



What's in a song?

An analysis of avian vocalization bouts in a northeastern forest

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Background

Within the morning chorus of north-temperate birds, there are a variety of songs and vocalizations used to attract mates or defend territory. But how are these crucial signals conveyed through song?

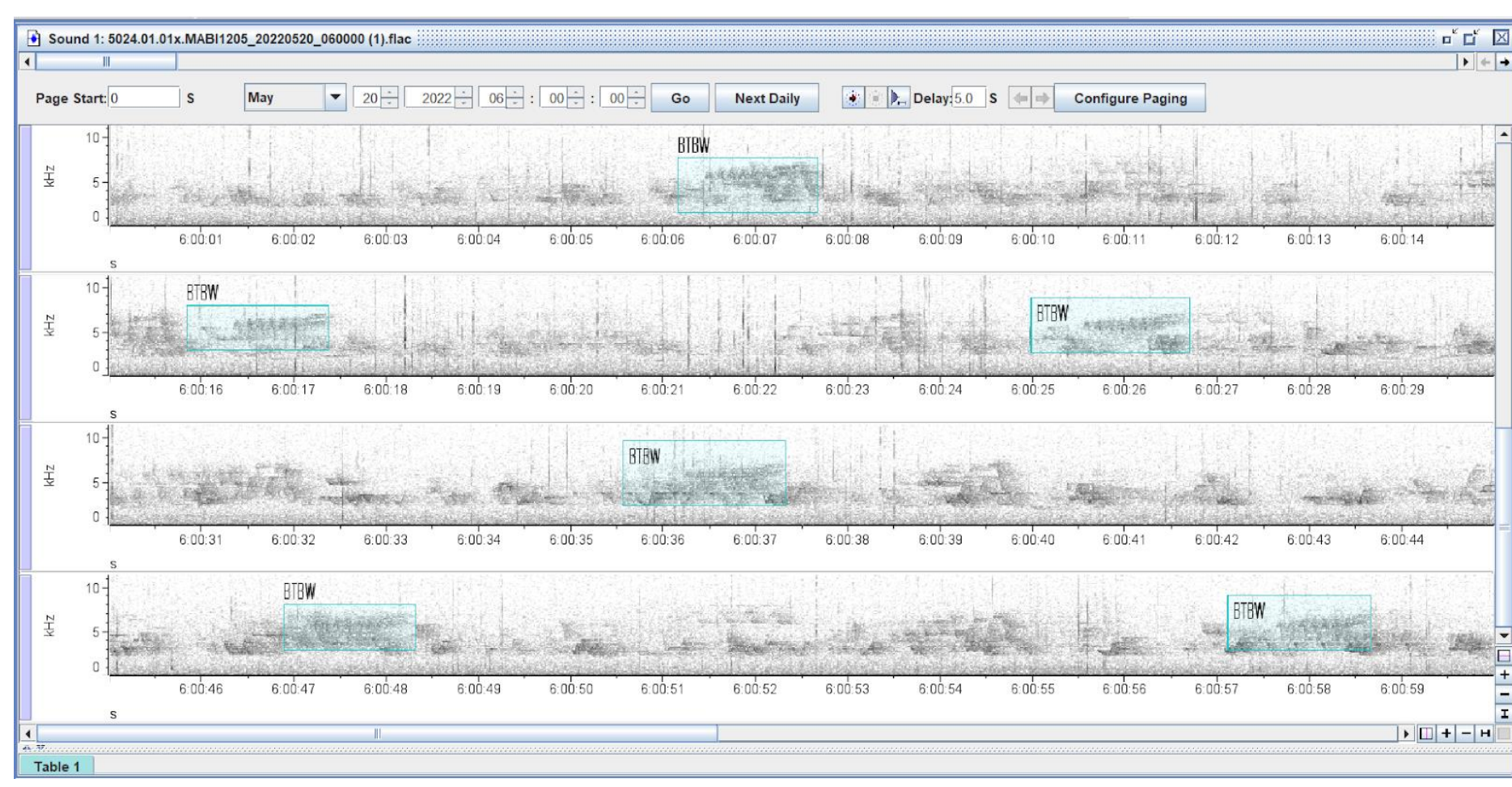
Vocalization patterns have been studied in katydids and crickets have been studied with respect to patterns of vocalization onset, vocalization duration, and vocalization duty cycles:

- **Phonotaxis** as sounds continue in a pattern, organisms are drawn to the source of that sound (Hedwig et al. 2017)
- **Zipf's Law of Brevity**- the more frequent a vocalization, the shorter that vocalization tends to be (Symes et al. 2021)
- **Tradeoffs exist**- longer and more complex vocalizations tend to be less frequent than shorter, simpler ones (Symes et al. 2021)

Songbirds vary in length of their songs and frequency of bouts:

- **Songbird cadence**, or the regular onset and offset of songs, can be important to **signaling a single individual source** (Beletsky 1989)
- The silent periods are **inter-song intervals (ISI)**, or more generally, **inter-vocalization intervals (IVI)**
- **Song frequency** can be important to individual discrimination and signal reception (Nagel et al. 2012)
- Both **bird vocalizations and human speech** rhythmicity is influenced by two genes **Neurexin I** and **Coenzyme Q8A** (Sebastianelli et al. 2024)
- **Acoustic adaptation hypothesis**- birdsong can be adaptively adjusted to the surrounding environment to enhance communication (Sebastianelli et al. 2024)

Methods



Upper: Annotation of Black Throated Blue Warbler songs in Raven Pro
Lower: The start time of songs over 600 seconds.

- 24 Passive acoustic monitoring recorders placed in **Marsh-Billings Rockefeller National Historical Park, Woodstock, VT, USA**
- Recorders were deployed for **20 days from mid-May to late June**
- We analyzed **10-minute samples starting 40 minutes after sunrise**.
- We analyzed **20 plots on 20 mornings (477 recordings)**.
- We used **Raven Pro** software for annotations.
- Analyses excluded cases with more than one bird singing
- **87,700 annotations from 75 bird species**

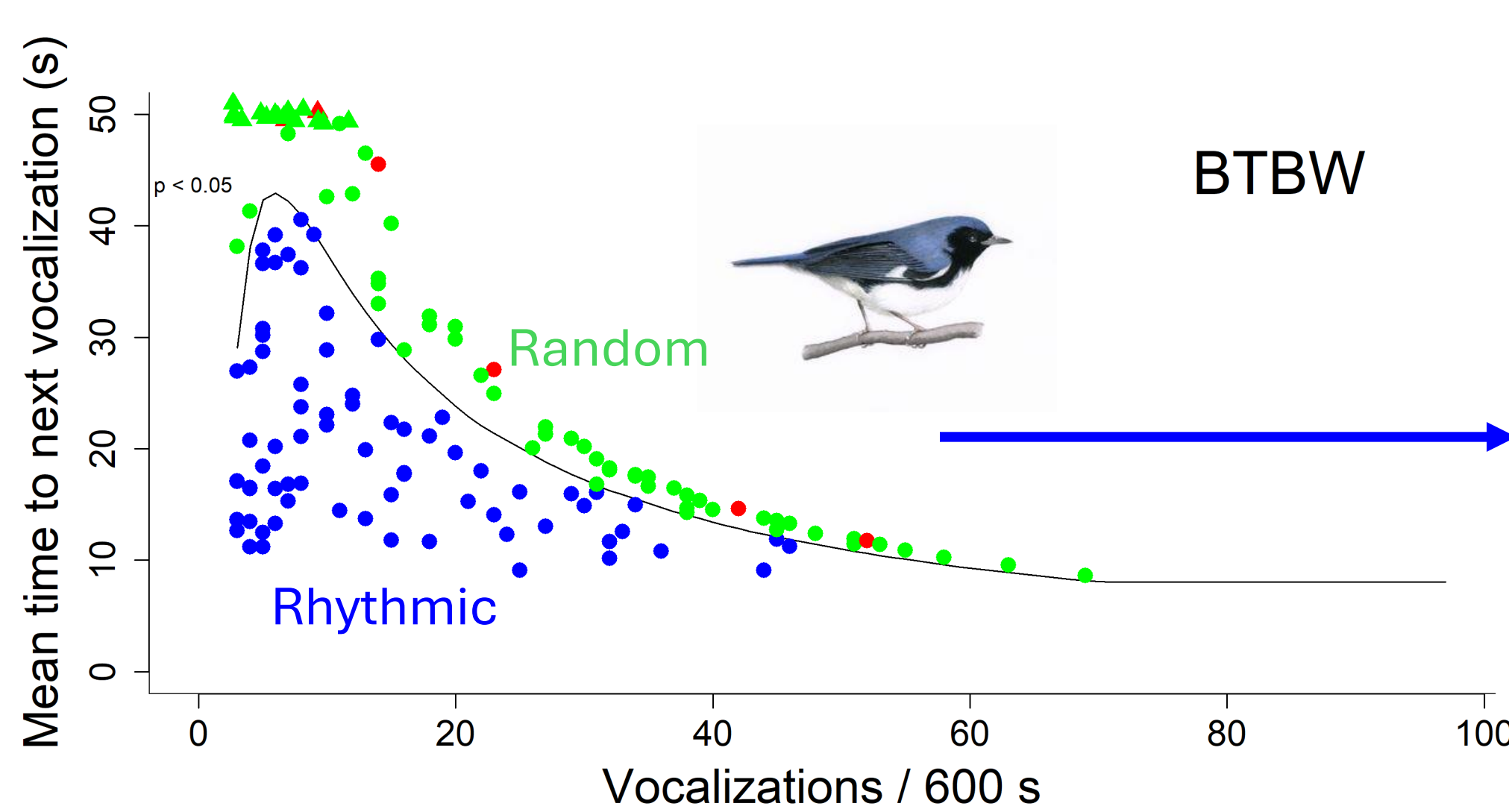


Fig. 1. The singing of Black-Throated Blue Warblers (*Setophaga caerulescens*) was frequently rhythmic (shorter time to next song than random). Each point represents one vocalizing male during 10 minutes on one morning. See Fig. 2 for summary of results for the community of birds

Do birds have rhythm?

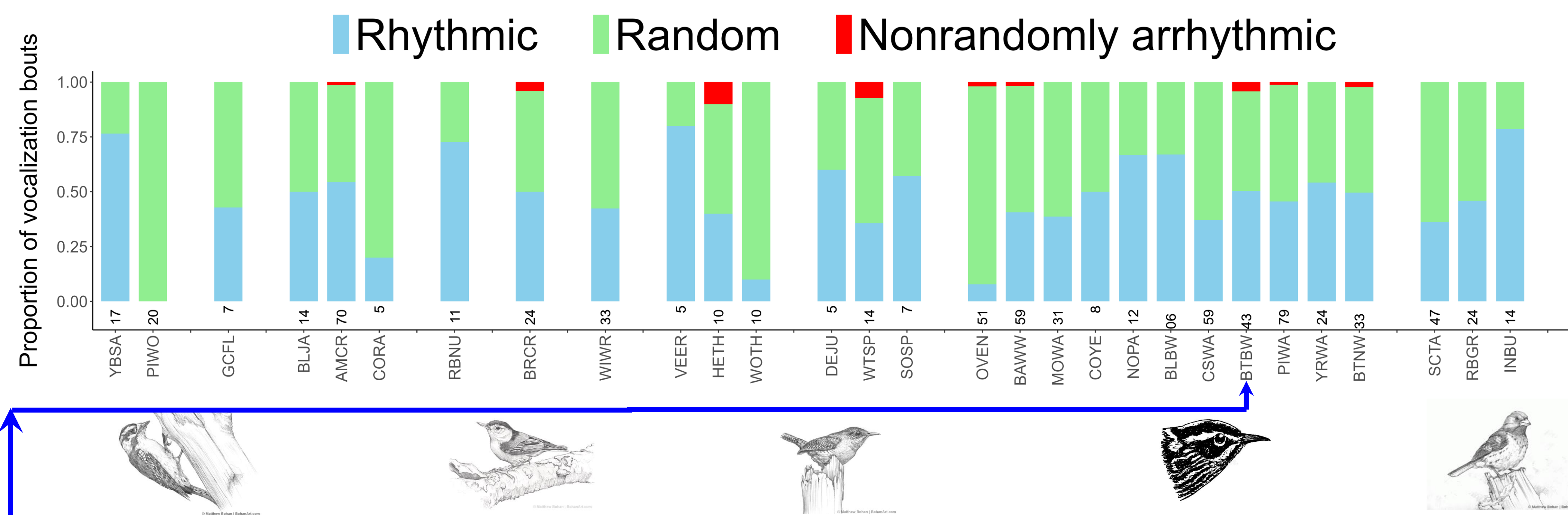


Fig. 2. Most species frequently displayed rhythmic vocalizations within 10-minute bouts. Pileated woodpeckers, common ravens, hermit thrush and ovenbirds notably less rhythmic. See Fig. 1 for bout-by-bout analyses for one species. Values above x-axis indicate number of 10-minute bouts.

How long between songs?

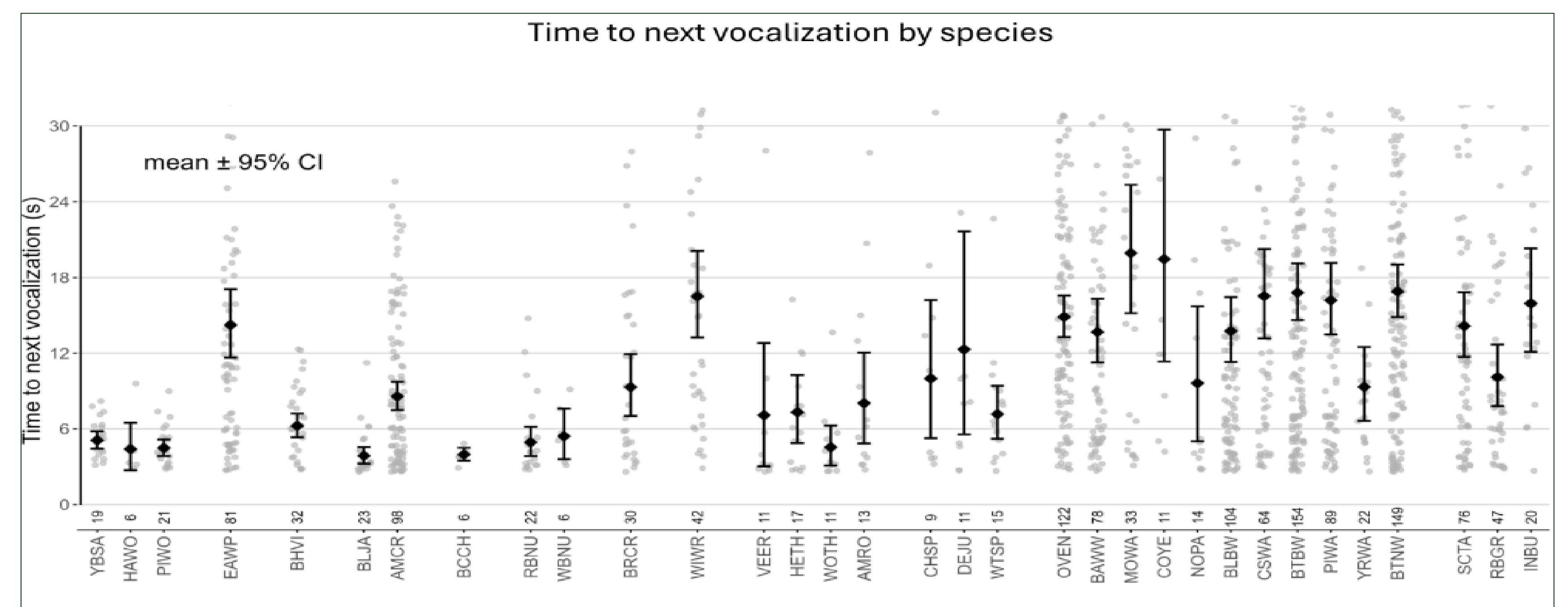


Fig. 3. Numerous species of Parulidae and Cardinalidae (clades at right) were relatively uniform in time to next vocalization (average of 10 – 20 sec).

How many songs make a signal?

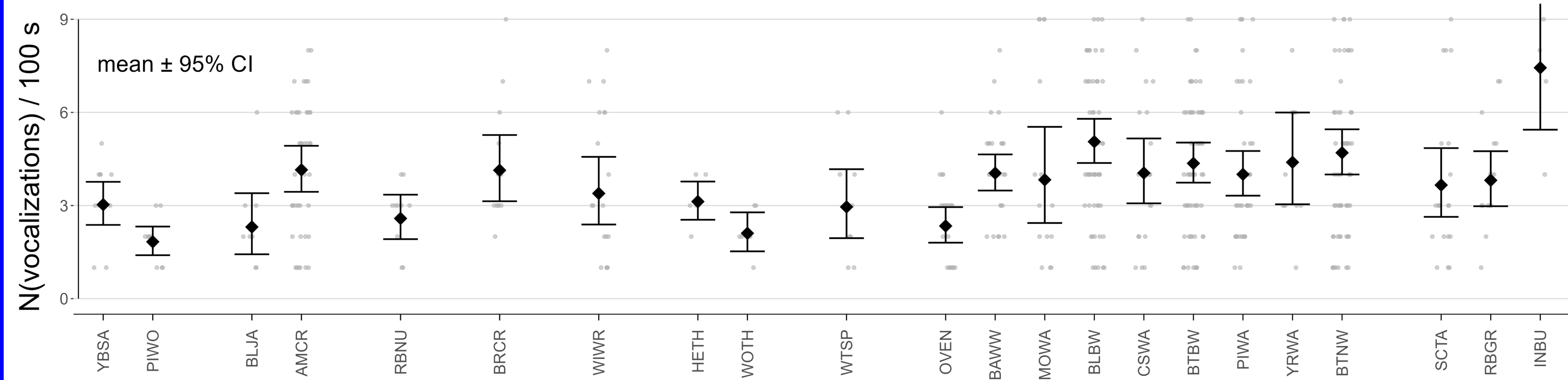
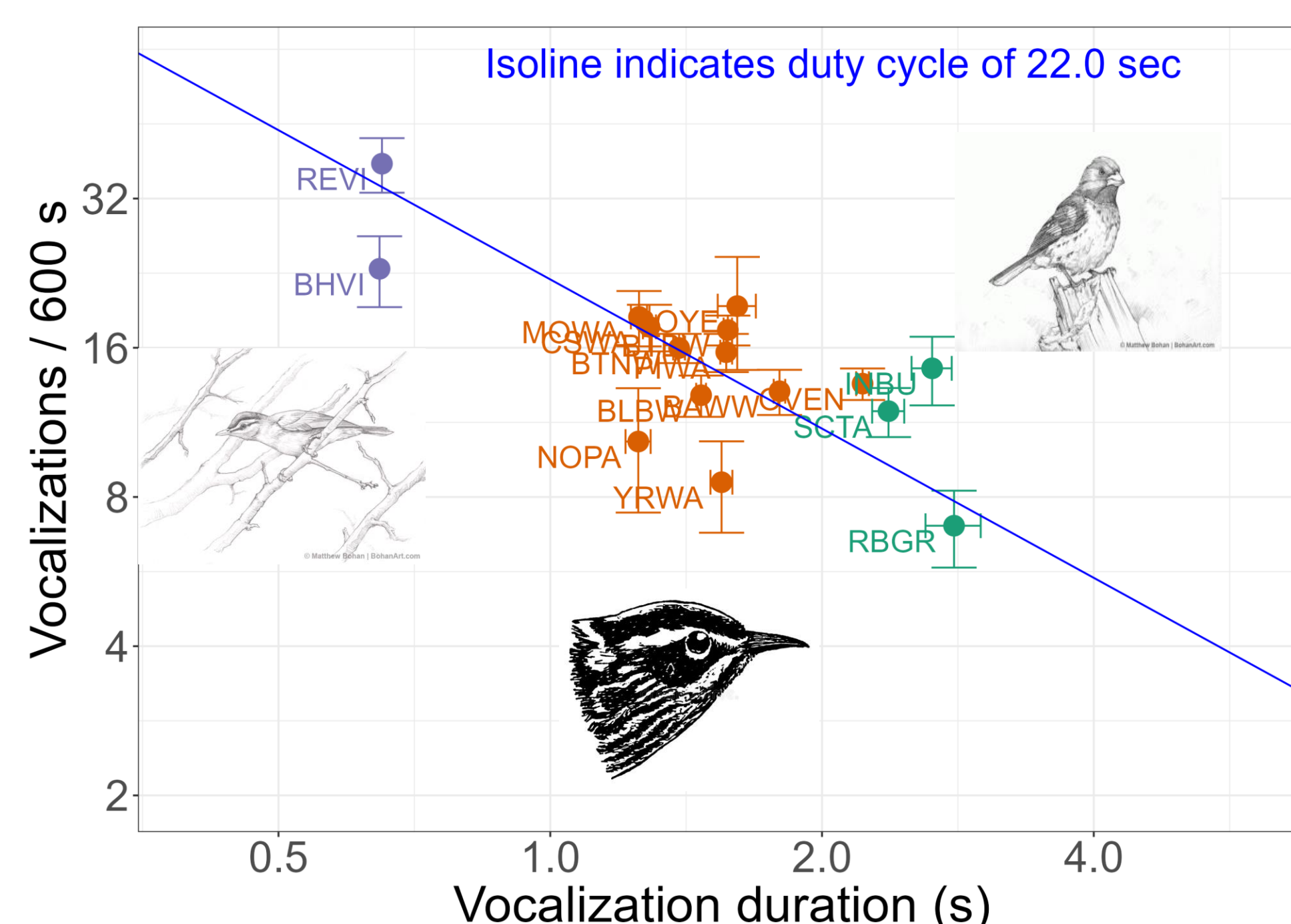
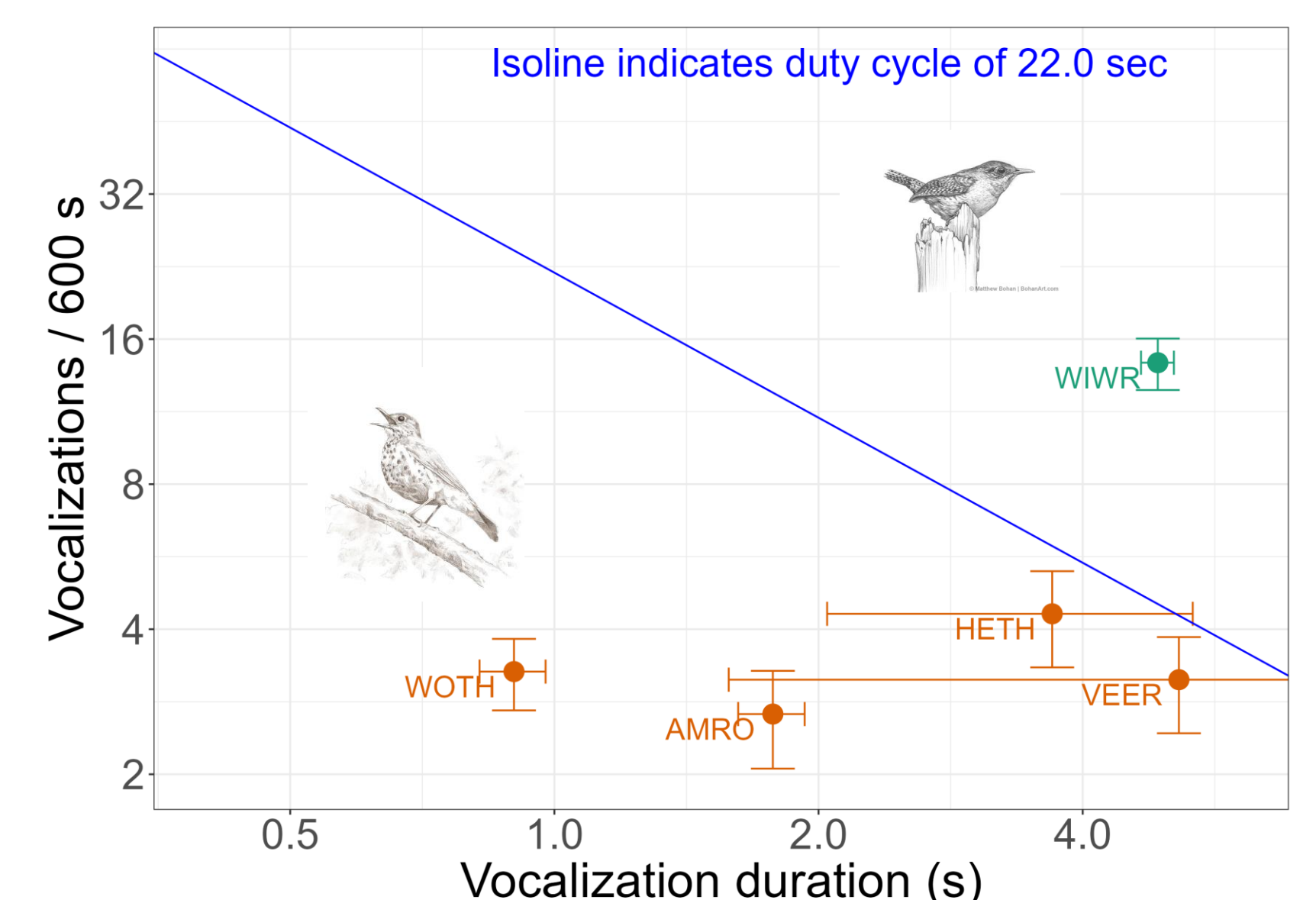


Fig. 4. Parulidae and Cardinalidae (clades at right) were also relatively uniform with respect to number of vocalizations (average of 3 – 4 vocalizations / 100 seconds).

Do birds conserve duty cycle?



Vireonidae displayed frequent short songs. Cardinalidae displayed fewer but longer songs. Parulidae were intermediate. On average, all three clades approximated the isoline for an average duty cycle of about 22 seconds per 600 seconds.



The winter wren (*Troglodytes hiemalis*) (right) was way above the average vocalization duty cycle by virtue of having long and frequent songs.
Four species of Turdidae all displayed an average of 3-4 songs / 600 sec, but varied in the length of their songs..

Future work may focus on Turdidae and Troglodytidae

- Why break the expectation of duty cycle conservation?
- Do thrushes convey more information in their songs?

Nonrandom vocalization patterns enhance communication by triggering pattern recognition systems in the neurobiology of listeners.

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Bird sketches by Matthew Bohlen from Bohlenart.com; Black and White Warbler by Edward Howe Forbush; Useful Birds and Their Protection (Boston, MA: Massachusetts State Board of Agriculture, 1907); Wood Thrush by Abby McBeck; Black Throated Blue Warbler by Tom Tymus