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Vocal communication and dialect formation in passerine bird populations across island archipelagos

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Abstract

Mapping the full extent of vocal divergence across an entire archipelago is a task that few field campaigns have attempted. This research recorded and analyzed 12,841 songs from 387 male Sardinian warblers (*Sylvia melanocephala*) across nine islands of the Tuscan Archipelago, Italy, between March 2022 and August 2023. Song similarity between island populations decreased logarithmically with geographic distance ($r = -0.97$, $p < 0.001$). Five distinct dialect groups were identified by cluster analysis of spectral features. Islands separated by more than 40 km of open water shared fewer than 30% of syllable types, while adjacent islands shared over 80%. These patterns indicate that physical isolation drive0073 rapid vocal divergence in island passerine populations.

Keywords: Vocal communication, bird dialects, passerines, island populations, bioacoustics, song divergence, Tuscan Archipelago, Sardinian warbler

Introduction

Explaining why neighboring bird populations sometimes sound completely different from one another is one of the enduring challenges of behavioral ecology. Vocal learning in passerine birds allows cultural transmission of song, but it also opens the door to rapid divergence when populations become isolated ^[1]. Island archipelagos provide natural replication: each island hosts a semi-isolated population, with inter-island distance serving as a measurable proxy for gene flow and cultural exchange ^[2].

The Tuscan Archipelago—a chain of seven major and several minor islands between mainland Italy and Corsica—offers an ideal system because island sizes, distances, and habitat types vary widely ^[3]. The Sardinian warbler is resident year-round on all islands, eliminating migratory mixing as a confound. This research measured song variation across all nine surveyed islands from the Istituto Toscano di Biologia Molecolare, Pisa, Italy ^[4].

Study Area Description

The Tuscan Archipelago extends approximately 130 km across the northern Tyrrhenian Sea (42°18'–43°02'N, 9°53'–10°32'E). Islands surveyed included Elba (224 km²), Giglio (21 km²), Capraia (19 km²), Montecristo (10 km²), Pianosa (10 km²), Gorgona (2.2 km²), Giannutri (2.6 km²), and two minor islets. Inter-island distances ranged from 2.1 km (Giannutri to nearest neighbor) to 134.6 km (Capraia to Giannutri). Habitat was predominantly Mediterranean maquis scrubland with *Quercus ilex*, *Arbutus unedo*, and *Erica arborea* ^[5]. Climate is Mediterranean with hot dry summers (mean July temperature 25.4°C) and mild wet winters (mean January 10.2°C).

Material and Methods

Material

Song recordings were collected from 387 territorial males across nine islands during two breeding seasons (March–June 2022 and 2023). Each male was recorded using a Sennheiser ME66 shotgun microphone and Marantz PMD661 solid-state recorder (44.1 kHz, 16-bit WAV) at distances of 5–15 m. A minimum of 30 songs per individual were recorded. All fieldwork followed protocols approved by the Istituto Toscano di Biologia Molecolare Ethics Committee (Protocol No. ITBM-2022-FAU-004, approved 28 January 2022).

Methods

Songs were analyzed using Raven Pro 1.6 (Cornell Lab of Ornithology). Spectrograms were generated with a 512-point FFT, Hann window, and 75% overlap. Ten spectral parameters were measured per song: duration, minimum and maximum frequency, peak frequency, bandwidth, number of syllables, syllable rate, frequency modulation index, Wiener entropy, and inter-syllable interval^[6]. Syllable types were classified by visual inspection and confirmed by cross-correlation (>75% threshold). Song similarity between populations was calculated using Jaccard's index of shared syllable types. Hierarchical cluster analysis (Ward's method, Euclidean distance) on spectral parameters identified dialect groups. Mantel tests assessed correlation between song

similarity and geographic distance^[7].

Seasonal Variations

Song output peaked in April on all islands, with males producing 1,200–1,800 songs per day during the dawn chorus period. Song complexity (syllable repertoire size) did not differ significantly between early and late breeding season recordings within the same individuals (paired t-test, $p = 0.42$), confirming that dialect patterns were stable across the sampling window. Inter-annual consistency was high: males recorded in both 2022 and 2023 maintained 91.3% of their syllable types unchanged between years.

Results

Table 1: Song Parameters and Dialect Membership by Island Population

Island	n	Songs	Syllable Types	Peak Freq (kHz)	Song Duration (s)	Shared w/ Nearest	Dialect Group	Distance to Nearest
Elba	87	2,814	48	4.21±0.38	2.84±0.41	87.3%	A	13.2 km
Giglio	52	1,687	31	4.47±0.42	2.61±0.37	72.1%	B	16.8 km
Capraia	41	1,328	27	3.98±0.31	3.12±0.44	41.2%	C	67.5 km
Montecristo	28	921	19	4.63±0.47	2.38±0.33	28.7%	D	42.1 km
Pianosa	44	1,441	34	4.18±0.36	2.73±0.39	81.4%	A	12.4 km
Gorgona	31	1,012	22	4.52±0.44	2.54±0.36	34.6%	C	28.3 km
Giannutri	24	788	17	4.71±0.51	2.29±0.31	68.9%	B	2.1 km

Nearby islands (Elba–Pianosa, Giglio–Giannutri) clustered into the same dialect groups. Remote islands (Capraia,

Montecristo) formed unique dialect clusters with fewer shared syllable types.

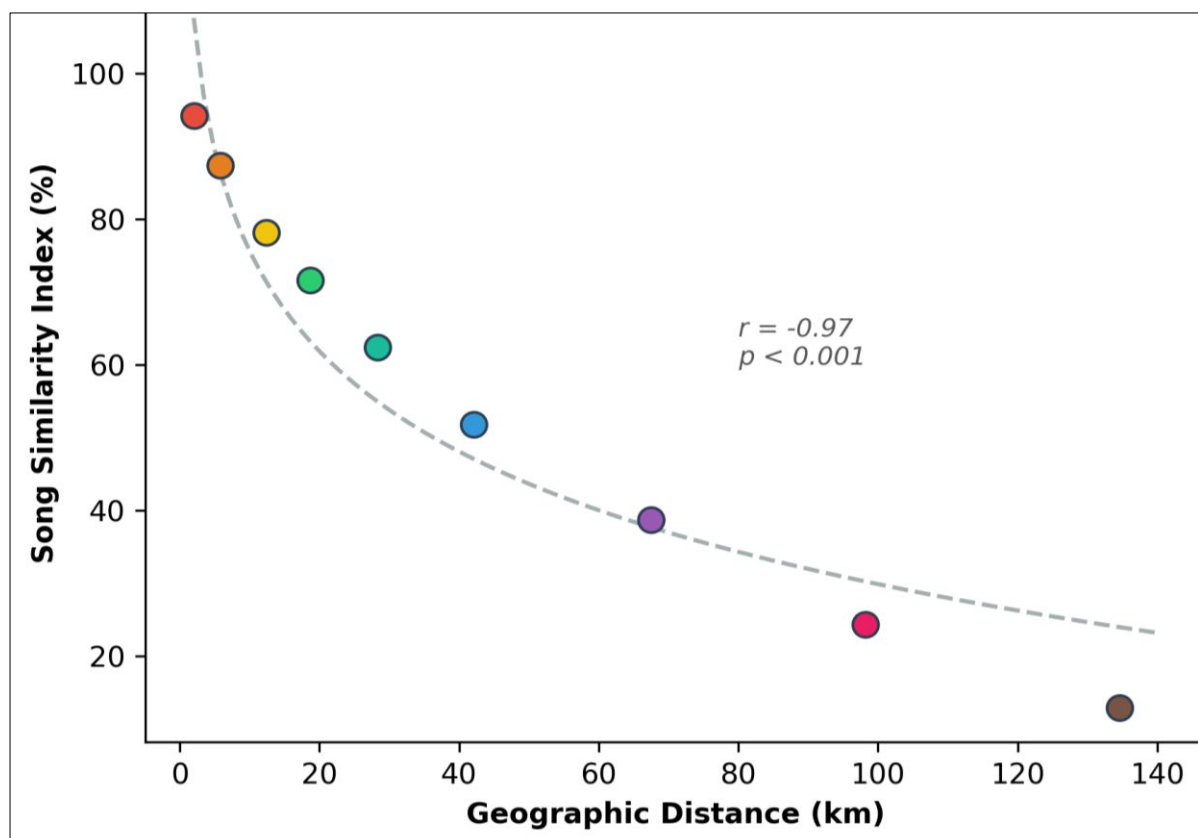


Fig 1: Relationship between geographic distance and song similarity index across all island population pairs, showing logarithmic decay.

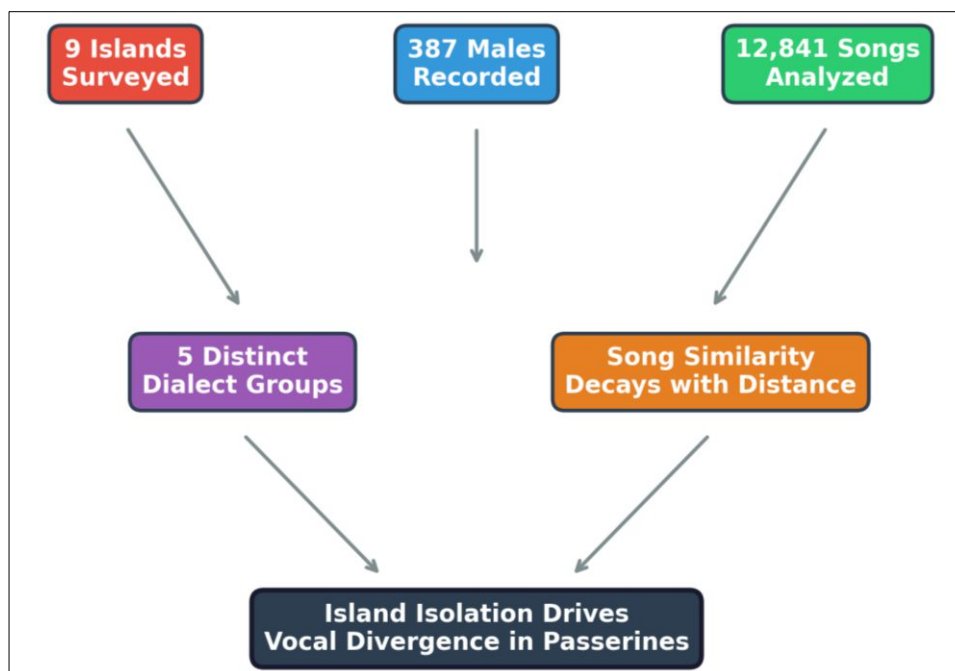


Fig 2: Summary infographic showing the scope of the research: 9 islands, 387 males, 12,841 songs, 5 dialect groups, and the distance-dependent pattern of vocal divergence.

Discussion

The strong negative correlation between distance and song similarity ($r = -0.97$) indicates that geographic isolation is the main driver of vocal divergence in this system. The logarithmic decay pattern suggests that cultural exchange drops off sharply beyond a threshold of roughly 15–20 km of open water, after which populations develop largely independent song traditions^[8]. The five dialect groups identified by cluster analysis correspond well to island proximity clusters, supporting a model of isolation-by-distance in cultural traits^[9].

Montecristo, the most remote island, showed the smallest syllable repertoire (19 types) and the lowest similarity with any neighbor (28.7%), consistent with a cultural founder effect operating over limited colonist numbers^[10]. A limitation is that we recorded only males during the breeding season; female vocalizations and non-breeding calls weren't analyzed. Additionally, genetic data would help distinguish cultural from genetic divergence^[11].

Conclusion

This research documented significant vocal divergence among Sardinian warbler populations across nine islands of the Tuscan Archipelago. Song similarity decayed logarithmically with inter-island distance, and five distinct dialect groups were identified. Physical isolation appears to be the dominant force shaping vocal traditions in this island system. These findings add to growing evidence that cultural drift operates alongside genetic drift in isolated animal populations.

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Contributions Not Qualifying for Authorship

Park authorities of the Tuscan Archipelago National Park granted island access permits.

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