Comparative Study of Computational Intelligence Methods for Audio Analysis in Animal Identification within Tropical Ecosystems

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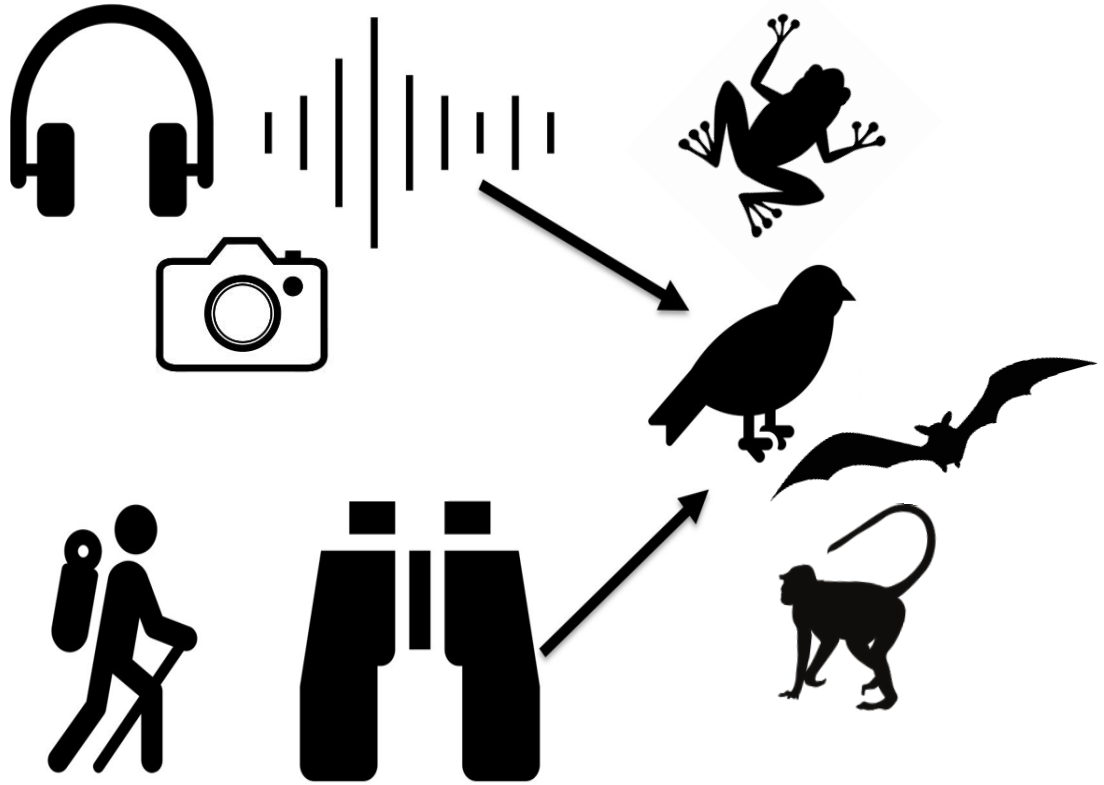
Academic background

Research interests: Unsupervised learning methods
Graph inference – learning
AI for biodiversity and conservation

Why wildlife monitoring?

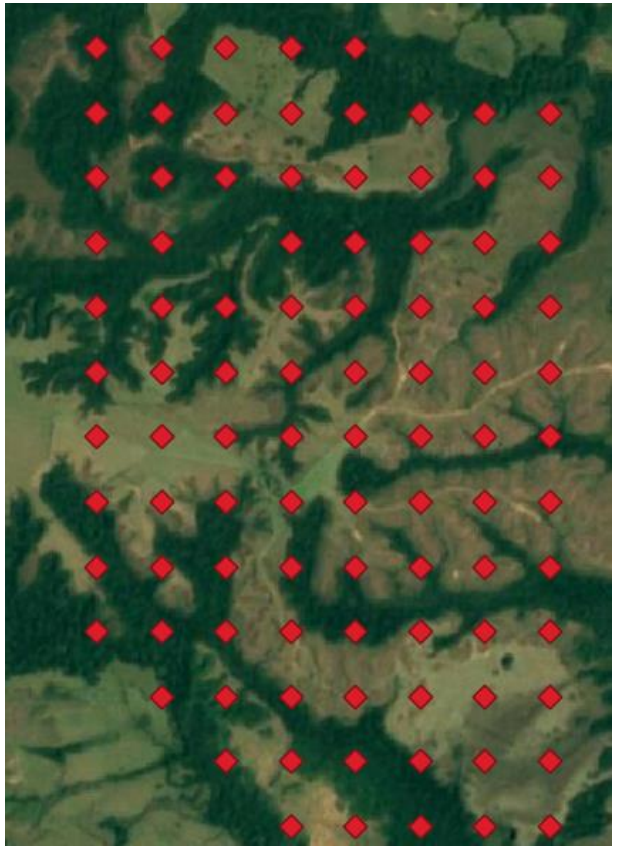


- Geographical distribution
- Abundance estimation
- Identification of individuals

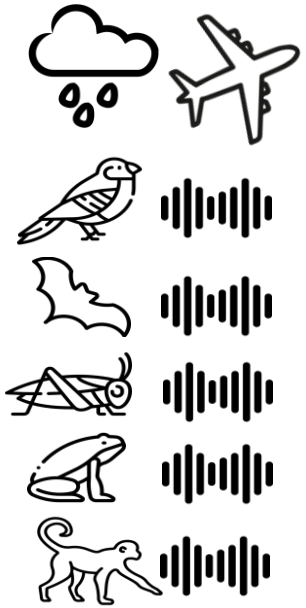
Essential for conservation science

Wildlife Monitoring

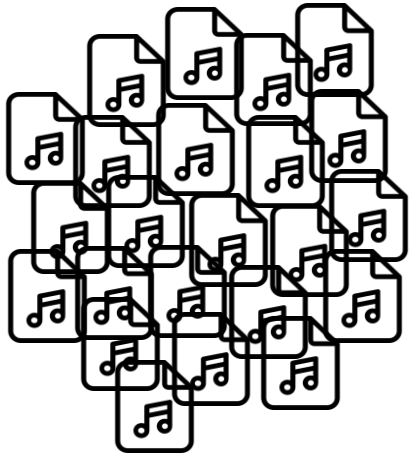
Passive Acoustic Monitoring (PAM)



~ 1750 ha

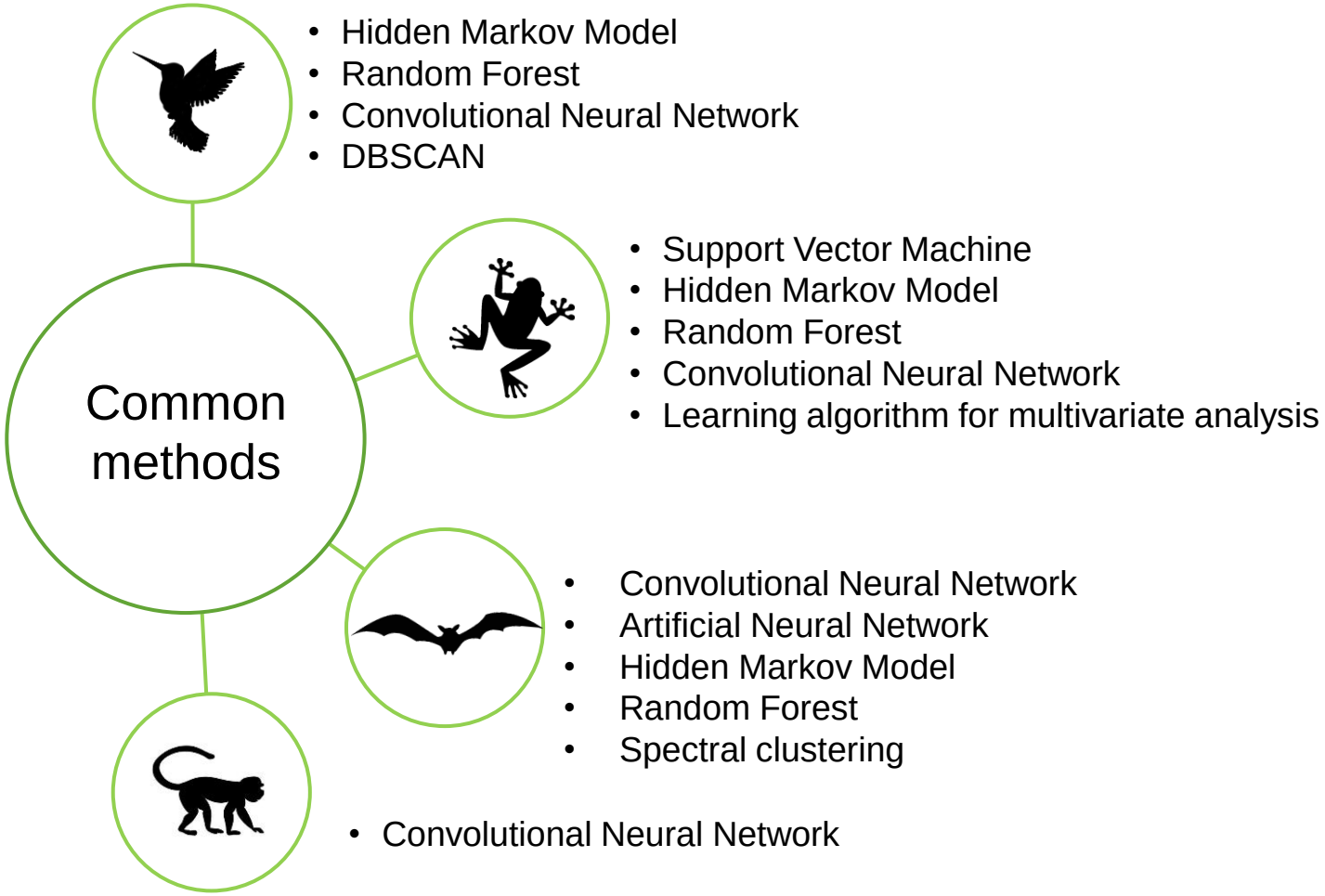


1 minute length recording each 10 minutes, 44 kHz



> 700,000 recordings per month

Species call identification



Research question

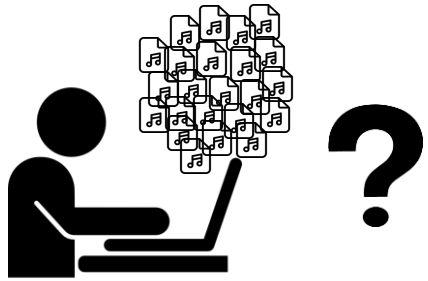
Species – specific

Labels

Prior knowledge

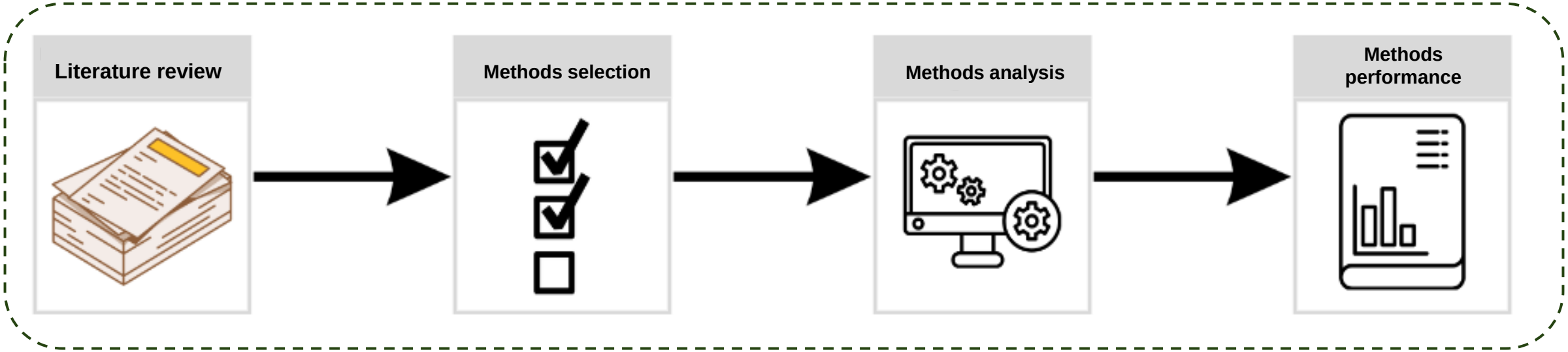
Taxonomic groups

Computational recourses



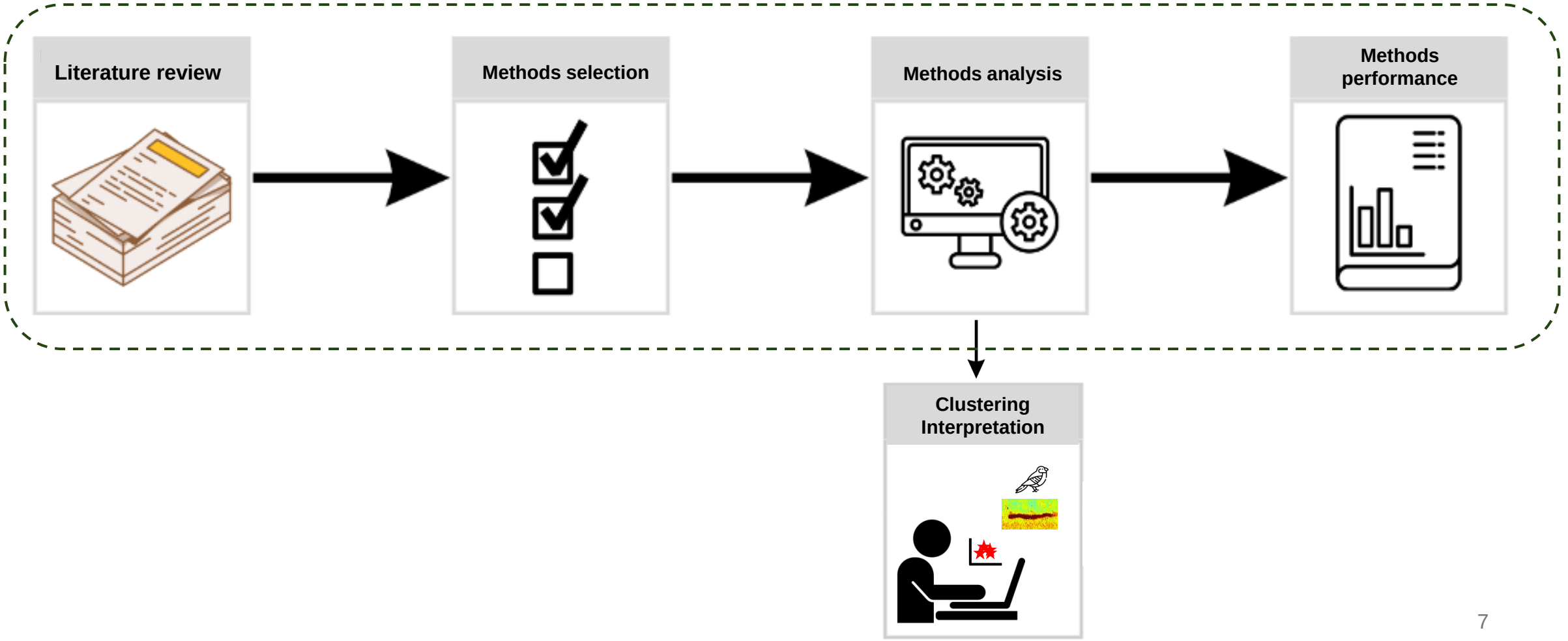
Comparative study of automatic animal sound identification

Methodology



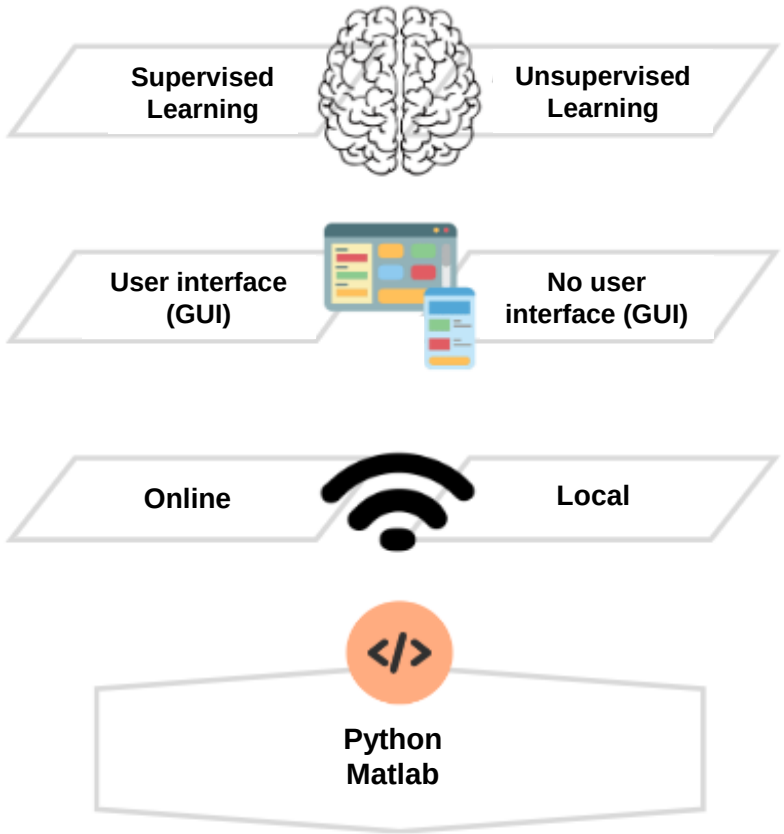
Comparative study of automatic animal sound identification

Methodology



Methods selection and evaluation metric

Methods selection



Evaluation metric

		Predicted 0	Predicted 1
Actual	0	TN	FP
Actual	1	FN	TP

$$Precision = \frac{TP}{TP + FP}$$

$$Recall = \frac{TP}{TP + FN}$$

$$F1 = \frac{2 \times Precision \times Recall}{Precision + Recall}$$

Methods selection

Supervised Learning		
Name	**Method**	**Authors**
ARBIMON	Random Forest	Rainforest Connection
Raven Pro - Koogu	Convolutional Neural Network	Cornell Lab of Ornithology

Unsupervised Learning		
Name	**Method**	**Authors**
ARBIMON	DBSCAN	Rainforest Connection
Kaleidoscope Pro	Spectral Clustering	Wildlife Acoustics
Acoustic Animal Identification	LAMDA 3pi	Guerrero et al., 2023

Guerrero, M. J., Bedoya, C. L., López, J. D., Daza, J. M., & Isaza, C. (2023). Acoustic animal identification using unsupervised learning. Methods in Ecology and Evolution, 14, 1500–1514.

Methods analysis

Supervised learning methodologies

Name	Method	Authors	Method setup	Characteristics
ARBIMON	Random Forest	RAINFOREST CONNECTION	• Pattern matching – Detection threshold • Absences and presence of the vocalization • Datset split (train and validation)	• User interface • Cloud storage • Online platform • Collaborative projects • Different taxonomic groups • Species – specific • Manual labeling
Raven Pro - Koogu	Convolutional Neural Network	The Cornell Lab of Ornithology	• Network achitecture (number and type of layers) • Activation function • Learning rate • Batch size • Number of epochs	• Different taxonomic groups • Species – specific • Manual labeling • Reproducible • Computational resources • Parameter setting • Python skills

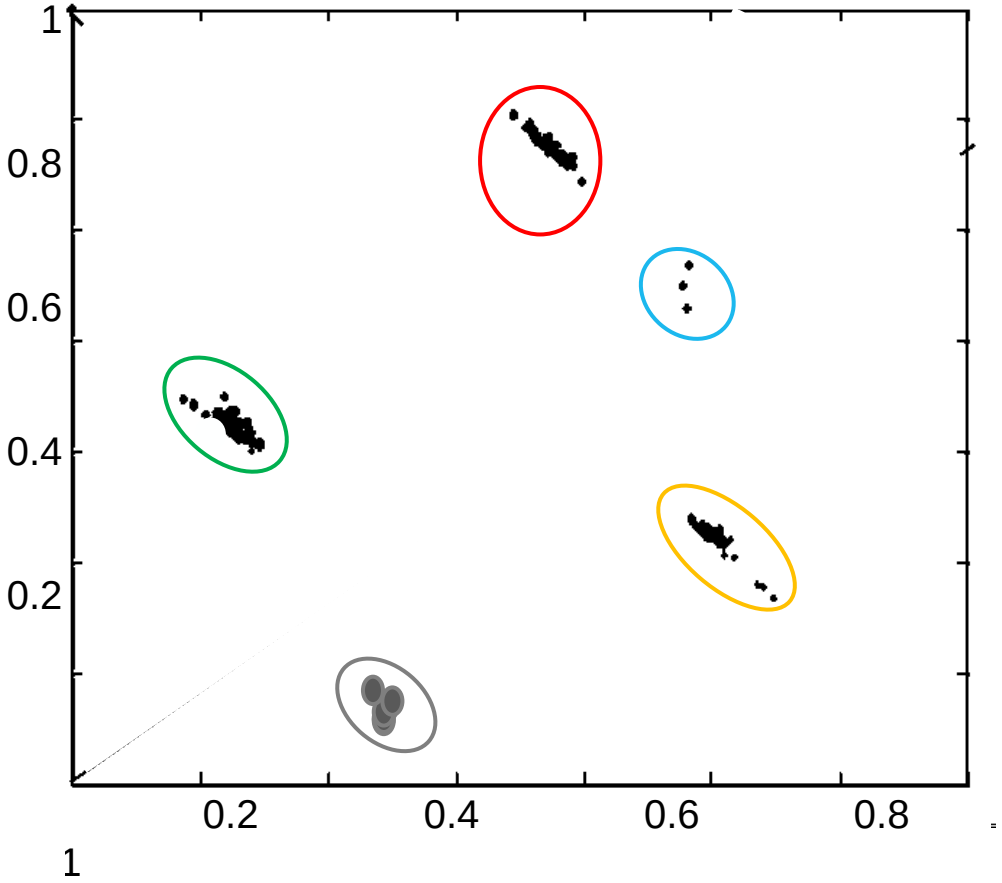
Methods analysis

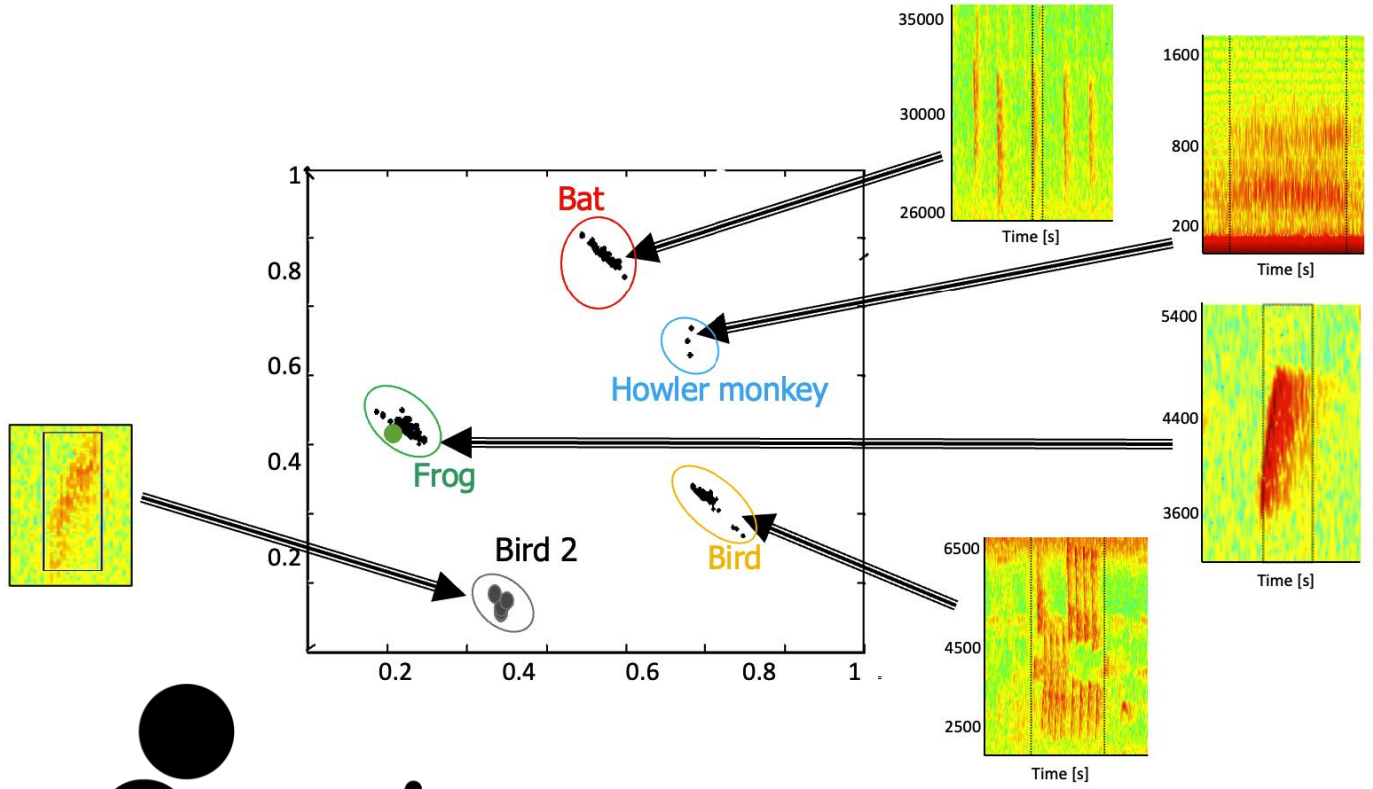
Unsupervised learning methodologies

Name	Method	Authors	Method setup	Characteristics
ARBIMON - BETA	DBSCAN	RAINFOREST CONNECTION	• AED parameter setting • Epsilon (maximum distance between points) • Minimum number of points to form a cluster • Cluster size	• User interface • Cloud storage – online platform • Collaborative projects • Different taxonomic groups • Species – specific • Parameter setting • Cluster interpretation
Kaleidoscope Pro	Spectral Clustering	WILDLIFE ACOUSTICS	• Frequency range • Vocalization duration • FFT window size • Maximum distance to cluster center • Max number of clusters	• User interface • Different taxonomic groups • Multiclass • Species – specific • Collaborative projects • Parameter setting • Manual cluster interpretation
Acoustic Animal Identification	LAMDA 3pi	Guerrero et al., 2023	No need	• Different taxonomic groups • Multiclass • Species – specific • Fuzzy clustering • Collaborative projects • Manual cluster interpretation

Guerrero, M. J., Bedoya, C. L., López, J. D., Daza, J. M., & Isaza, C. (2023). Acoustic animal identification using unsupervised learning. Methods in Ecology and Evolution, 14, 1500–1514.

Clustering Interpretation

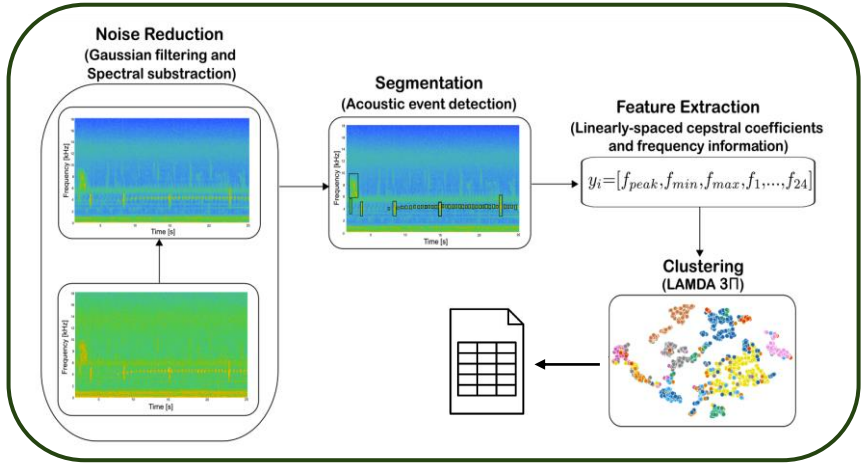




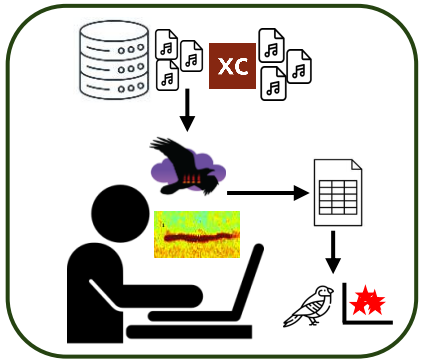
User intervention

Cluster to animal call association

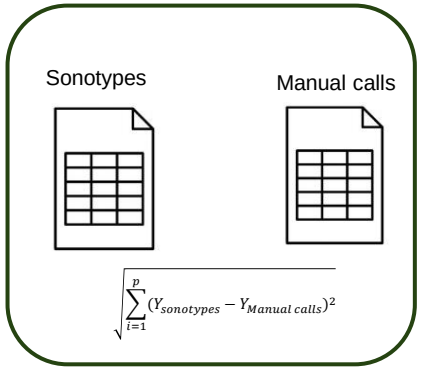
Sonotypes identification
using Guerrero et al., 2023



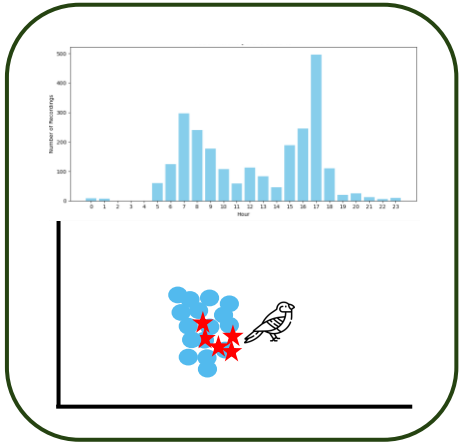
Animal calls segmentation
and labeling process



Similarity analysis



Animal call identification



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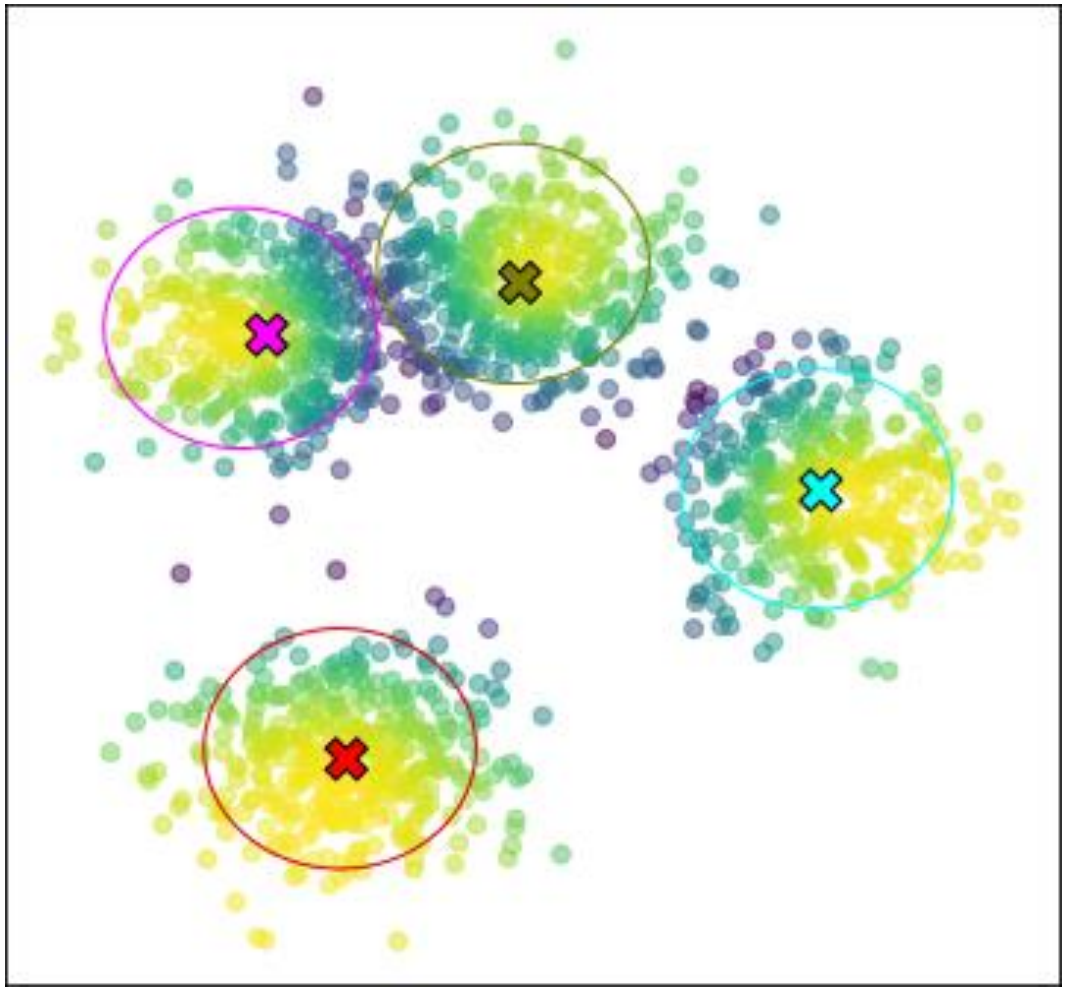
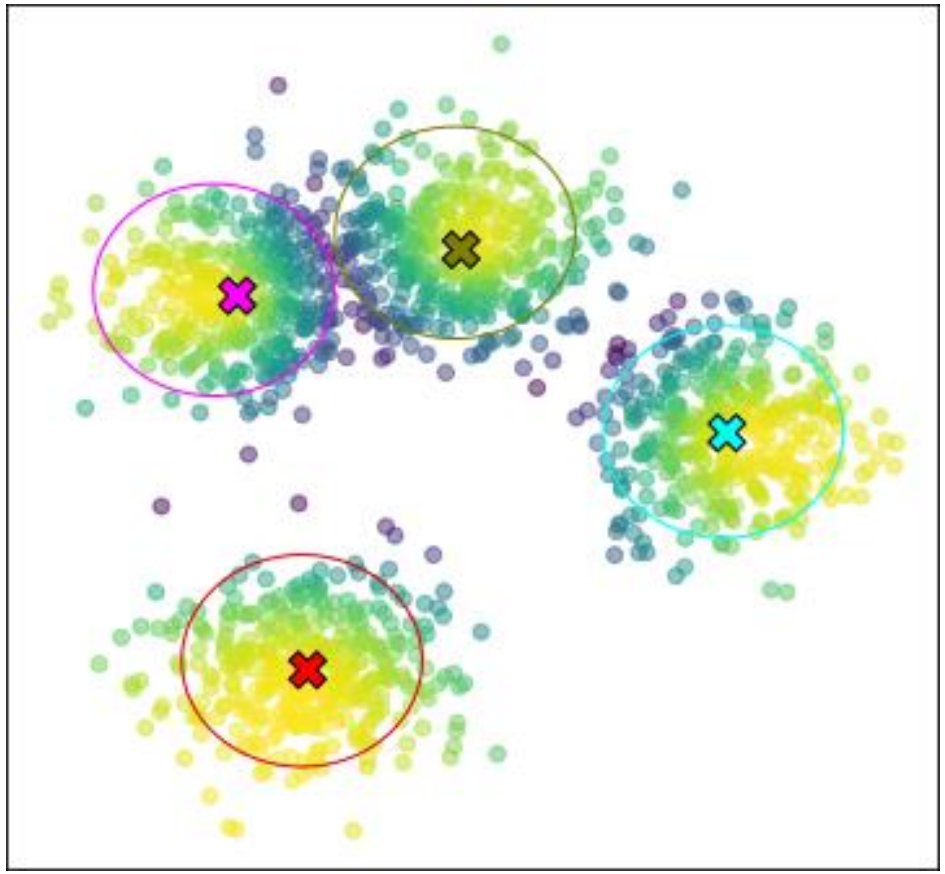
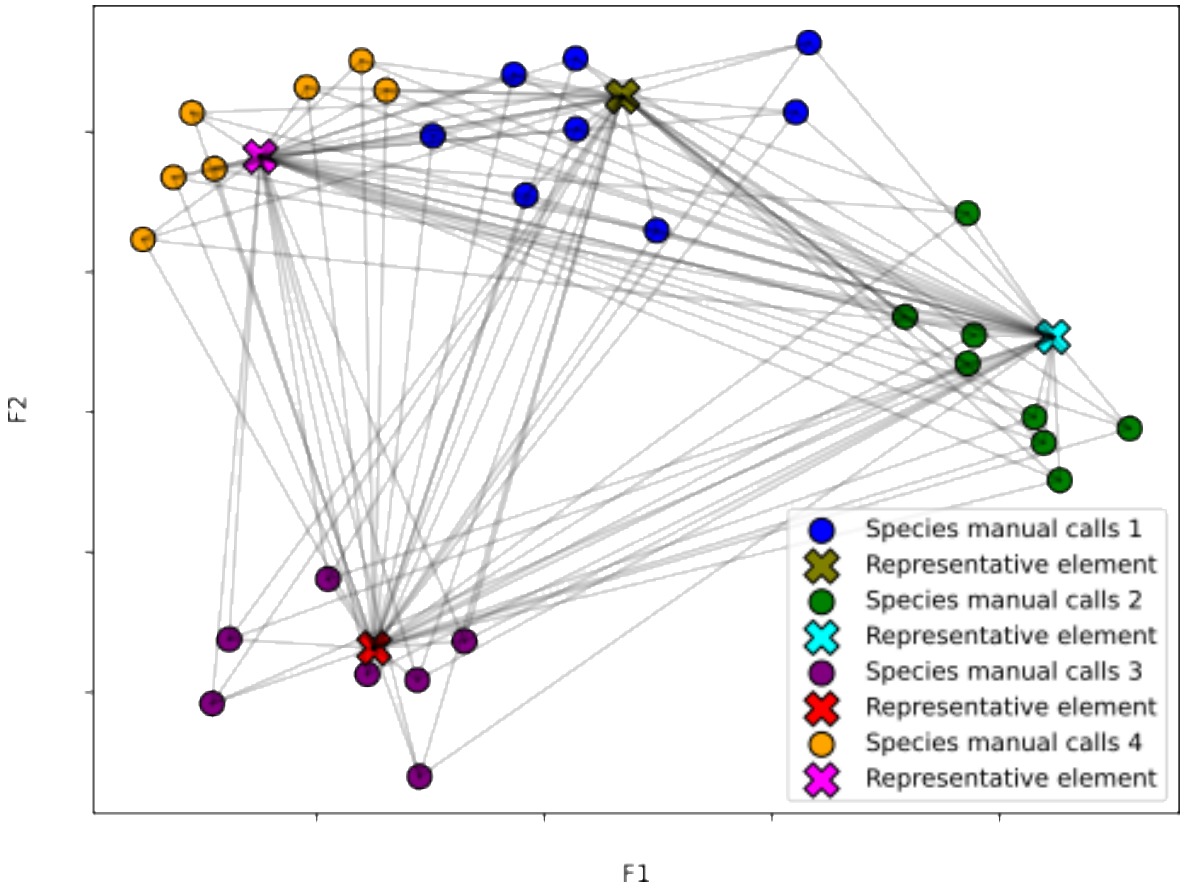
Similarity analysis



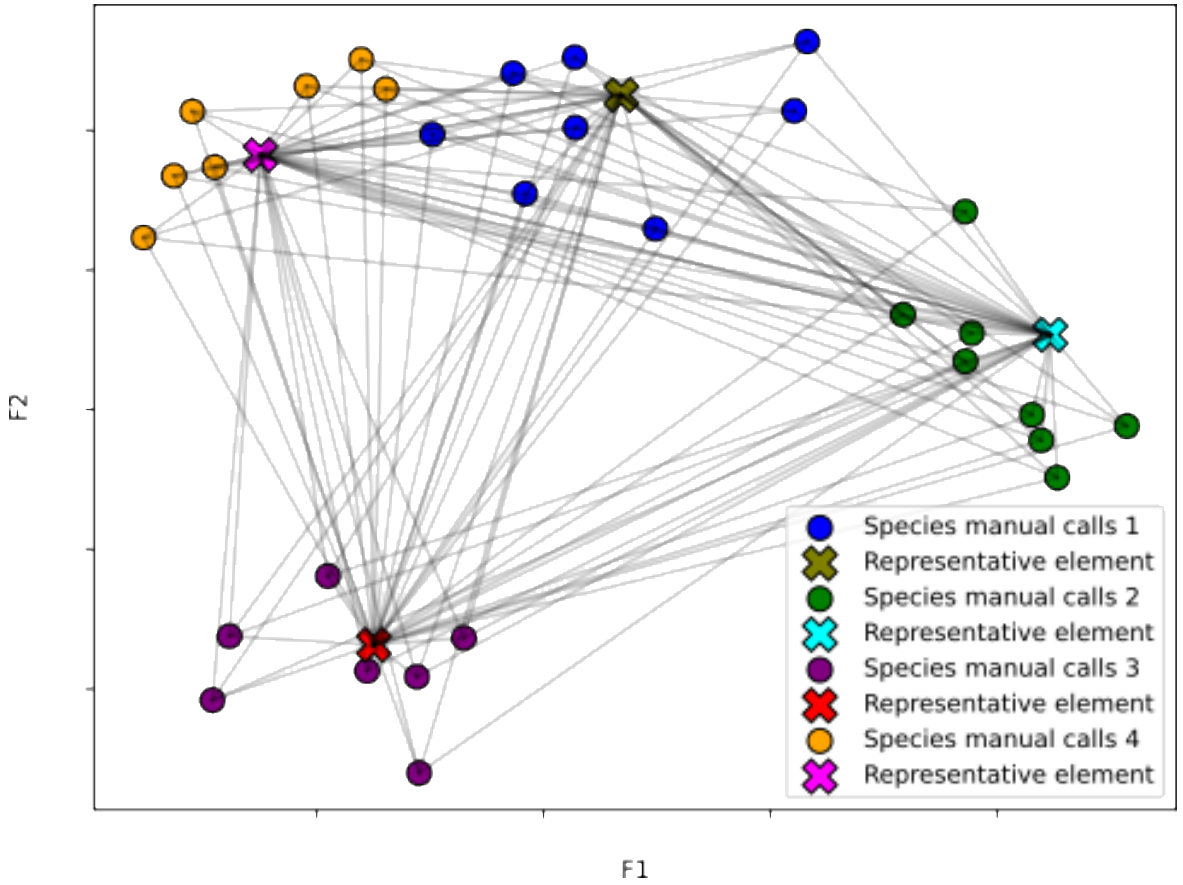
Similarity analysis

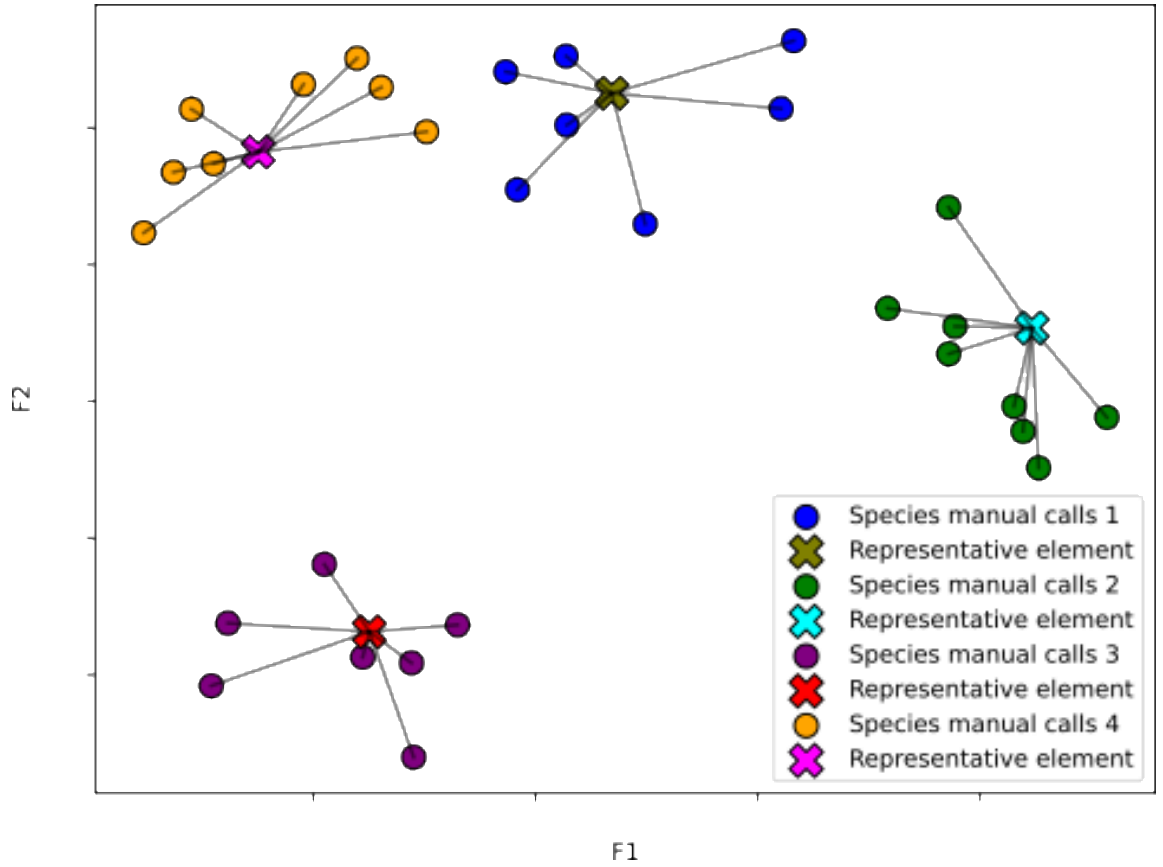




$$\sqrt{\sum_{i=1}^{p}(Y_{sonotypes} - Y_{Manual\ calls})^2}$$

Animal call identification

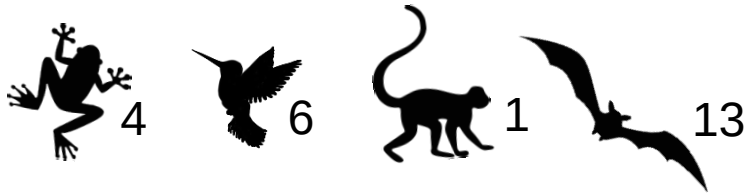




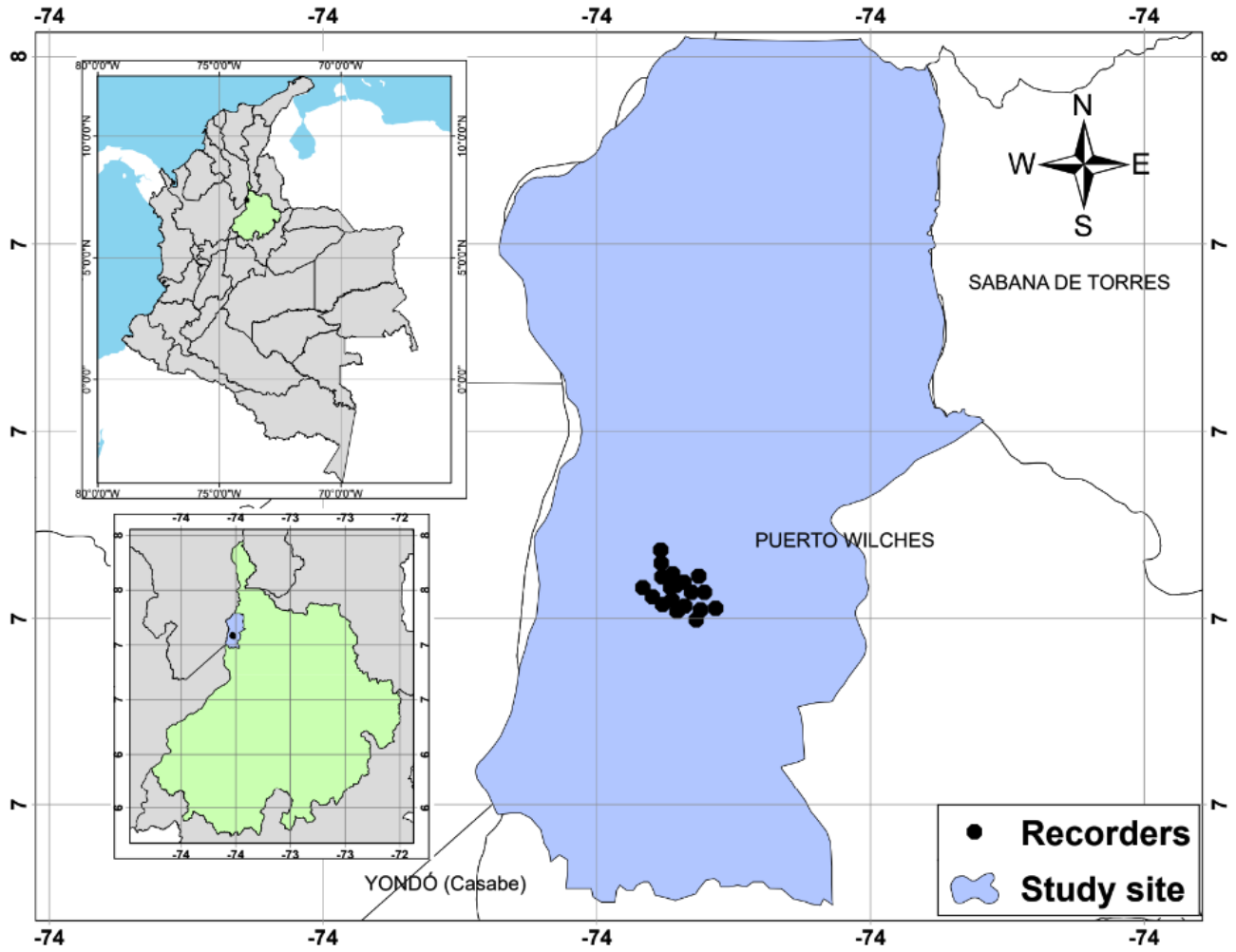
Acoustic dataset

Oil palm plantation – Puerto Wilches Santander, Colombia

Total Files: 19,598
Labeled Files: 207
Device: Song Meter Mini and Mini bat
Length: 1 minute each 15 minutes
Sampling rate: 48 kHz – 384 kHz
Date: March and June 2021



Presence-absence detection

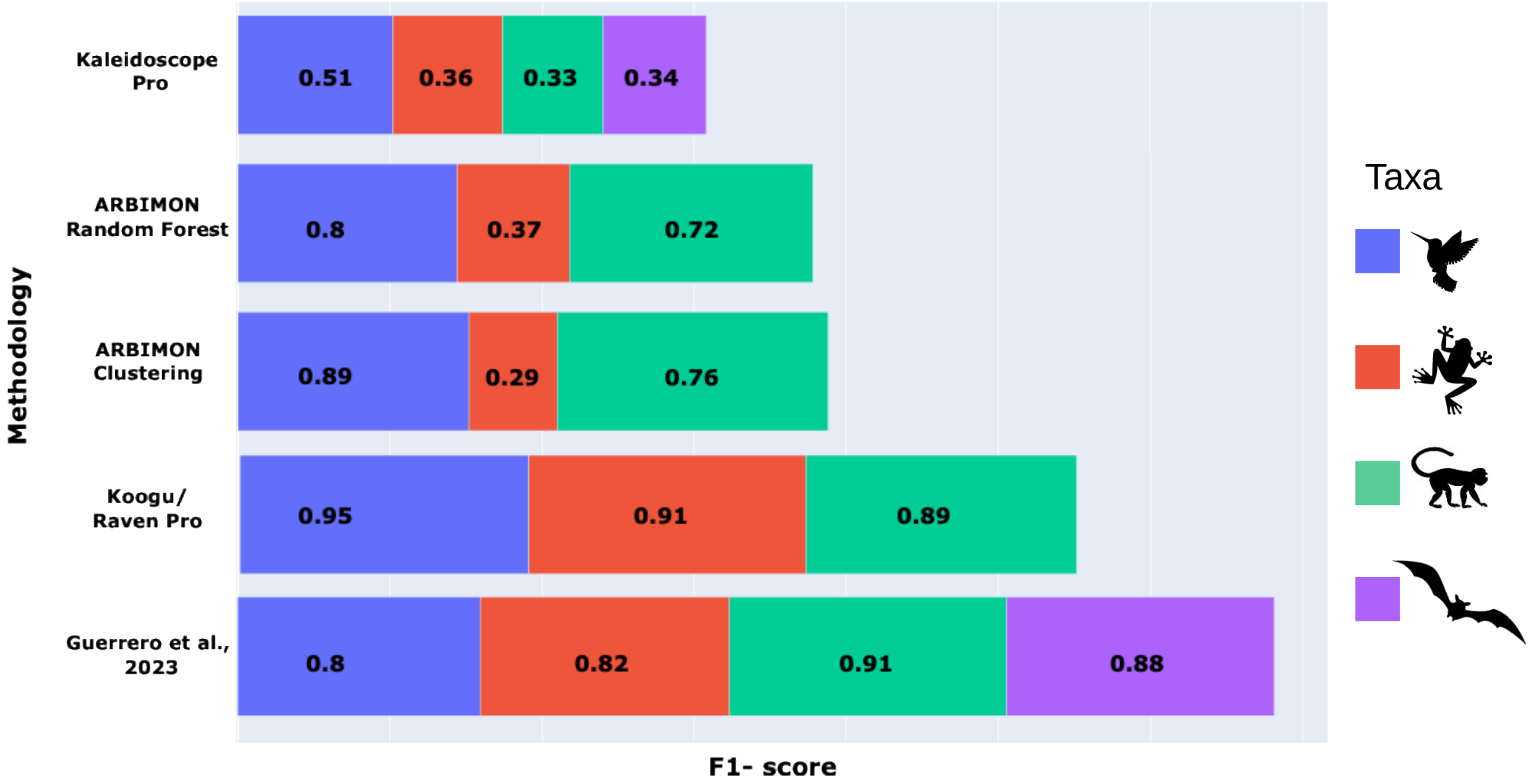


Results

Analysis of computational intelligence methods for animal call identification

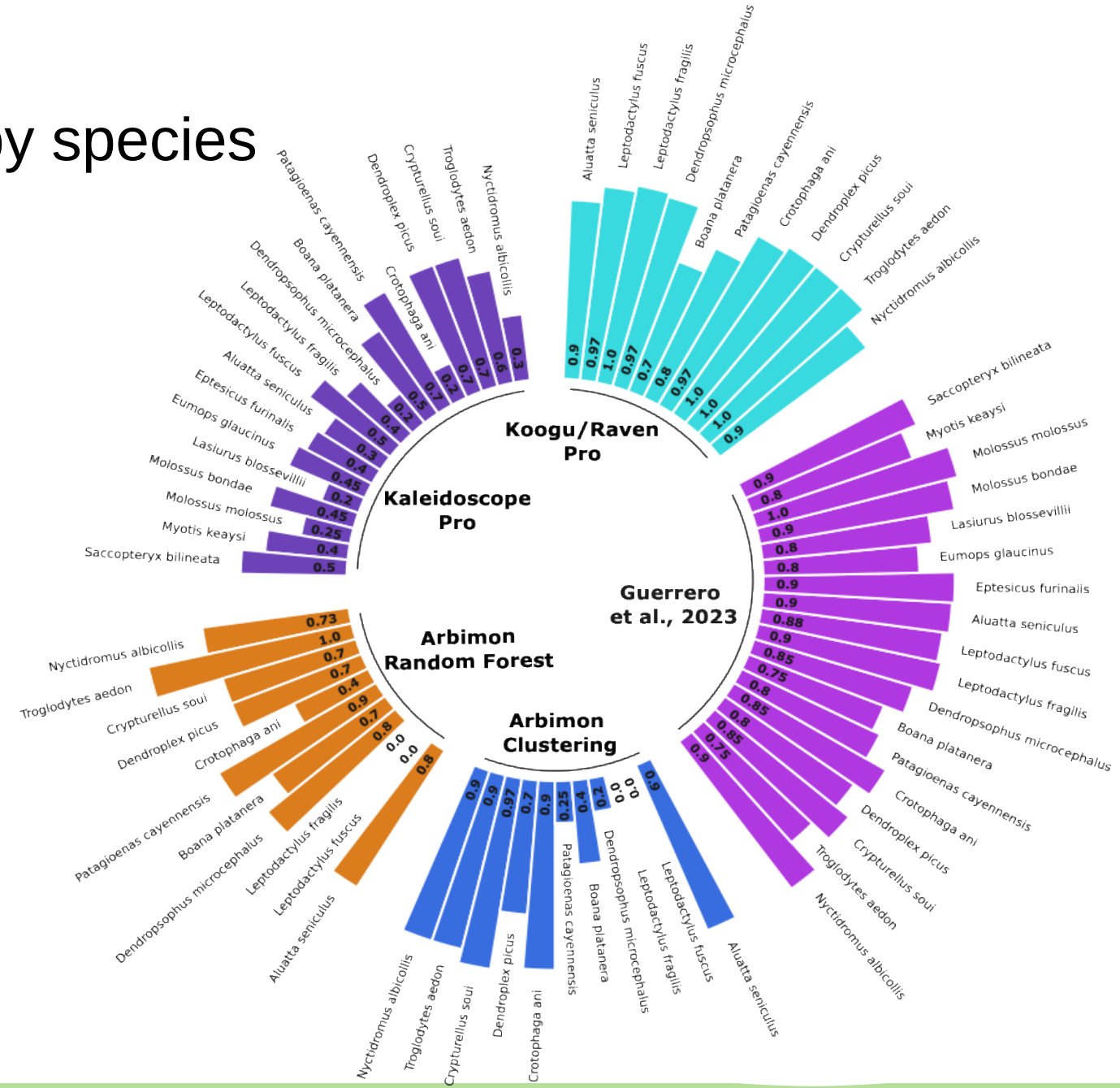
Results

Performance by taxonomic group



Results

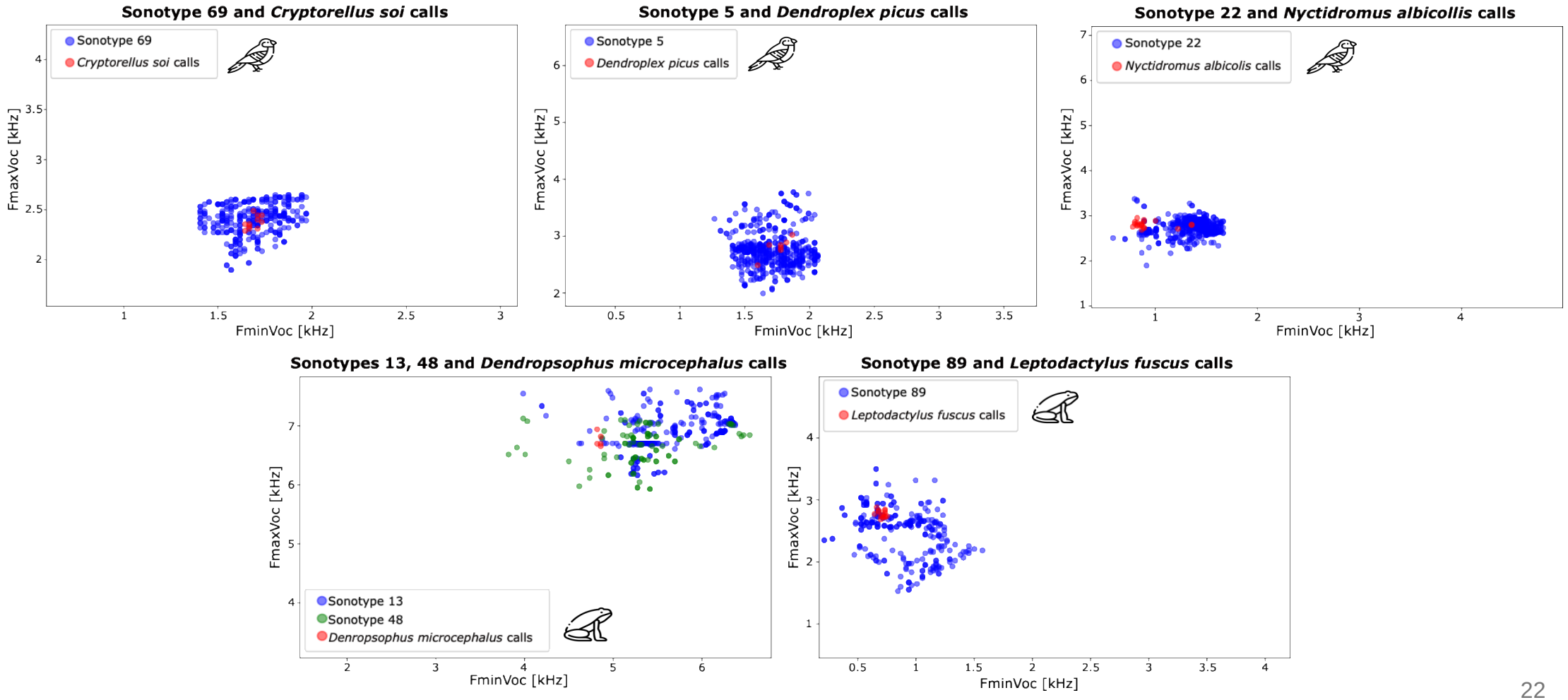
Performance by species



Results
Clustering Interpretation

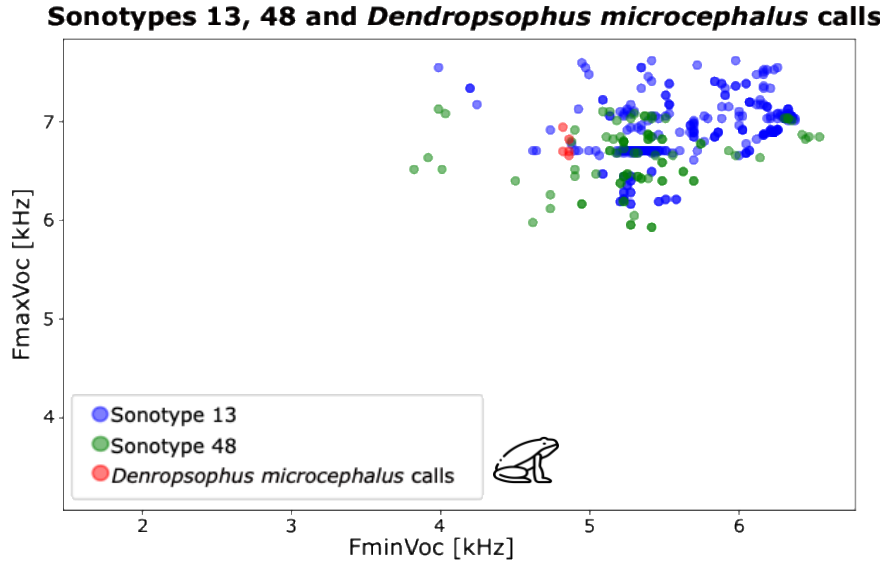
Results

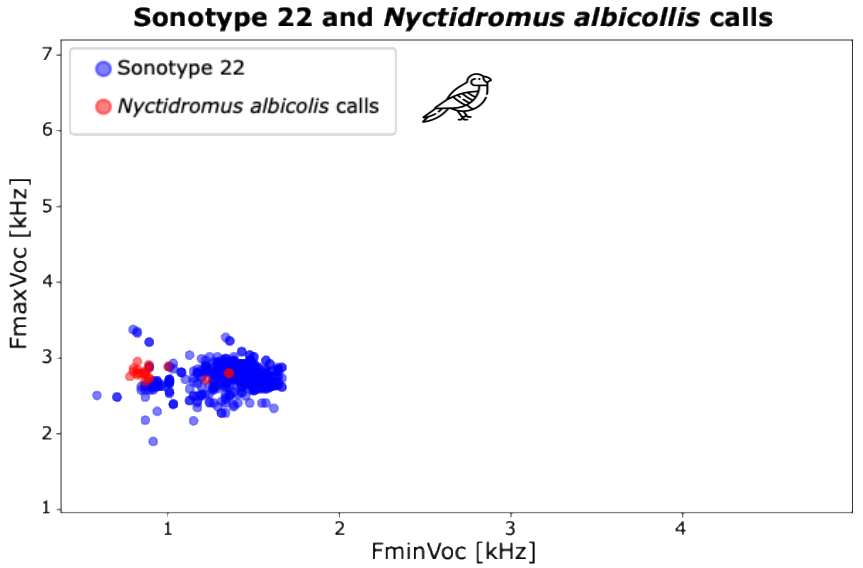
- 130 clusters
- 6 successfully assigned to 5 species calls

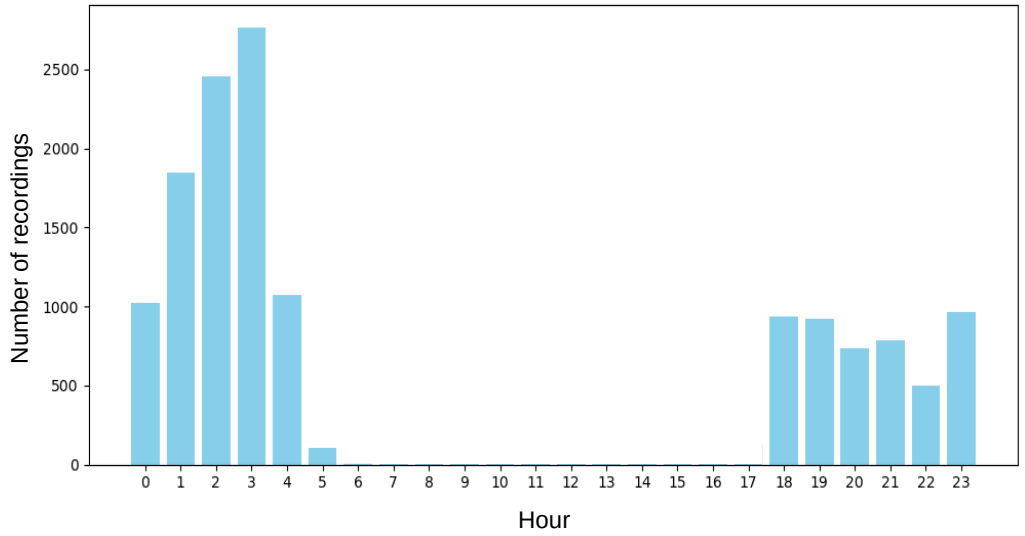


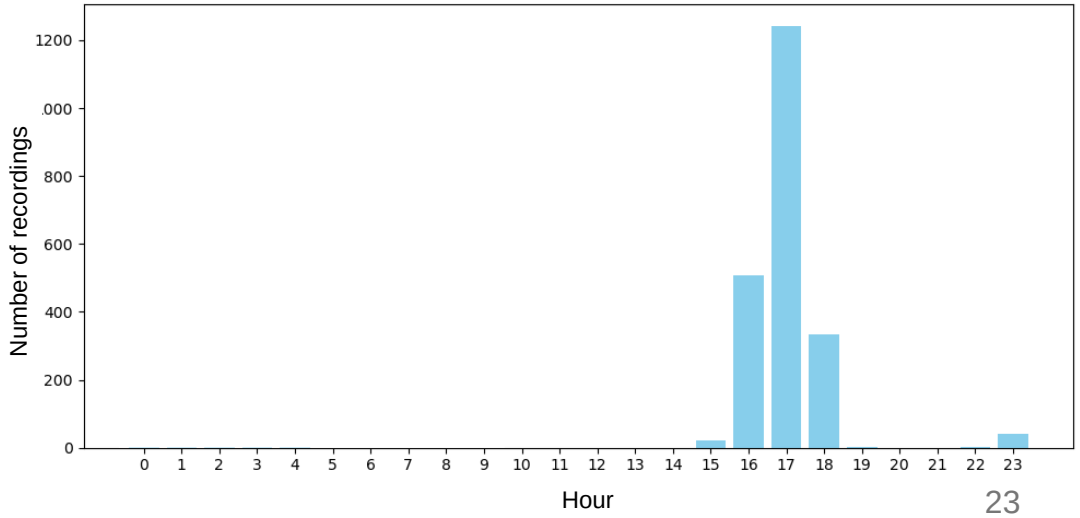
Results

Acoustic temporal pattern









Conclusions and future work

- **Methodology Selection**: It is essential to choose tools that fit the specific requirements of the target species to optimize biodiversity monitoring.
- **Importance of Input Preparation**: Preparing comprehensive input data, including labels and audio formats, is crucial for effective model training.
- **Performance of Methods**: Supervised learning methods like CNNs are highly effective with sufficient labeled data, while unsupervised methods are beneficial in data-scarce environments.
- **Sharing Results from Manual Segmentation**: Facilitate the sharing of not only audio recordings but also the results from manually segmented selection tables to improve reproducibility and collaboration.
- **Streamlining Parameter Configuration:** Improve strategies for parameter configuration to enhance the reproducibility of results across different studies.

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Thank you!

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