3 years PhD project at the University of Burgundy, Lab Biogeosciences

Ecole Doctorale Environnement Sante UBFC

**Does urbanization impact interspecific competition?**

**Acoustic and behavioral responses in blue and great tits**

**Abstract**

Understanding the mechanisms of coexistence between species is not only one of the pilar of Ecology but has also become a major societal issue due to the acceleration of the biodiversity decline during the Anthropocene. While the recent advent of Urban Ecology highlights the effect of new anthropogenic constraints on the composition and structuring of communities or even the dynamics of populations and individual characteristics, taking into account the behavioral mechanisms of the coexistence between ecologically similar species is still a neglected aspect of the discipline that needs to be explored. In an unprecedented way, this thesis will specifically evaluate the impact of acoustic pollution due to urban anthropogenic activities on the competition between Great tit (*Parus major*) and Blue tit (*Cyanistes caeruleus*) and the repercussions this has on communication (the song) and territorial responses in these two species. The thesis will aim to i) test the characteristics of the song of the two species along gradients of urbanization and interspecific competition in France, ii) determine the effect of these changes in communication on territorial responses and iii) address the processe(s) of song variations by estimating the heritability of this trait. Therefore, this empirical field study will test the effect of acoustic pollution on the fine mechanisms of coexistence, an innovative aspect of Urban Ecology.

**Context**

In the current context of global environmental changes, understanding the mechanisms that allow species to coexist has become a major scientific and societal issue (Parmesan, 2006; Van der Putten, 2012). The study of coexistence between species is rooted in early modern ecology (Gause, 1934; Lotka, 1932; Volterra, 1926), and has focused in recent decades on identifying the conditions under which species coexistence can occur (Chesson, 2000; Tilman, 1982). Thus, interspecific competition has been identified as a powerful agent of evolution (Grant, 1972; Losos, 2009), particularly between ecologically related species that share common characteristics (morphology, behaviors, and resources; Violle et al., 2011). Schematically, if interspecific competition is greater than intraspecific competition, two outcomes are possible: exclusion of the dominated species (Gause, 1934; Lotka, 1932; Volterra, 1926), or a species "response" through phenotypic plasticity (Pfennig & Pfennig, 2012) or genetic adaptation (Brown & Wilson, 1956; Grant, 1972; Schluter, 2000). Phenotypic evolution in response to interspecific competition is central to coexistence research with, in particular, the concept of character displacement (Brown & Wilson, 1956; Grant, 1972; Schluter, 2000; Stuart & Losos, 2013). This evolutionary process is expressed by a change on traits (ecological or reproductive) minimizing interspecific competition via the partitioning of the ecological niche between competing species, inducing a stable coexistence between them (Brown & Wilson, 1956; Dufour et al., 2019, 2020; Dufour et al., 2017; Grant, 1972; Pfennig & Pfennig, 2012; Schluter, 2000)

Current anthropogenic changes (e.g., climate change, habitat fragmentation, urbanization) are reshaping environmental constraints on organisms and community composition. While the effect of new anthropogenic constraints is intensively studied at the level of community composition and structuring or population dynamics and individual characteristics (giving rise to new disciplines in Ecology such as Urban Ecology), the effect of these anthropogenic pressures on interspecific competition and therefore the fine mechanisms of coexistence between ecologically related species is still a neglected aspect. However, the conditions imposed by the anthropization of the environment can exacerbate, or even reduce, interspecific competition. This is particularly true in the context of urbanization.

Taking into account the behavioral mechanisms of coexistence between ecologically related species is an original axis of Urban Ecology. In a new way, this thesis will specifically aim at evaluating the impact of noise pollution due to urban anthropic activities (road traffic and other noisy activities) on the competition between the great tit (*Parus major*) and the blue tit (*Cyanistes caeruleus*) and the repercussions that this has on communication (song) and behavioral responses (territorial for example) in these two species.

The study of competition between the blue tit and the great tit has played an important role in understanding the mechanisms of coexistence (Dhondt, 2012). These two passerines - ecologically related, territorial, and occurring in sympatry across Europe - compete for food and directly through interference for nest site and through aggressive song responses between species (Dhondt, 2012; Doutrelant, Leitao, et al., 2000; Møller et al., 2018; Torok & Toth, 1999).

In oscines, song, in contrast to call, has a long, complex structure and is primarily emitted by males (in temperate areas) for territorial purposes and for breeding (Marler, 2004). Blue and great tits sing in similar frequency ranges and syntaxes, resulting in acoustic competition (Doutrelant & Lambrechts, 2001). In response to this interspecific competition, a shift in song character (addition of trills) has been shown in blue tits, reducing the aggressive territorial behavior of great tits (Doutrelant, Blondel, et al., 2000; Doutrelant, Leitao, et al., 2000). In addition, urbanization can impact song: great tits sing at higher minimal frequencies in response to urban noise pollution (Slabbekoorn & Peet, 2003).

Thus, the potential responses of the song of blue and great tits to both noise pollution and interspecific competition allows us to test the effect of urbanization on the mechanisms of coexistence between these ecologically related species. Moreover, the territorial behavior of these two species in response to songs makes it possible to determine the consequences of the observed variations of the song in terms of intensity of the interspecific competition for the acoustic resource. Finally, song is the result of the interaction between cultural and genetic evolution and thus evolves more rapidly than a culturally uninherited trait (Feldman & Laland, 1996). Thus, the underlying processes of song variation can be tested at the two-generation level.

Two recent pilot studies have provided very encouraging results by showing the joint effect of urbanization and the potential for interspecific competition on certain characteristics of blue tit and great tit songs in Bourgogne-Franche-Comté. The thesis will therefore aim to i) refine the characterization of songs in the context of urbanization and interspecific competition and test the generality of these results by expanding the geographical working scale by studying gradients of urbanization cities-forests and pressures of interspecific competition, ii) determine the effect of these changes on territorial responses in the two species and iii) estimate the processes of song variation. All study data will be taken *in natura*.

*- Axis 1: Study of the link between song variability and gradients of acoustic pollution and interspecific competition*

Songs of blue and great tits will be recorded and analyzed in order to understand the variability (intra-individual, inter-individual and inter-population) of this trait along gradients of urban-forest acoustic pollution and relative densities of blue and great tits by targeting 6 replicates of urban/forest pairs in France An original analysis approach of description and quantification of the song, considering the 3 dimensions (frequencies, amplitude and time) will be developed.

*- Axis 2: Study of the impact of song changes on territorial response*

The second axis will lead to the deployment of song play-back behavioral experiments along the gradients of urbanization and competition in order to characterize the territorial behaviors of the blue tit and the great tit in response to the different characteristics of the songs. This experiment will determine the impact of song changes on territorial response between the two species. The development of playbacks may include artificially modified songs.

*- Axis 3: Preliminary study of the mechanisms of song variation origin*

The study of song heritability will be approached by comparing the known song of parents (recording year n) with the song of their descendants (year n+1). For this, the parents and their chicks (year n) will be identified (marked) and characterized (morphological measurements) in the nesting box in Dijon and in the forest of Auxonne (n=600 nesting boxes monitored since 2012). The following year, the songs of the marked chicks will be recorded to compare their songs with those of their parents.

The articulation of the different aspects of this thesis (behavior, bioacoustics, morphology) will be ensured by the complementarity of the team: Dr. Claire Dufour, Prof. Bruno Faivre and Dr. Paul Alibert of the Biogeosciences laboratory (Dijon), Dr. Claire Doutrelant of the CEFE laboratory (Montpellier) and Dr. Thierry Lengagne of the LEHNA laboratory (Lyon).

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**Required knowledge and skills**

The candidate should have a strong interest in and mastery of evolutionary ecology concepts, particularly behavioral ecology concepts.

A maturity and a pronounced aptitude for field ecology are required (fieldwork over 4 months/year, involving conditions that may be restrictive with sound recording and behavioral experiments *in natura* in Burgundy-Franche-Comté and beyond).

She/he should also ideally have skills in statistical and bioacoustic analysis (on R software), as well as good writing skills.

**How to apply to the Ecole Doctorale Environnement Santé UBFC**

2023 COMPETITION CALENDAR

Candidates must send their file (PDF) before May 10, 2023, 12 p.m. to [christelle.caillot@u-bourgogne.fr](mailto:christelle.caillot@u-bourgogne.fr) (copy to [Claire.dufour@u-bourgogne.fr](mailto:Claire.dufour@u-bourgogne.fr))

See <https://e2s.ubfc.fr/concours-2023-sujets-et-calendrier/> for more information

For shortlisted candidates, auditions will take place on July 4-6, 2023

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