NGOs *NaBu* and *LBV* is an established citizen-science bird census project in Germany (with participation from Austria and Switzerland). It takes place every year during a weekend in early May, and is hence suitable for a rough comparison with project Dawn Chorus. In this project, participants are called to count the number of different birds (maximum number of simultaneously occurring birds of the same species) observed during one hour in their gardens or in other locations. Table 3 shows the frequencies (% of occurrences) of all mentioned non-scientific species names at the different locations in Germany (n=713) for project Dawn Chorus. Table 4 compares the frequencies of bird species (excluding non-specific names) mentioned in Dawn Chorus and Die Stunde der Gartenvögel (2020). Some results are apparently similar or identical, for instance, the Common blackbird (*Turdus merula*) and Great tit (*Parus major*) both occupy places 1 and 2, respectively, in both projects. Other results differ strongly, for example, the Common cuckoo (*Cuculus canorus*), Eurasian blackcap (*Sylvia atricapilla*), Common chiffchaff (*Phylloscopus collybita*) and Eurasian wren (*Troglodytes troglodytes*), all among the top 10 in Dawn Chorus, only appear in places 44, 23, 28, 24, respectively, in Die Stunde der Gartenvögel.

These differences may be associated with the differences between the recording times (early morning versus the entire day) and data collection periods (entire month versus one weekend) of project Dawn Chorus and Die Stunde der Gartenvögel, respectively. However, another very strong difference between the projects lies in the different focus of methodology: in "normal" bird census or bird observation projects, the focus strongly lies on making visual observations, while acoustic information is provided much more scarcely, if at all. For instance, the species identification guides provided by Die Stunde der Gartenvögel are images of different bird species, and do not contain examples of the characteristic song. Hence, and given that humans are highly visual creatures, only a minority of participants would be expected to focus on acoustic cues without being specifically encouraged to do so, as in project Dawn Chorus. Yet many bird species are often easier heard than seen, and even untrained lay people may easily recognise some species via the characteristic vocalisations (e.g. the Common cuckoo (*Cuculus canorus*)). Also, some species are difficult to tell apart by eye, but produce very distinct songs, such as the Willow warbler (*Phylloscopus trochilus*) and its close relative, the Common chiffchaff (*Phylloscopus collybita*). In other cases, it may be easier to provide pictures than sounds for species identification (e.g. House sparrow (*Passer domesticus*) versus Eurasian tree sparrow (*Passer montanus*)). Eventually, however, one of the biggest advantages of project Dawn Chorus is that the available sound recordings

would (if recording quality and an efficient bioacoustic analysis pipeline permit) allow verifying, complementing and correcting the species information provided by the participants – which is important both for the educational component, as well as for answering biodiversity questions.

Interestingly, Tables 3 and 4 show that the Great tit (*Parus major*) was detected much more frequently than the Blue tit (*Cyanistes caeruleus*). This could be due to a time effect (GT sing later than BT), and may also be due to the fact that blue tits sing higher and may not be heard as well by human ear, especially by older people. However, it may also reflect what has been going around the media: a virus-induced population decline in the Blue tit. Indeed, Die Stunde der Gartenvögel 2020 noticed a 25% drop in numbers compared to in 2019.

Table 3: Percentage of all 132 mentioned non-scientific bird species names (data from Germany)

| **Species name** | **Locations (%)** | | | | |
|---|---|---|---|---|---|
| Blackbird | 80.1 | Tawny owl | 1 | Sardinian warbler | 0.3 |
| Great tit | 22.4 | Goldcrest | 1 | Sedge warbler | 0.3 |
| Blackcap | 14.2 | Thrush | 0.8 | Thrush nightingale | 0.3 |
| Cuckoo | 13.2 | Skylark | 0.8 | Feral pigeon | 0.3 |
| Robin | 11.8 | Stock dove | 0.8 | Common gull | 0.3 |
| Crow | 11.5 | Mallard | 0.8 | Wood warbler | 0.3 |
| Tit | 10.9 | Reed warbler | 0.8 | Warbler | 0.3 |
| Chaffinch | 10.5 | Whitethroat | 0.7 | Hoopoe | 0.3 |
| Sparrow | 10.5 | Jay | 0.7 | Meadow pipit | 0.3 |
| Carrion crow | 9.1 | Greylag goose | 0.7 | Wagtail | 0.1 |
| Wood pigeon | 8.7 | Domestic chicken | 0.7 | Tree pipit | 0.1 |
| Pigeon | 8 | Dunnock | 0.7 | Common snipe | 0.1 |
| Wren | 8 | Firecrest | 0.7 | Curlew | 0.1 |
| Chiffchaff | 7.4 | Goldfinch | 0.7 | Whinchat | 0.1 |
| House sparrow | 7.3 | Duck | 0.6 | Siskin | 0.1 |
| Starling | 6.6 | Spotted flycatcher | 0.6 | Grasshopper warbler | 0.1 |
| Black redstart | 6.3 | Green woodpecker | 0.6 | Icterine warbler | 0.1 |
| Song thrush | 5.9 | Gull | 0.6 | Goshawk | 0.1 |
| Blue tit | 5.6 | Raven | 0.6 | Woodlark | 0.1 |
| Greenfinch | 4.1 | Black woodpecker | 0.6 | Lesser black-b. gull | 0.1 |
| Nightingale | 3.5 | Coal tit | 0.6 | Canada goose | 0.1 |
| Magpie | 2.8 | Kestrel | 0.6 | Cormorant | 0.1 |
| Domestic chicken (m) | 2.7 | Turtledove | 0.6 | Leaf warbler | 0.1 |
| Collared dove | 2.4 | Coot | 0.4 | Yellow-legged gull | 0.1 |
| Pheasant | 2 | Grey heron | 0.4 | Medium spotted woodp. | 0.1 |
| Tree sparrow | 1.8 | Ring-necked parakeet | 0.4 | Peacock | 0.1 |
| Redstart | 1.8 | Lapwing | 0.4 | Boreal owl | 0.1 |
| Short-toed tree creeper | 1.7 | Lesser whitethroat | 0.4 | Ruddy shelduck | 0.1 |
| Yellowhammer | 1.7 | House martin | 0.4 | Redwing | 0.1 |
| Jackdaw | 1.4 | Barn swallow | 0.4 | Redshank | 0.1 |
| Finch | 1.4 | Reed bunting | 0.4 | Swallow | 0.1 |
| Common redstart | 1.4 | Marsh warbler | 0.4 | Swan | 0.1 |
| Common swift | 1.4 | Pied flycatcher | 0.4 | Long-tailed tit | 0.1 |
| Willow warbler | 1.3 | Spotless starling | 0.3 | Cetti's warbler | 0.1 |
| Garden warbler | 1.3 | Pallid swift | 0.3 | Waxwing | 0.1 |
| Bullfinch | 1.3 | Rock dove | 0.3 | Golden bishop | 0.1 |
| Woodpecker | 1.3 | Little ringed plover | 0.3 | Blacktailed godwit | 0.1 |
| Fieldfare | 1.3 | Goose | 0.3 | Eagle owl | 0.1 |
| Spotted woodpecker | 1.1 | Owl (Kauz) | 0.3 | Common treecreeper | 0.1 |
| Nuthatch | 1.1 | Black-headed gull | 0.3 | Willow tit | 0.1 |
| Serin | 1 | Lark | 0.3 | White-backed woodpecker | 0.1 |
| Warbler (Grasmücke) | 1 | Mistle thrush | 0.3 | Wild pigeon | 0.1 |
| Oriole | 1 | Hooded crow | 0.3 | Bright-capped cisticola | 0.1 |
| Rook | 1 | Red-backed shrike | 0.3 | | |

Table 4: Comparison of the top 20 bird species mentioned in the German dataset of project „Dawn Chorus" and in „Die Stunde der Gartenvögel" (2020)

| Rank (% of locations) | Dawn Chorus (Rank in SdG) | Stunde der Gartenvögel (SdG) |
|---|---|---|
| 1 | Blackbird (1) | Blackbird |
| 2 | Great tit (2) | Great tit |
| 3 | Blackcap (23) | House sparrow |
| 4 | Cuckoo (44) | Blue tit |
| 5 | Robin (6) | Magpie |
| 6 | Chaffinch (9) | Robin |
| 7 | Carrion crow (12) | Wood pigeon |
| 8 | Wood pigeon (7) | Starling |
| 9 | Wren (24) | Chaffinch |
| 10 | Chiffchaff (28) | Greenfinch |
| 11 | House sparrow (3) | Tree sparrow |
| 12 | Starling (8) | Carrion crow |
| 13 | Black redstart (16) | Great spotted woodpecker |
| 14 | Song thrush (36) | Jay |
| 15 | Blue tit (4) | Collared dove |
| 16 | Greenfinch (10) | Black redstart |
| 17 | Nightingale (53) | Common swift |
| 18 | Magpie (5) | House martin |
| 19 | Domestic fowl (no mention) | Common redstart |
| 20 | Collared dove (15) | Wagtail |

# DISCUSSION

Due to the restrictions of public life in early 2020, people all over the world had to massively and unexpectedly reduce their usual activities. There have been many reports that this pandemic-induced "silent spring" seems to have heightened people's awareness to nature and specifically to nature's sounds. Project Dawn Chorus took advantage of this unexpected situation to raise awareness towards biodiversity and anthropogenic noise, by encouraging participants to stop and listen, and experience this beautiful natural phenomenon.

Overall, participation and media attention of project Dawn Chorus were very positive, especially given the short preparation phase, and despite the challenge of getting up very early in the morning. It is possible that project Dawn Chorus may have achieved higher participation numbers compared to in "normal" years. Yet participation remained high even after the strict lockdown was eased (in Germany), and it is not inconceivable that lockdown situations may have to be repeated in the future. We believe that another reason for the high participation numbers was the low "entry-level" – using one's everyday smartphone – required for making a valuable contribution.

Given the short preparation phase in 2020, there is obviously room for improvement in a number of aspects, in order to establish project Dawn Chorus as a (citizen) science project that aims to quantify biodiversity in different habitats, and the effects of human-made noise, in a multi-year approach. This includes solving technical issues, as well as establishing collaborations with IT scientists for the bioacoustic analysis. We also seek to expand the project's scientific and educational value, and its character as a citizen science project, with stronger involvement of the participants, with improved, detailed and appealing background information, and focusing more strongly on anthropogenic noise and biodiversity. We hope that with more time for preparation at hand, we will be able to develop a simplified recording process and improved instructions (ideally an app) for the future, to welcome a broader audience, boost participation numbers (especially repeated participation), and help project Dawn Chorus to steadily gain attention over the years.

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First and foremost, we would like to thank all our participants – without them, project Dawn Chorus would not have been such a success! We also thank our scientific advisors, Prof. Kathrin Böhning-Gaese, Prof. Manfred Gahr, Dr. Bernie Krause and Dr Robert Lachlan. We are grateful to our project partners, Bayerische Akademie für Naturschutz und Landschaftspflege, Bayerisches Staatsministerium für Umwelt und Verbraucherschutz, Bayerisches Staatsministerium für Wissenschaft und Kunst, Bund Naturschutz in Bayern e.V., LBV, NABU, Vielfaltsmacher (Bayerischer Landesverband für Gartenbau und Landespflege e.V.), WWF, Staatliche Naturwissenschaftliche Sammlungen Bayerns, UN-Dekade Biologische Vielfalt.

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# LIST OF TEXT BOXES, TABLES AND FIGURES

## Text boxes



## Tables



## Figures