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DATA DESCRIPTOR

# A large-scale acoustic dataset of a passerine with spatially variable vocal behavior: fine-scale annotations of song and call types

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The study of bird vocal behavior provides insights into ecology, evolution, and conservation. Prior research has mostly focused on bird songs, with limited attention to calling behavior. Although the origins and functions of these vocalizations differ, no detailed annotated acoustic datasets are currently available including both bird songs and calls. Here, we present an acoustic dataset with standardized recordings and detailed annotations of singing and calling behavior in the Dupont's lark (*Chersophilus duponti*), a passerine with spatially variable vocal behavior. Recordings were collected across a large spatial scale (20 populations) to capture geographic variation in vocalizations. The dataset includes 4,297 annotated songs from 191 singing males, representing 401 song types, and 795 annotated calls from 97 calling males, representing 80 call types. Annotations provide precise categorization of song and call types, enabling comparisons of individual and population vocal repertoires, geographic variation, and potential effects of habitat fragmentation on vocal behavior. This dataset is intended for reuse in studies of bird vocal behavior, comparative analyses of song and call patterns, and research on passerine acoustic communication.

## Background & Summary

Given the multiple implications, bird vocalizations have attracted the interest of scientists and ornithologists since the late 19<sup>th</sup> and early 20<sup>th</sup> centuries<sup>1,2</sup>. Among other aspects, the study of avian vocal behavior provide valuable insights into: (i) individuals' reproductive status, including its role in mate attraction and courtship signaling<sup>3,4</sup>, (ii) physical condition and individual identity<sup>5,6</sup>, (iii) the processes driving local adaptation and population differentiation<sup>7,8</sup>, (iv) group cohesion and social structure, as seen in contact calls used by flocking species<sup>9</sup>, (v) the provision of parental care, including nestling begging calls<sup>10</sup>, (vi) the location and sharing of food resources, such as food calls in corvids or cooperative breeders<sup>11</sup>, and (vii) alarm and predator-related communication, including threat, mobbing or distress calls aimed at deterring predators or warning conspecifics<sup>12</sup>. Despite this interest from disciplines as ecology, evolution, behavior, and neurobiology, much remains to be discovered regarding the origin, evolution, and function of bird vocalizations<sup>13</sup>. Indeed, the evolution and function of bird vocalizations are context dependent, varying among species, populations, and studies. This

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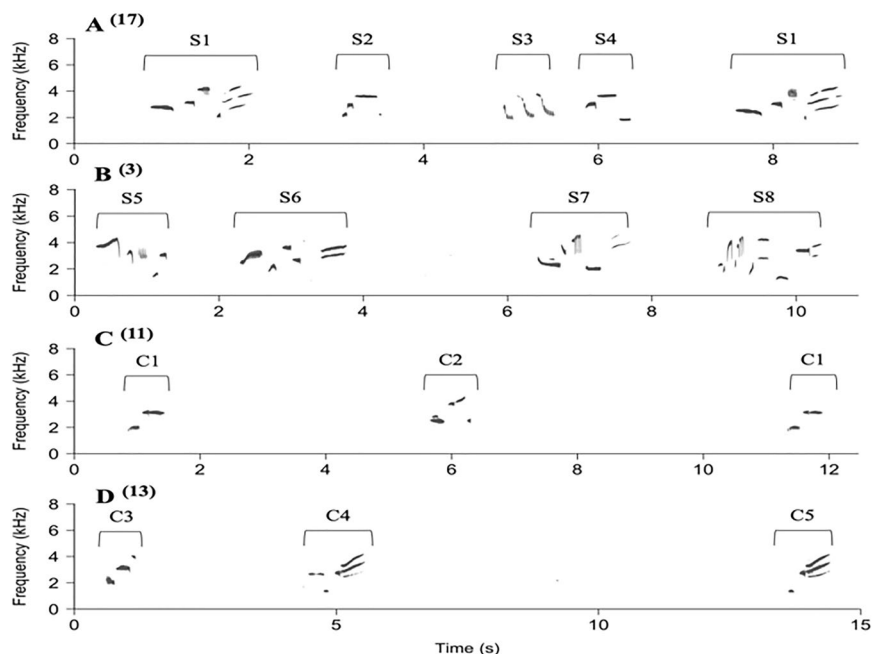
variation among research is partly explained by the wide diversity of vocalizations produced by birds, which include songs, territorial, warning, group, distress, and begging calls, among others<sup>14</sup>. Two of the commonest vocalizations produced by birds, and thus the most studied, are songs and territorial calls (hereafter “calls”).

Songs are typically complex and, in many bird species, learned from tutors. In males, and in some species also in females, songs are often linked to several aspects of sexual selection, including mate attraction, intra- and inter-sexual competition, and communication within and between pairs, including duetting species. In contrast, calls, which can also be produced by both sexes, are commonly described as innate and tend to be shorter than songs, and often associated with territorial defense or immediate communicative purposes<sup>14–16</sup>. It is worth noting that the distinction between what is a song and a call is not always clear and may vary among species<sup>17</sup>. Comparative studies of both vocalization types offer valuable insights into both the ecology and behavior of the species and the origin and function of songs and calls. For example, analysing diel and monthly variation in songs and calls for the same species can clarify the distinct functions of each vocalization type<sup>18,19</sup>. Similarly, seasonal changes in vocal output may also provide important information about the breeding period and migration timing of birds<sup>20,21</sup> and behavioral responses to environmental changes, such as reactions to intruders or predators<sup>22</sup>. Consequently, although still rare in the literature, comparative studies of both songs and calls recorded in the field hold potential to deepen our understanding of avian vocal behavior and spatial organisation, laying potential for interpreting population dynamics in changing ecological contexts.

In addition to behavioral and ecological applications, in recent decades, the study of bird vocalizations has also become an important tool in conservation biology<sup>23</sup>. Vocal learning occurs on many bird species, including passerines, parrots and hummingbirds<sup>24</sup>, which facilitates the development of regional dialects (i.e., distinct spatial vocalization patterns) that offer crucial insights into the adult dispersal, gene flow and connectivity between populations<sup>25,26</sup>. Likewise, analysing the variations in the degree of vocalization sharing among groups of neighbouring and non-neighbouring individuals can reveal patterns of social interactions and habitat fragmentation, as disruptions in vocal exchange often indicate barriers to adult movement and increased isolation among groups and populations<sup>27,28</sup>. In this sense, acoustic parameters such as the diversity of vocalizations within and among individuals and the vocal activity rate serve as indicators of population status and viability<sup>29,30</sup>, as well as reproductive status, with higher complexity and frequency of vocalizations often linked to active breeding and better condition of individuals<sup>3,4</sup>. Thus, by studying birds’ vocal behavior, researchers can non-invasively detect early-warning signs of environmental change, assess population viability and reproductive success, and guide conservation monitoring and management efforts<sup>23</sup>.

In recent years, several large-scale collaborative initiatives have substantially increased the availability of avian acoustic data, including publicly accessible repositories such as Xeno-Canto ([www.xeno-canto.org](http://www.xeno-canto.org)), Avibase<sup>31</sup>, and the Macaulay Library ([www.macaulaylibrary.org](http://www.macaulaylibrary.org)). These platforms have facilitated global access to thousands of crowd-sourced recordings, enabling research on geographic variation in bird vocalizations<sup>32,33</sup>, global analyses on bird song frequency<sup>34</sup>, and other large-scale ecological patterns<sup>35</sup>. In addition to these repositories, numerous annotated acoustic datasets have emerged as valuable resources for studying avian vocal behavior. Such datasets are typically generated within the context of regional monitoring programs, species-specific research projects, or conservation initiatives. Therefore, most of these datasets remain constrained in geographic and taxonomic coverage and often rely on opportunistic sampling, limiting their suitability for broader ecological applications<sup>13,36,37</sup>. A notable exception in terms of scale is the recently published World Annotated Bird Acoustic Database (WABAD), which contains fine-scale annotations of over 1000 bird species from 27 countries and distributed across 13 biomes<sup>38</sup>. While WABAD represents a major step forward in the curation of global acoustic datasets, its annotations do not explicitly distinguish the different vocalization types detected (e.g., song, territorial call, contact call, alarm call), thereby limiting its applicability to fine-scale behavioral studies. In parallel, the development of smartphone applications powered by deep learning algorithms—most prominently BirdNET<sup>39</sup> and Merlin<sup>40</sup>—has greatly expanded ornithological citizen science participation worldwide. These mobile applications have generated tens of millions of georeferenced acoustic detections that have been used to examine song dialect boundaries, migratory movements, and seasonal vocal activity at continental scales<sup>41</sup>. Nonetheless, these data also lack standardised sampling protocols and detailed annotations distinguishing vocalization types, which reduces their utility for behavioral and ecological analyses requiring precise vocalization-type categorisation.

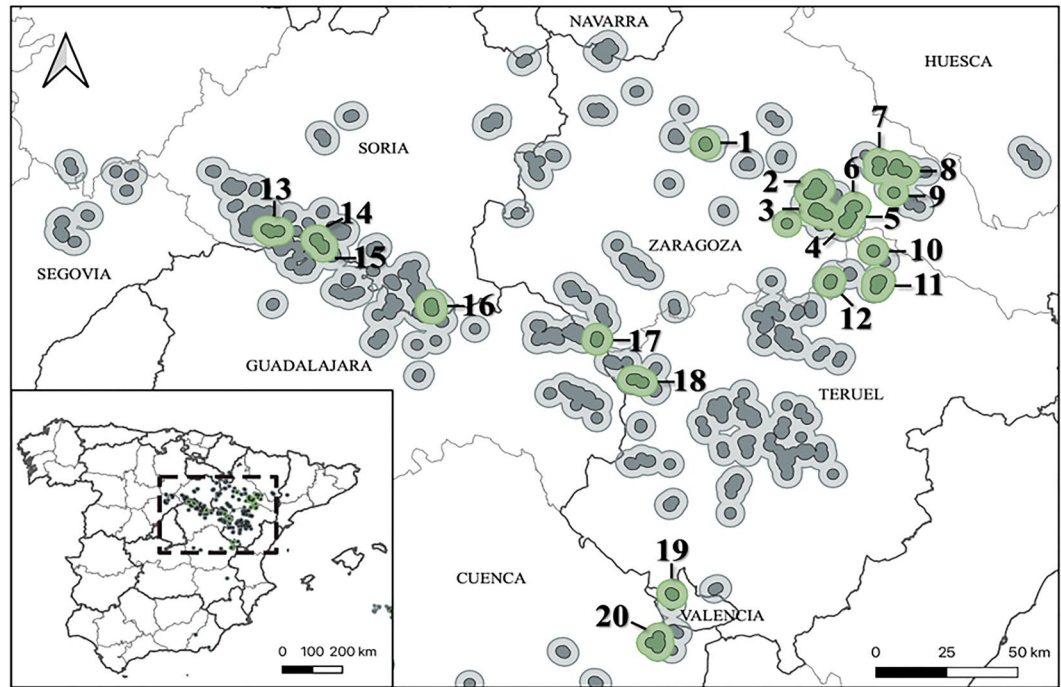
To address the lack of acoustic datasets with detailed annotations of different song and call types, we present a fully curated and annotated acoustic dataset on the vocal behavior of the Dupont’s lark (*Chersophilus duponti*) covering most of the species’ distribution area in Europe. We selected the Dupont’s lark as a target species because it has been the subject of extensive acoustic research<sup>19,28,29,42–45</sup>, providing a strong background for further comparisons. Moreover, the Dupont’s lark utters songs and calls at a high rate and exhibits extraordinary spatial variability among populations, often including distinct dialects among groups of males inhabiting the same habitat patch<sup>28</sup>, which makes the Dupont’s lark an ideal model for investigating differences in song and call usage and assessing the effects of habitat fragmentation on birds’ vocal behavior. To enhance reproducibility and facilitate further use of the dataset, we: (i) followed a standardized field protocol ensuring the complete recording of individuals’ song and call repertoires, and (ii) applied a strict annotation protocol categorizing every recorded song and call recorded at the type level. Additionally, our dataset is accompanied by two metadata files. One contains vocalization level information, including the onset and offset times of each vocalization within the recording, minimum and maximum frequency, vocalization type labels, and the ID of the recorded individual. The other metadata file provides detailed information for each recorded male (date and population where recorded, geographic coordinates) and for each surveyed population, enabling further analyses relating individual or population vocal behavior to habitat metrics. We hope that our dataset—currently the largest publicly available acoustic dataset with detailed annotations of both song and call types for a bird species—will significantly contribute to advancing research on avian ecology, vocal behavior, and conservation.



**Fig. 1** Sonograms showing the songs (A,B) and calls (C,D) of four Dupont's larks. Boxes indicate the different song and call types identified within each individual. The classification of songs and calls was based on spectrogram morphology, temporal patterns, frequency characteristics, and number of notes. For example, song type S1 and call type C1 each appear twice in sonograms A and C, respectively. The population where each sonogram was recorded is indicated in brackets after the corresponding capital letter, according to the ID column in Table 1.

Population ID	Population	Patch size (ha)	Population size	SONG			CALLS		
				Males with song recorded	Population song repertoire	Mean individual song	Males with calls recorded	Population call repertoire	Mean individual call
1	Urrea Jalón	158,69	32	10	35	7,4	7	6	2,71
2	Mediana	510,13	53	13	54	6,69	3	7	2,33
3	Planerón Lomaza	771,64	75	13	38	6,08	8	11	2,75
4	Planerón Sur	239,96	50	7	20	5,57	9	4	2,44
5	Planerón Norte	90,23	26	12	17	5,67	4	4	1,5
6	Fuentes	260,81	9	7	12	6	1	3	3
7	Pina Rabasa	105	29	10	17	5,2	1	4	4
8	Pina Castane	486,43	43	12	34	6,5	6	4	1,5
9	Pina Lerín	26,97	3	3	8	7	2	2	1,5
10	Azaila	42,06	21	15	12	6,07	8	3	2,38
11	Albalate	370,17	26	9	27	6,89	7	18	3,29
12	Lécera	126,71	32	9	20	5,44	4	8	3
13	Retortillo	356	73	10	26	5,5	7	7	2,14
14	Barcones Riba	132	17*	7	12	5,14	7	5	2,43
15	Barcones Pitfall	393	48	7	14	5,71	4	3	2
16	Layna	888	77	9	23	5,22	5	4	2,6
17	Embid	110	22	9	12	5	4	6	2
18	Blancas	536	23	8	24	5,88	5	9	3,2
19	Hontanar	198,9	12	10	12	4,5	0	0	0
20	Moya	274	33	11	24	5,64	5	6	2,6
Total				191	401	5,86	97	80	2,46

**Table 1.** Summary table indicating the ID and name of each Dupont's lark population, along with patch size (ha) and population size (number of males counted). For each vocalization type, the table also shows the number of males recorded, the population repertoire, and the mean individual repertoire for each population. The "Total" line shows the total number of males singing and calling recorded, the total number of song and call types identified in the study, and the mean individual song and call repertoire across all studied populations.



**Fig. 2** Distribution range of the Dupont's lark in Spain (grey circles). The green circles identify the 20 Dupont's lark populations included in this study. Numbers correspond to the population id as shown in Table 1.

## Methods

The Dupont's lark (*Chersophilus duponti*) is a resident, territorial, and socially monogamous passerine, although extra-pair copulations may occur<sup>46</sup>. The species is distributed through North Africa and Spain, the only European country where the species occurs. It is a diurnal species with high vocal activity during the hour before sunrise. The Dupont's lark uses many vocalization types, mainly songs and territorial calls, which have been extensively studied<sup>28,42,43,45</sup>, but its repertoire also includes distress calls, warning calls, and clucking calls, which are more rarely uttered<sup>42,45</sup>. Songs and territorial calls (calls hereafter), the two vocalization types considered in this study, are only uttered by males and both uttered at high output during the dawn chorus of the species<sup>19</sup>. Songs, which are learned after summer dispersal from nearby adult males<sup>29</sup>, typically includes 3–8 discrete song types, which are largely shared and repeated in the same order by neighbouring males<sup>29</sup>. A song type consists of a small number of song units (usually 2–4) occurring together in a specific sequence (Fig. 1). The territorial call of the Dupont's lark consists of discrete, short whistles — typically between one and three — that are regularly repeated in the same order<sup>29</sup> (Fig. 1). Territorial calls have been proposed to be learned before dispersal after a short learning phase in summer<sup>47</sup>.

**Study area.** The study was carried out from March to June (main breeding period of the Dupont's lark<sup>48</sup>) during 2024 and 2025, covering 20 steppe remnants occupied by the species in Spain (Fig. 2). The study areas (hereinafter referred to as “populations”) were patches of shrub-steppe vegetation, with some scattered trees embedded within a matrix dominated by cereal crops. We selected 20 populations that were well distributed across the European range of the species and differed in patch size (ha, estimated as the total amount of potential vegetation within that area), Dupont's lark abundance estimated through line transects, and isolation. Two populations were considered distinct when separated by more than 1 km of non-natural vegetation. Populations are considered here to represent spatially discrete areas, although they may not be completely genetically isolated. The patch size of the populations ranged from 80 to 1,903 ha, and the local population abundances, estimated through the line transect method<sup>49</sup> varied between 3 and 77 males (Table 1).

**Bird recording.** Each population was surveyed at least once per year during the hour before sunrise, when Dupont's lark vocal activity reached its peak<sup>19</sup>. Males were recorded within their territories from the closest possible distance (ranging from 10–70 m) without disturbing their natural vocal behavior. Recordings were made via portable digital flash-memory recorders — a Marantz PMD 661 or a TASCAM DR40 — both equipped with a Sennheiser ME 67 shotgun microphone with a K6 powering unit and wind protection. The frequency response of these microphones is largely flat in the range 20–20,000 Hz. Both recorders were programmed to record in.wav format with a sampling rate of 44.1 kHz and 24-bit resolution. Recordings were obtained only under favourable weather conditions (i.e., no rain and windless days). The location of each recorded male was determined via a GPS device (3–5 m accuracy). Although birds were not individually marked, all recordings of a given male, as well as those males within a 500 m radius, were obtained on the same day to minimise the risk of recording the same individuals on successive days.

Following assessments carried out in prior studies, singing males were recorded for at least two minutes, which has been proven to be sufficient to ensure that the complete individual song repertoire is captured<sup>27</sup>. Nonetheless, four of the 191 singing males (2.1% of the total) were recorded for less than two minutes, with a mean recording length of 94 seconds. With respect to calling behavior, we recorded a minimum of three calls per individual, which is sufficient to capture the individual's entire call repertoire<sup>42</sup>. In total, we recorded songs from 191 males and calls from 97 males. Due to low-light conditions under which recordings were obtained and shy behaviour of the species, it was not possible to reliably determine whether song and call recordings may correspond to the same individual. Therefore, individuals could not be matched between the song and call datasets. A summary table showing the number of individuals recorded singing and calling in each population, as well as summary statistics on the species' vocal behavior of the species at the population level, is provided in Table 1.

**Audio annotation protocol.** For data standardisation we developed a detailed annotation protocol. The audio annotation process consisted of opening an audio recording in Raven Pro 1.6<sup>50</sup>, a commercial software commonly used by the scientific community working with wildlife vocalizations. The annotations were made on the spectral view of Raven Pro 1.6, using the default configuration parameters (Window type = Hann, DFT size = 512 samples, brightness = 50, contrast = 50). The display axes were kept constant, with the Y-axis extending to 10 kHz and the X-axis showing approximately 16 s per screen. Nonetheless, the annotator was free to adjust the parameters of the spectral view, especially brightness and contrast, to aid in identifying the target vocalizations.

The audio annotation process was carried out by a single expert ornithologist (C.D.A-M), familiar with the Dupont's lark vocal behavior, and consisted of visually and aurally checking each audio file in Raven Pro 1.6. The annotator marked with a box the portion of the file where a Dupont's lark vocalization, song or call, occurred. The box was narrowed to include every Dupont's lark vocalization in the recording and mark the exact starting and ending time, as well as the maximum and minimum frequency of each vocalization. We did not apply any quality criteria (e.g., considering only vocalizations of high signal-to-noise ratios or high amplitudes) to annotate Dupont's lark vocalizations in the dataset; the only criterion was that the expert was able to identify the vocalizations in the recording and to ensure that the recorded vocalizations belonged to the target individual (i.e., background vocalizations of neighbouring males were discarded). In total, we identified 401 different song types from 4,297 annotated songs from 191 singing males recorded, and identified 80 different call types from 795 annotated calls recorded from 97 calling males.

Once the annotation of the entire audio file was completed, the annotations were exported as a.txt file with the default Raven Pro format and with the exact same name as the audio file. However, to allow users to open the annotations via a free audio software we also saved the annotations as a.txt file compatible with the Audacity software (<https://audacityteam.org/>). Both software programs allow users to create, open, and modify annotations of audio files.

**Vocalization identification.** To characterize the presence of different song types in the audio files we conducted a detailed visual and aural inspection of the sonograms. To ensure consistent classification, a single observer (C.D.A-M) assessed all the audio recordings blindly. Each song type detected was coded with an ordinal number (e.g., S1, S2, S3; Fig. 1). When we found a song type that had been previously catalogued, we labelled it accordingly, and if it was a new song type it was categorized with a new label and added to the catalogue. Following prior research, the classification of song types was based on spectrogram morphology, temporal patterns, frequency characteristics, and number of notes<sup>42,43</sup>. In summary, two song types were considered the same if they matched in at least 75% of their notes and showed high similarity in note shape, timing, and frequency (Fig. 1). The same methodological procedure was applied to characterize the presence of different call types in audio recordings.

## Data Record

The dataset presented in this study is open access and accessible through Zenodo<sup>51</sup>. Within the Zenodo repository, there are two ZIP folders that follow the following structure:

```

/Song.zip/
├── DL_S1/
│   ├── DL_S1.wav
│   ├── DL_S1_Raven.txt
│   └── DL_S1_Audacity.txt
├── DL_S2/
│   ├── DL_S2.wav
│   ├── DL_S2_Raven.txt
│   └── DL_S1_Audacity.txt
└── -----
/Call.zip/
├── DL_C1/
│   ├── DL_C1.wav
│   ├── DL_C1_Raven.wav
│   └── DL_C1_Audacity.txt
└── -----

```

**Song folder.** This folder contains 191 subfolders identifying the Dupont's lark males recorded singing during the study. Each folder is identified by its ID name, which is composed of the code "DL" identifying the species (Dupont's Lark), the code "S" identifying the vocalization type (Song in that case) and a numeric value identifying each individual (for example, "DL\_S1"). Inside the folder of each individual we can find their respective recording (.wav format) files and annotations (.txt files). The annotations are provided in two formats, Raven Pro and Audacity (see Data annotation section). Raven Pro annotations contain eight columns with the following information:

- **Selection:** Selection ID
- **View:** Whether the information comes from the spectrogram or from the waveform
- **Channel:** Channel of origin of the recordings
- **Begin Time (s):** Start second of the selection
- **End Time (s):** End second of the selection
- **Low Freq (Hz):** Lowest frequency of the selection
- **High Freq (Hz):** Highest frequency of the selection
- **Song (or call) type:** Song (or call) type

Each annotation in Audacity is in two consecutive columns: the first column refers (following the prior nomenclature) to the Begin Time (in s), the End Time (in s), and the song (or call) type, and the next row, which starts with a "\", is the Low Freq (in Hz) and the High Freq (Hz).

**Call folder.** This folder follows the same structure and subfolders as those explained above, but contains in that case the calls of the 97 Dupont's lark recorded calling during the study and using the code "C" (call) to identify the vocalization type (for example, "DL\_C1").

The dataset also includes six additional files to support further analyses: (1) a metadata file ("*Metadata.csv*") containing detailed information for each recorded individual, including their ID, date of recording, approximate latitude and longitude (geographic coordinates in decimal degrees; rounded to within  $\pm 1$  km owing to the threatened status of the species) of recording, population where recorded, and recorder ("Tascam" or "Marantz") employed; (2) two binary presence-absence matrices ("*Song\_binary\_matrix.csv*" and "*Call\_binary\_matrix.csv*") indicating the presence or absence of each song or call type identified; (3) two distance matrices ("*Song\_distance\_matrix.csv*" and "*Call\_distance\_matrix.csv*") representing the spatial distances (in m) between all pairs of males and their Acoustic (Jacard) similarity indexes, and 4) an R script ("*Technical\_validation.R*") detailing the steps implemented to perform the technical validation.

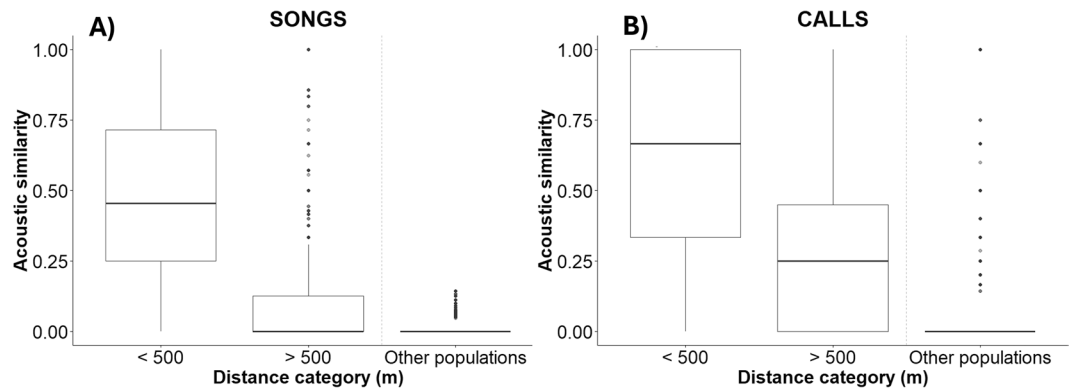
### Technical Validation

To ensure the technical quality and reliability of the annotated acoustic dataset, multiple quality-control procedures were implemented throughout all stages, from field recording to annotation, classification, and data processing.

**Quality of field recordings.** All the recordings were obtained: (i) under adequate weather conditions, (ii) using the same high-quality directional microphone, and (iii) with a reduced distance to the bird, which guarantees audio clarity and minimises external noise. Moreover, we followed a strict protocol regarding the minimum recording length for each male and minimized the risk of recording the same individual between successive visits by avoiding revisiting the same territory.

**Metadata standardization and file naming consistency.** Each audio recording included in the dataset is accompanied by a complete metadata record including rounded geographic coordinates of the recorded male, date and hour of recording, and recording equipment used, among others. This detailed metadata ensures the traceability of each recording and facilitates its further integration into larger-scale ecological and bioacoustic studies. Moreover, to prevent mismatches between recordings and their annotation files, a strict naming convention was enforced to ensure that both files share the same nomenclature. This procedure required renaming the original audio and annotation files following the structure described in the *Data record* section. Moreover, the annotation files are provided in the format of two of the most common audio software programs (Raven Pro and Audacity), which ensures data traceability, interoperability and facilitates its further use by researchers via different analytical tools.

**Consistency and agreement in audio annotation.** Audio annotation was performed using professional audio software and by a single expert ornithologist (C.D.A-M) who was highly familiar with the Dupont's lark vocalizations, following a standardized audio annotation protocol (see the Audio annotation protocol). The decision to have a single primary annotator ensured consistency in the classification process. Nonetheless, all cases in which i) the classification of a song or call type was uncertain, and ii) that a song or call type was annotated to be shared among populations, were reviewed by at least one additional experienced ornithologist to ensure its classification. This verification step involved independent inspection of the relevant spectrograms and audio files by up to two additional experts. Only when agreement was consistently agreed upon by at least two researchers was the vocalization type confirmed. This cross-checking procedure provides an additional safeguard against misclassification, ensuring that the final catalogue of song and call types is reliable and robust. Moreover, after this classification, the dataset underwent a thorough quality-control process to verify that the same vocalization type was never duplicated under different labels, and to confirm that all the annotation files correctly matched to their respective audio recordings.



**Fig. 3** Acoustic similarity (Jaccard) index of Dupont's lark songs and calls among males across three spatial categories: neighbouring males (<500 m), males from the same population at >500 m, and males inhabiting different populations.

**Repertoire metrics and song sharing analysis.** As the dataset was primarily designed for ecological and behavioral studies, we tested its applicability for ecological purposes by evaluating the impact of spatial distance among Dupont's lark males on the acoustic similarity of songs and calls.

To do this, first, we constructed binary (presence/absence) matrices for each individual, representing the occurrence of each distinct song or call type. From these matrices, we calculated the acoustic similarity among each pair of males, estimated via the Jaccard similarity index. The Jaccard similarity index, which ranges from 0 (no shared elements) to 1 (identical elements), is a metric that quantifies similarity between two sets based on the proportion of shared elements (i.e., vocalizations) relative to the total number of elements present in either set<sup>52</sup>. Using the real coordinates (not rounded) of each individual we calculated the Euclidean distance (in meters) for each pair of males. For each vocalization type, the comparisons were made across three distance categories: (i) neighbouring males (<500 m), (ii) males inhabiting the same habitat patch but excluding pairs of males in the first group (>500 m), and (iii) those occupying different habitat patches.

The results revealed a clear pattern of decreasing acoustic similarity with increasing distance for both vocalization types, with values close to zero for males inhabiting different populations (Fig. 3). Moreover, for the same spatial categories, calls consistently presented greater acoustic similarity than songs did. Overall, the average acoustic similarity index for males within 500 m was approximately 0.45 for songs and 0.60 for calls, whereas the acoustic similarity index decreased to nearly zero for males separated by more than 500 m within the same population but remained at ~0.25 for calls within the same population.

**External validation with prior research.** The quantitative measures derived from the dataset are consistent with previously published studies on Dupont's lark vocal behavior. In particular, the mean individual call repertoire size of 2.46 agrees with prior research on the species (range 1.88 – 2.12)<sup>44</sup>. Likewise, the patterns of song sharing — including greater sharing among neighbouring males and similarity close to zero for males of different populations — match the species' known spatial structuring of vocal repertoires<sup>28,42</sup>. This agreement with established findings provides additional evidence for the reliability and biological validity of the dataset.

### Usage Notes

This section provides technical guidance to assist researchers who wish to reuse the dataset. The audio annotations are provided in plain text format compatible with both Raven Pro and Audacity software but can also be converted to CSV files or other readable formats for further processing. We recommend using programming languages such as R to efficiently read, manipulate, and analyze these data tables. An example script for loading and preparing the data for ecological analyses is included in the Code Availability section.

Regarding the further use of the acoustic dataset, given the spatial variability in song and call types among, and even within, populations, we recommend focusing on parameters such as song and call diversity (i.g., repertoire size) and song rate (i.e., vocal activity uttered per unit of time) for within- and among-population comparisons. In contrast, analyses relying on comparison of acoustic features, such as frequency parameters, should be avoided because of the high spatial variability (i.e. dialects) among populations, which limits meaningful comparisons of acoustic features.

### Data availability

The dataset presented in this study is open access and accessible through Zenodo (<https://doi.org/10.5281/zenodo.17264916>). Detailed description regarding the files in the Zenodo repository can be read in the “Data Record” section of this article.

### Code availability

The code used to reproduce the analyses in the Technical Validation section is open access and accessible on Zenodo<sup>51</sup> with the name “Technical\_validation.R”.

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## Author contributions

C.P.-G. and C.D.A.-M. conceived the study, C.P.-G., C.D.A.-M., A.B. and P.S.-G. conducted the experiments and analysed the results, C.D.A.-M. managed the data collection and annotation, C.P.-G. and J.T. led the project management. All the authors contributed to the data annotation review and manuscript preparation.

## Competing interests

The authors declare no competing interests.

## Additional information

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