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Identification of Woodpecker Species through Drumming

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POLYTECH MONS

Faculté des Sciences

Symposium on Ecology and Acoustics

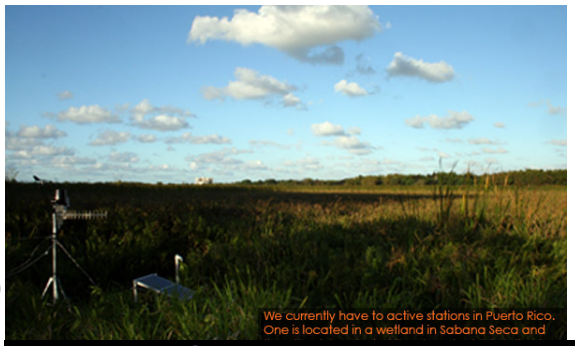
June 16-18 2014 - Musée national d'Histoire Naturelle, Paris

Wildlife automated acoustic monitoring

Image: AmiBio

Image: QUT

Image: Arbimon



- Progress in human voice recognition opens up possibilities
- Bird songs contain specie information
- Existing projects
  - AmiBio (EU) – 17 recording stations on mountain Hymettus near Athens, 10 TB transmitted trough GSM network
  - Arbimon - continuous monitoring with web interface, Puerto Rico and Costa Rica
  - QUT (Brisbane, Australia), 100 TB
  - Pilot studies in other megadiverse countries

The recognition algorithms lag behind

Acoustic features and classification algorithms

Sound files of several seconds or minutes…

… are reduced to a vector of **acoustic features**…

$$\begin{bmatrix} f_{main} \\ spread \\ octave_{1000} \\ \dots \\ octave_{10000} \end{bmatrix}$$

… which the **classifier** will process

It's a goshawk!

Acoustic features and classification algorithms

Acoustic features

- Massive data reduction
- What's a proper description of the sound?

$$\begin{bmatrix} f_{main} \\ spread \\ octave_{1000} \\ \dots \\ octave_{10000} \end{bmatrix}$$

Classifier

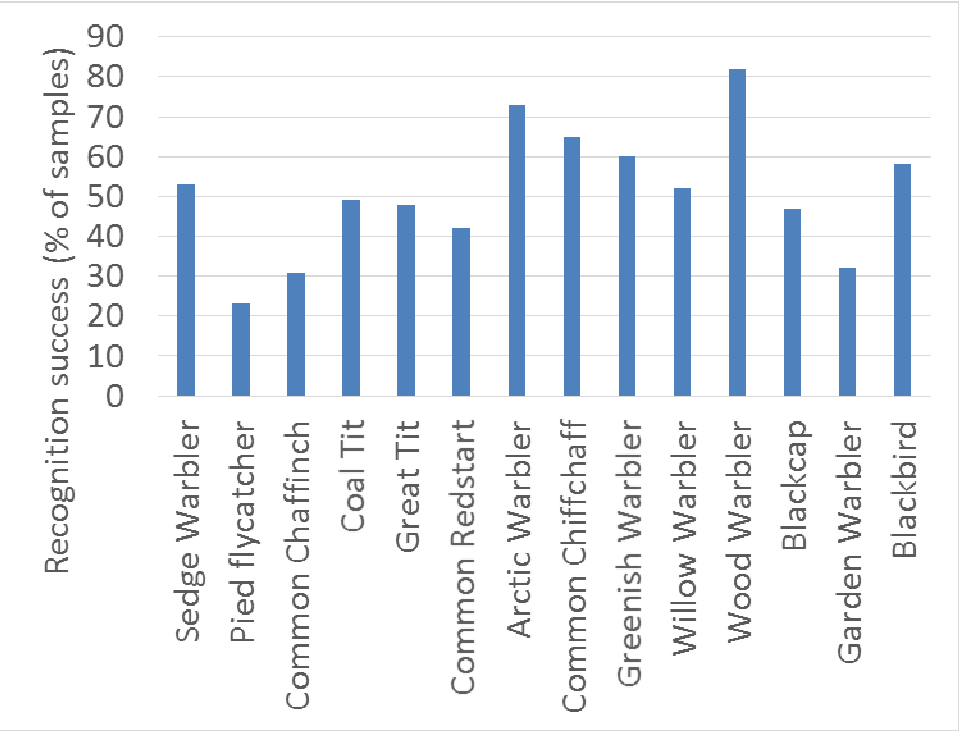
- Recognize, cluster, map…
- Nuances in capacities of algorithms
- Use of templates

Popular : MFCC + Hidden Markov Models

Current performances

Somervuo et al. (2006)

- The numbers are 99% for whales…
- For birds there is a glass ceiling of 70%
  - Somervuo, Härmä and Fagerlund (IEEE 2006) with MFCC + HMM
- Not unlike performance by actual ornithologists

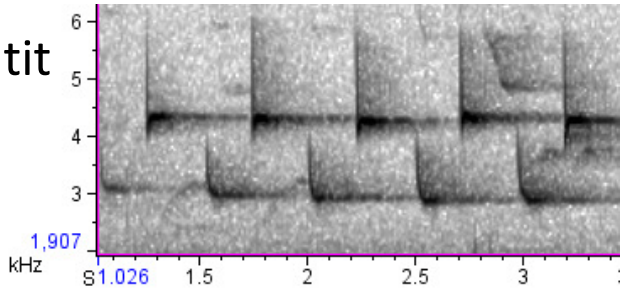


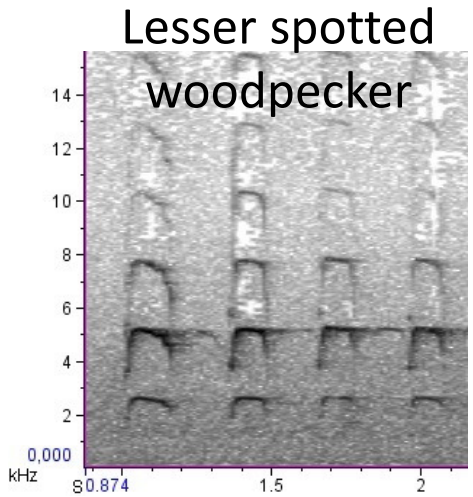
Why? →

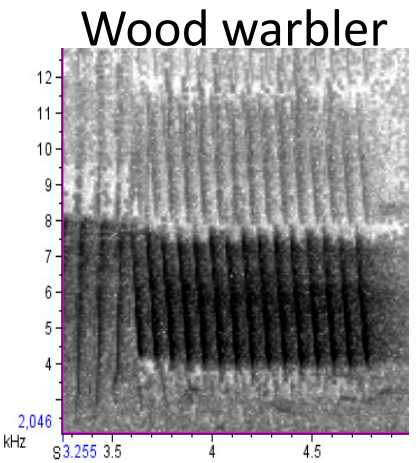
- Variability of the songs ≠ using templates or training in recognition
- Quality of acoustic features

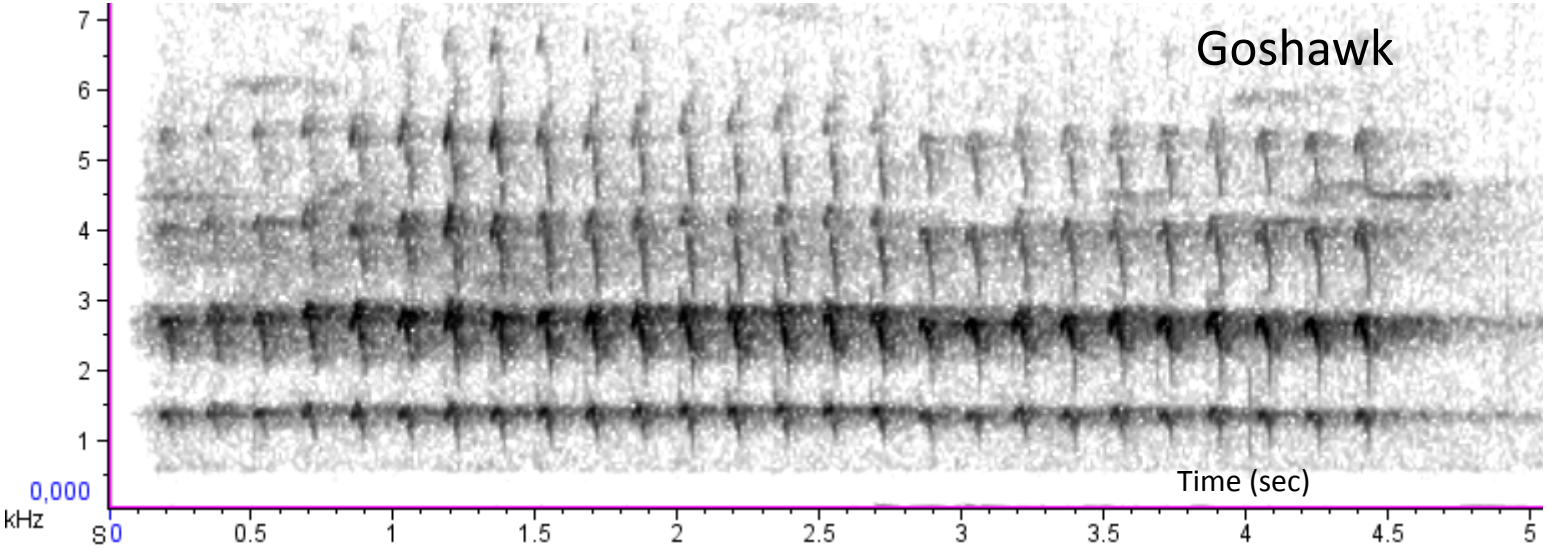
Spectrograms

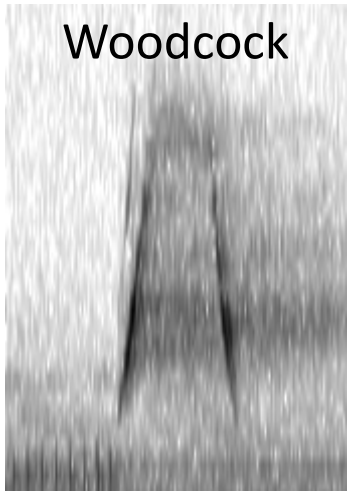
- The picture summarizes the song
- Challenge: reduce data to a vector
- But what is critical?











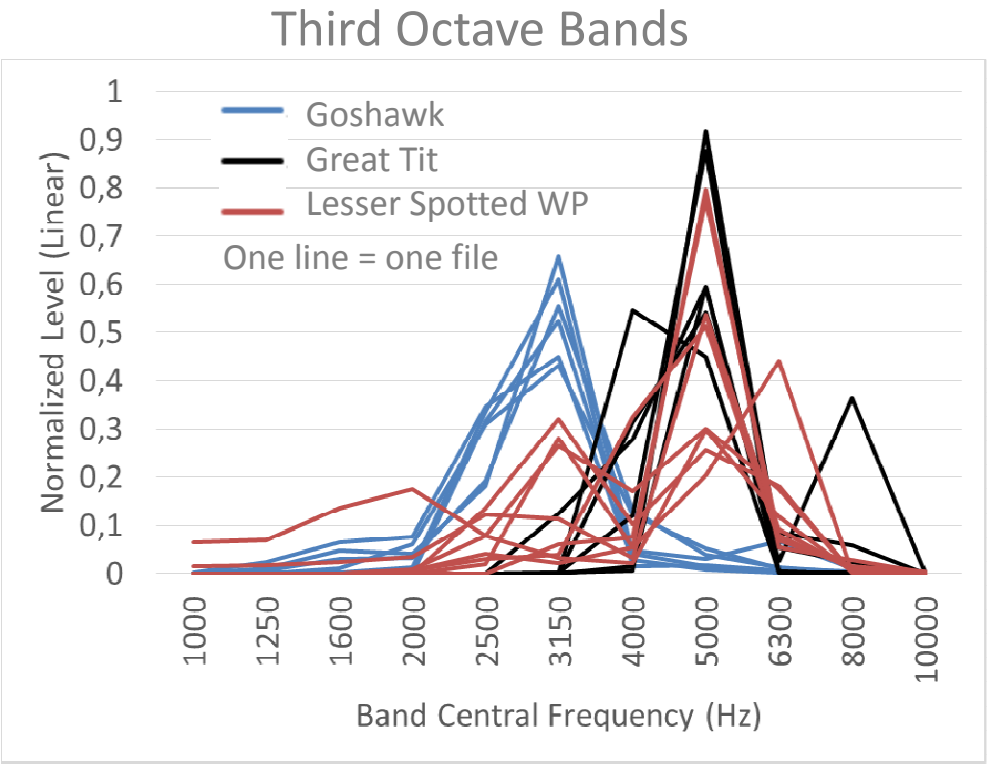
Data from Xeno-Canto

Clustering Early Trials

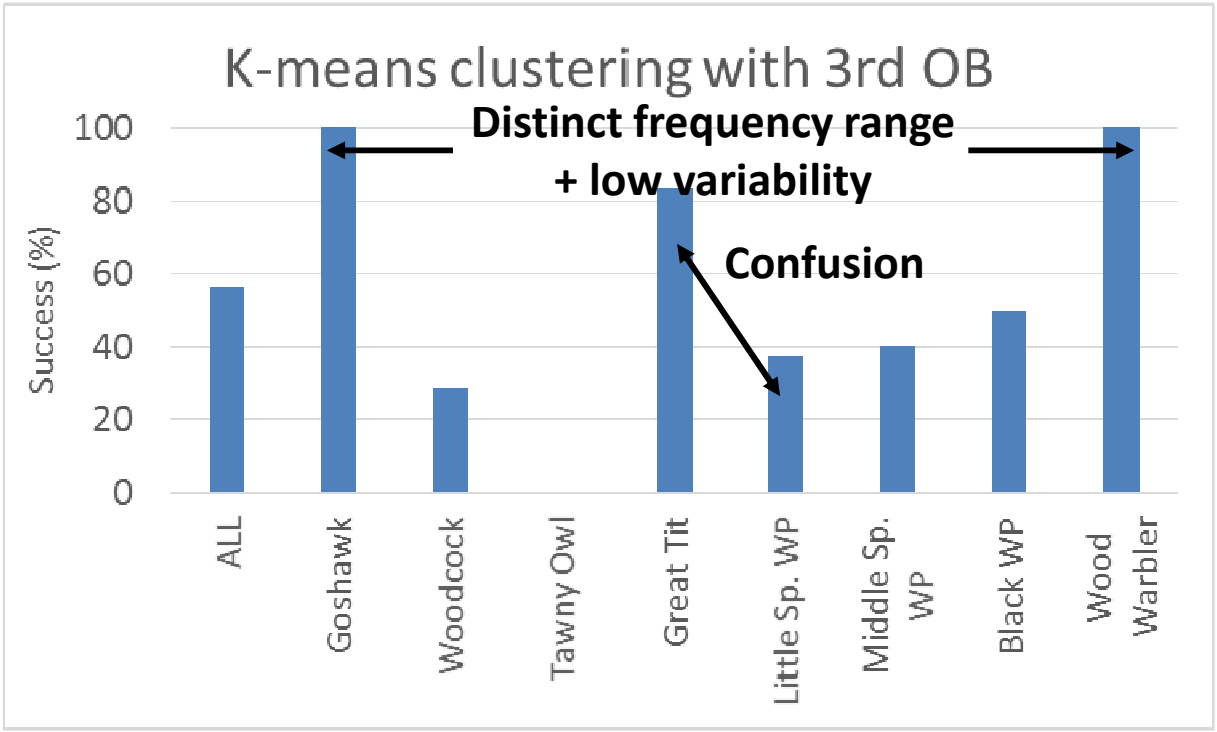
- Small Xeno-Canto sample (29 files)
- Third octave bands / MFCC describe the frequency content: relevant but not sufficient
- Struggle intra-specie variability > between species

- Questionable hypotheses:
  - One set of features fits all birds
  - Humans have better features

- The most efficient is what the birds use
- Species dependent



Early clustering trials (results)



+ Results with time-averaged MFCC are dismal (23% success)

Confusion matrix

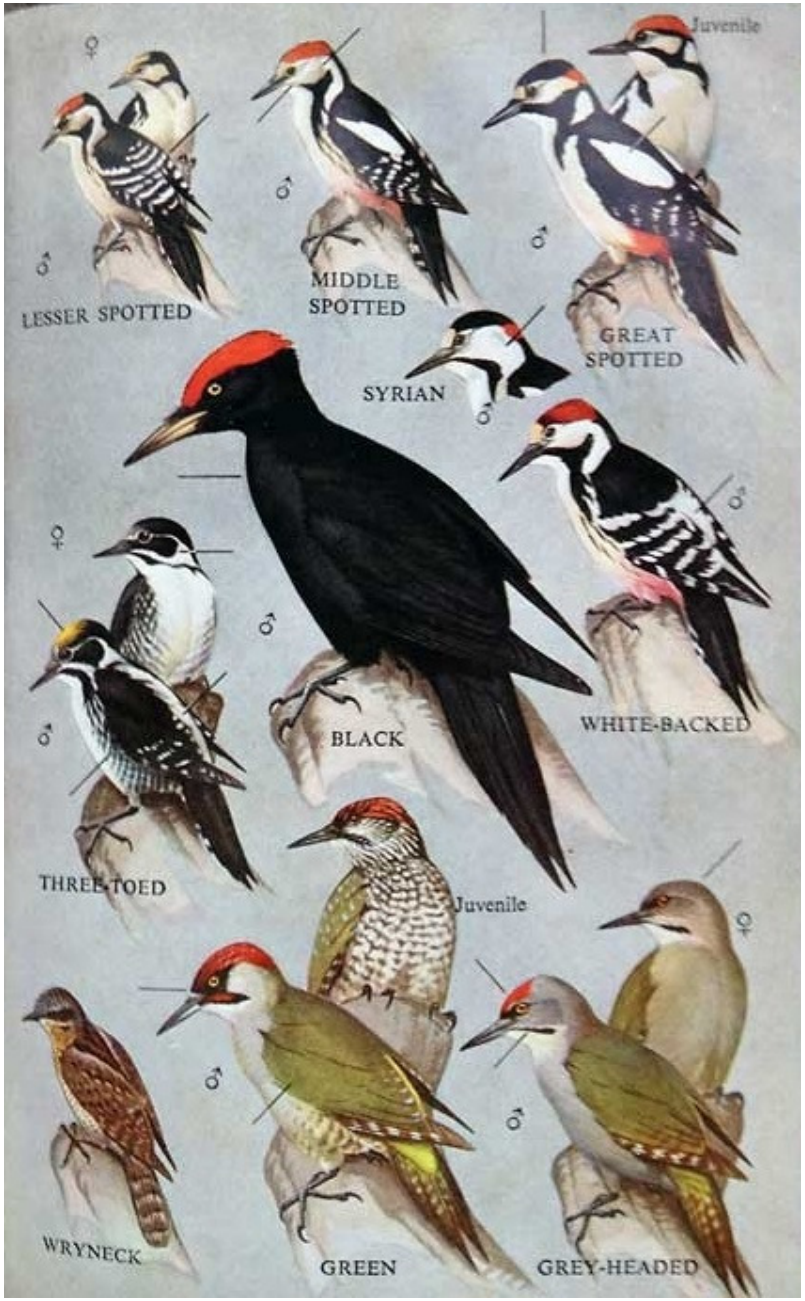
	Goshawk	Woodcock	Tawny Owl	Great Tit	Little Sp. WP	Middle Sp. WP	Black WP	Wood Warbler
Goshawk	100%	14%	0%	0%	0%	20%	50%	0%
Woodcock	0%	29%	0%	0%	0%	0%	0%	0%
Tawny Owl	0%	14%	0%	0%	0%	0%	0%	0%
Great Tit	0%	0%	0%	83%	50%	0%	0%	0%
Little Sp. WP	0%	0%	0%	0%	38%	40%	0%	0%
Middle Sp. WP	0%	0%	100%	17%	0%	40%	0%	0%
Black WP	0%	0%	0%	0%	0%	0%	50%	0%
Wood Warbler	0%	43%	0%	0%	13%	0%	0%	100%

50% of black WP are correctly assigned, 50% are wrongly identified as goshawks

European Woodpeckers

- WP are not songbirds
- WP also drum on tree trunks for territory marking / advertising

- Mikusinski and Angelstam (1998) show that the WP are markers of forest biodiversity
- AVES news 27/02/2014 : will start two-year program to monitor the grey-headed woodpecker population in Belgium (endangered)
- Swedish program for white-backed WP reintroduction



The Peterson Field Guides

Woodpecker sounds

Source: Frank Hidvegi, wildechoes.org
Jack Berteau XC 156178

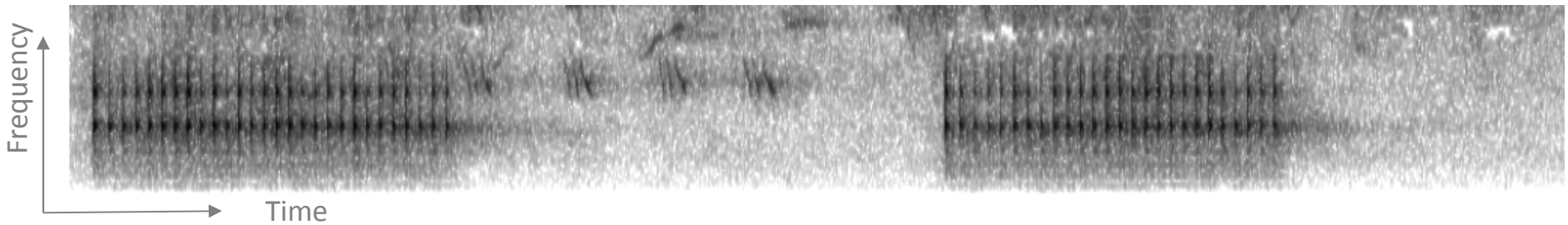
Name (English)	Name (French)	Name (Latin)	Drumming	Song	Call
Great spotted	Epeiche	*Dendrocopos major*	 ✓	✗	✓
Middle spotted	Mar	*Dendrocopos medius*	× (rare)	✓	✓
Lesser spotted	Epeichette	*Dendrocopos minor*	✓ (discrete)	✓	✓
Black	Noir	*Dryocopus martius*	✓	✓	✓ × 2 Contact call and flight call
Green	Vert	*Picus viridis*	× (rare)	✓	✓
Grey-headed	Cendré	*Picus canus*	✓	✓	✓
Wryneck	Torcol	*Jynx torquilla*	✗	✓	✓
White-backed	À dos blanc	*Dendrocopos leucotos*	✓	✗	✓

Database of Drumming Sounds

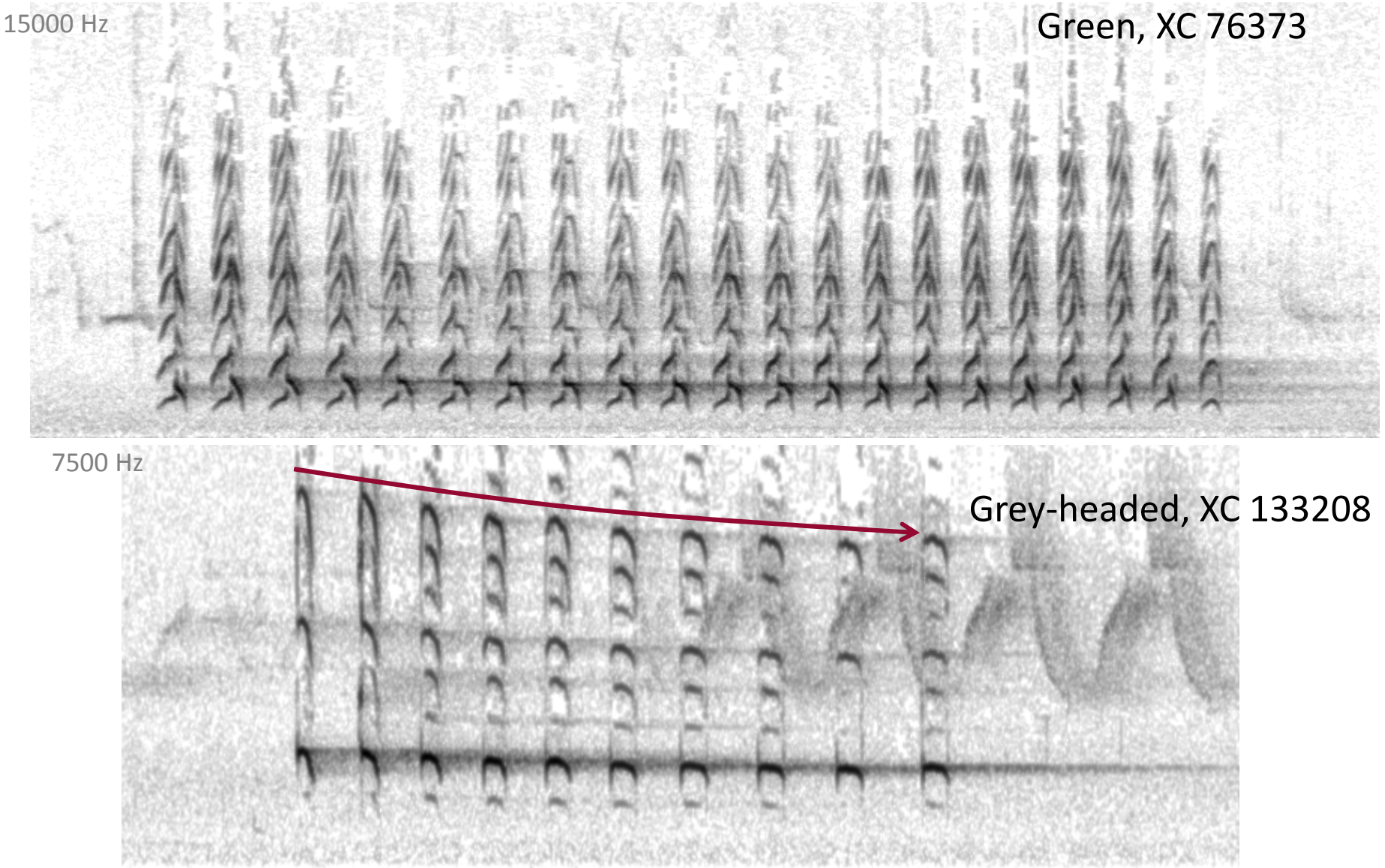
- Xeno-Canto is an invaluable resource
- Data quality A, some B

Taxon	Xeno-Canto Files	Drumming Episodes
Little Spotted	25	633
Middle Spotted	1	1
Green	2	4
Grey-headed	13	51
Great Spotted	73	539
Black	17	64
White-backed	37	229
TOTAL	**168**	**1521**

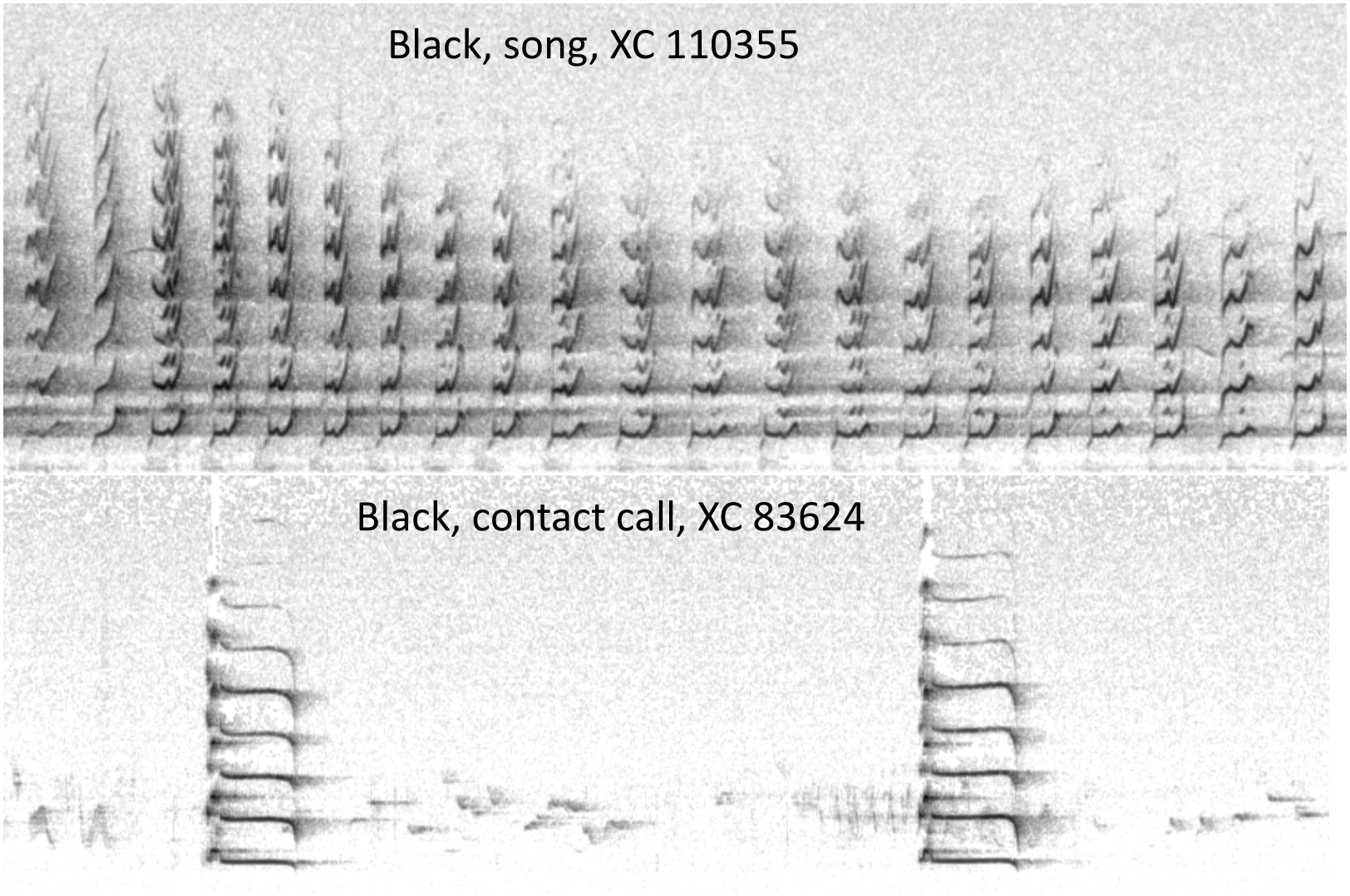
Lesser spotted woodpecker, XC 173209



WP Spectrograms

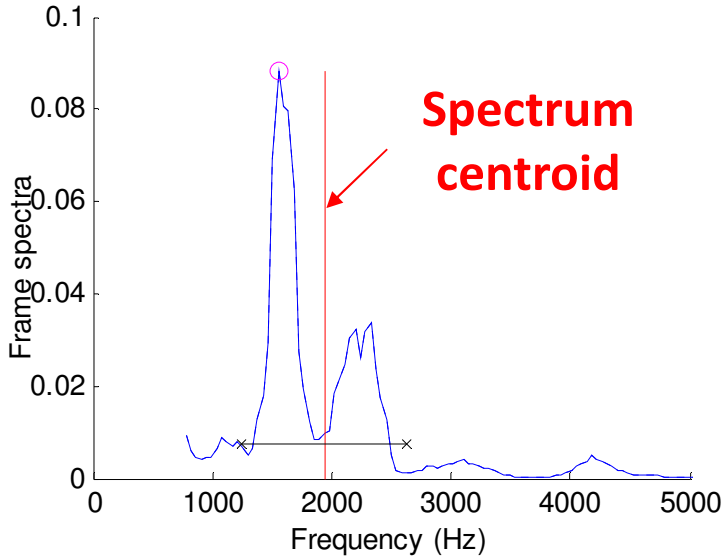


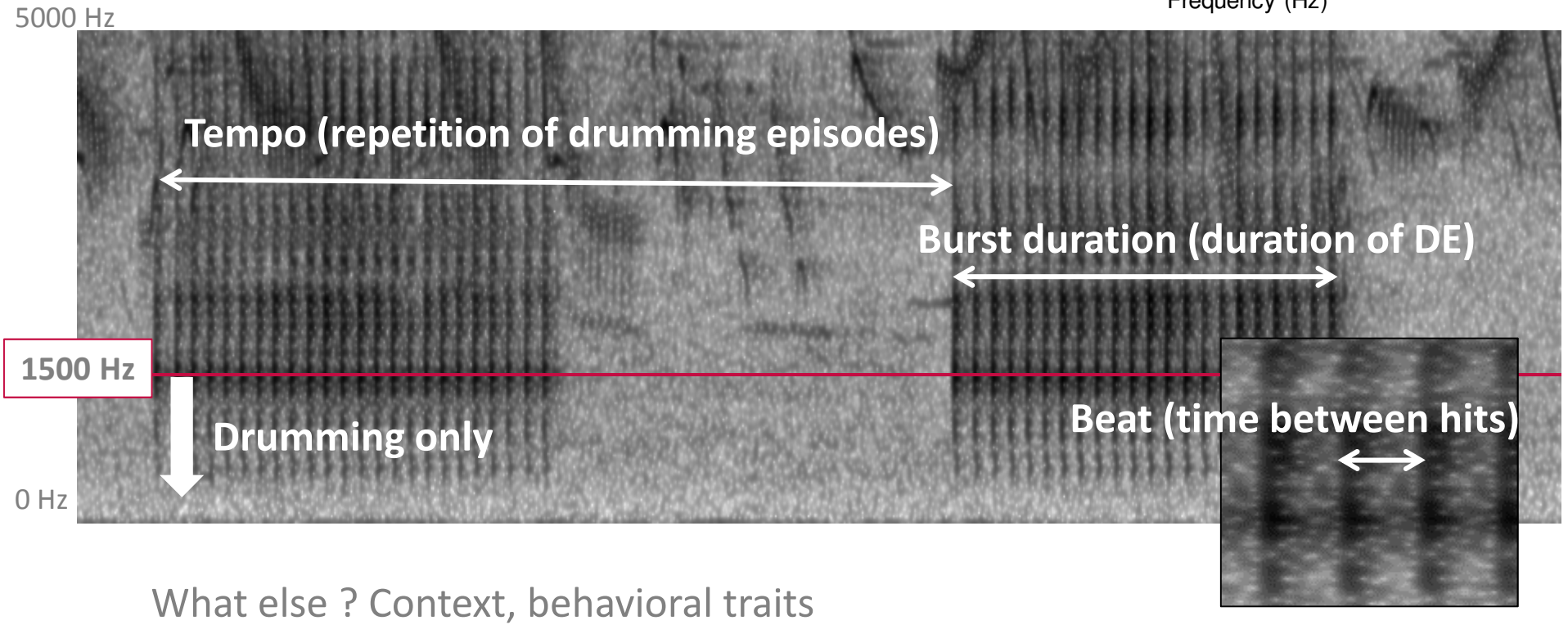
WP Spectrograms



Drumming Features

- All drumming episodes look the same
- The remarkable low-frequency content allows isolating drumming episodes
- The frequency content depends on the tree but the bird chooses the tree

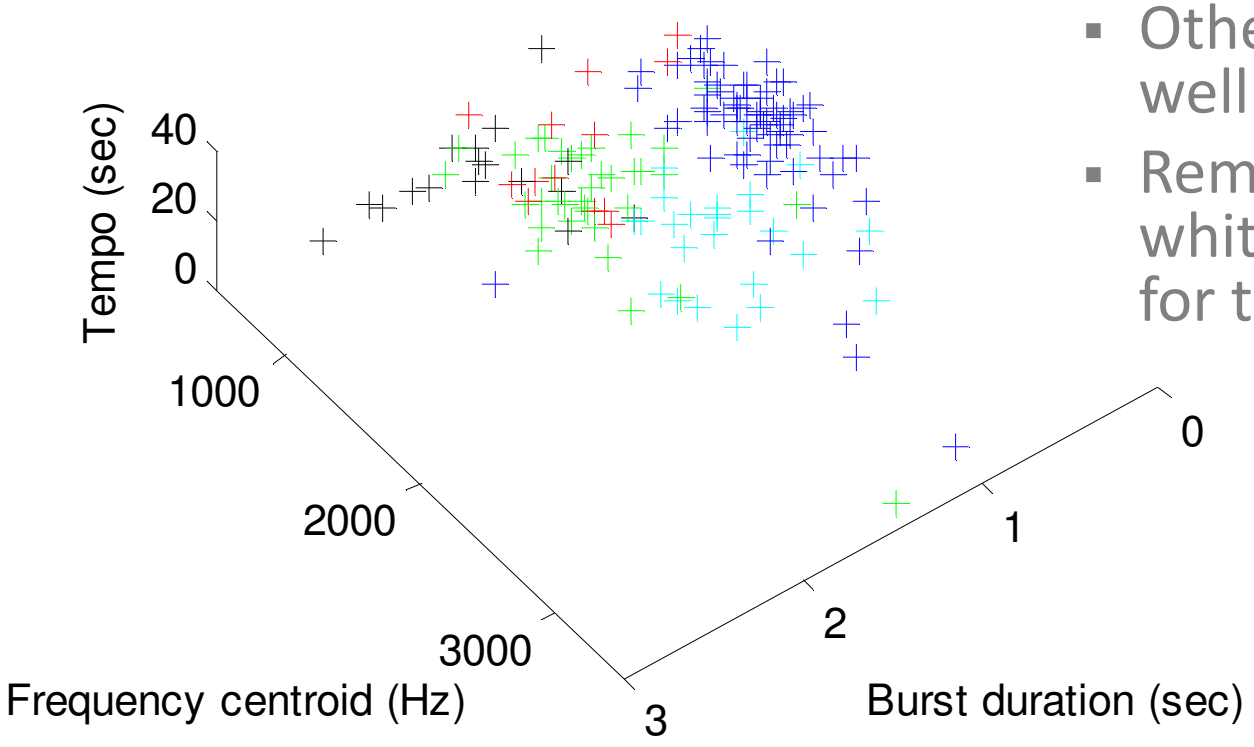




What else ? Context, behavioral traits

Lesser spotted woodpecker, XC 173903

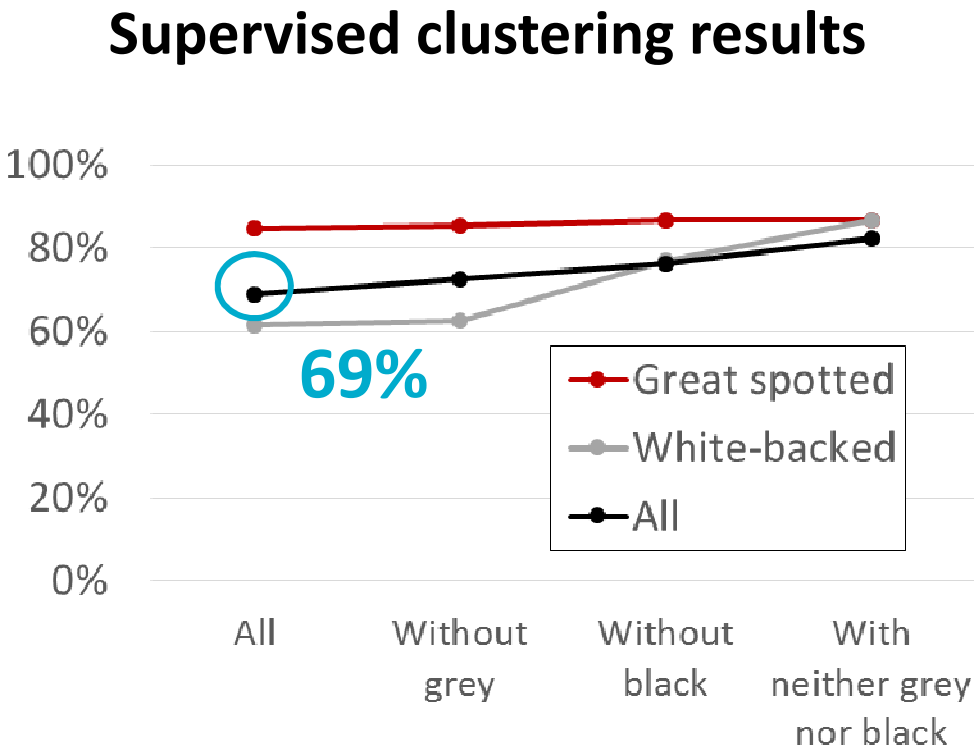
Clustering preview



- The burst duration is a critical feature, the beat less so
- The grey-headed and white-backed occupy a similar range
- Others are reasonably well separated
- Reminder : great sp. and white b. use drumming for territorial claims

Little spotted – *Ddr. minor*
Grey-headed – *P. canus*
Great spotted – *Ddr. major*
Black – *Dryo. martius*
White-backed – *Ddr. leucotos*

Clustering results



- Tried two methods:
  - K-means: unsupervised, initial conditions are supplied (overall success 67%)
  - Knn: supervised, with random 10% training set, 200 experiments
- Success is driven by the great spotted WP
- Dismal results with MFCC

- 69 % does not exceed the typical ceiling…
- … But this is chapter 1 of the story

Limiting factors / Development

- Assumption of one bird per file, one specie per file; indicators are eventually averaged over each file
- Some ornithologists cut up their files to shorten the time between signals
- An average tempo value is assigned when none can be computed (too few drumming events in file)
- Three-toed WP data will be added
- Next up: discriminant analysis and evolving tree

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Thank you

Arlette Berlie

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