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AUTOMATED ECOACOUSTIC MONITORING: EVALUATING CLASSIFIER PERFORMANCE FOR COMMON CUCKOO (*CUCULUS CANORUS*) DETECTION

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ABSTRACT

This study evaluates the effectiveness of automated bioacoustic classifiers in detecting the vocal activity of the common cuckoo (*Cuculus canorus*) within the Chornobyl Exclusion Zone (CEZ). Data were collected from 12 recording locations using Wildlife Acoustics Songmeter 3 (SM3) units during May 2015. Acoustic data were analysed using Kaleidoscope Pro, focusing on the left channel to avoid duplicate detections. The classifier scanned recordings for target sounds based on specified signal parameters and employed cluster analysis to categorise events. The classifier demonstrated high precision (95.1%) and a low false negative rate (0.5%), with most misclassifications due to other bird species with similar frequencies. The recall rate averaged 61%, varying from 40% to 100% across different recorders. Variations in recall rate were influenced by habitat structure, environmental noise, and distance between the target species and the recorder. This study highlights the potential of automated classifiers in ecoacoustic monitoring.

Keywords: *ecoacoustics, biodiversity, monitoring,*

1. INTRODUCTION

Ecoacoustics, the study of environmental sounds and their relationship with the ecosystem, plays a crucial role in monitoring biodiversity. Automated classification, a method that uses machine learning algorithms to identify species from acoustic data, enhances the efficiency and accuracy of such studies. By leveraging these technologies, researchers can effectively monitor species.

The common cuckoo (*Cuculus canorus*) is a migratory brood parasite that relies on other species to raise its young. Females remove host species' eggs and nestlings before laying their eggs in the nest [1]. Common cuckoo breed extensively in Europe and parts of North Africa, and winter in Africa and southern Asia. In Europe, they are summer visitors from April to September, with peak breeding in May and June [2,3]. They inhabit diverse habitats, including woodlands, forests, scrub, heathland, meadows, reedbeds, lowlands, and moorlands. Their diet mainly consists of insects, particularly caterpillars, crickets, and dragonflies [2].

Common cuckoos are solitary outside the breeding season but communicate vocally during breeding [2]. Detection through traditional methods like point counts and line transects is challenging due to their isolated behaviour. The species is characterised by distinct vocalisations, with males emitting loud "cu-coo" calls audible over 2-3 km. These vocalisations make acoustic monitoring highly effective for detecting common cuckoos [4].

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Here, the vocal activity of the common cuckoo was monitored throughout May 2016, one of the most active months for this species [5], to investigate the common cuckoo across the CEZ. The objective of the study was to evaluate the effectiveness of automated detection for this species.

2. METHODS

2.1 Data Collection

Wildlife Acoustics Songmeter 3 (SM3) units were deployed in the CEZ. In total, 12 locations were used. Data were collected continuously between 10th May 2016 and 3rd June 2016.

2.2 Acoustic Data Analysis

The data collected during the specified period was analysed using Kaleidoscope Pro (ver 5.3.6) (Wildlife Acoustics, https://www.wildlifeacoustics.com). To avoid duplicate detections, only the left channel of the recordings was used (channel 0), a method validated by previous studies [6,7,8]. Kaleidoscope Pro scanned recordings for target sounds based on specified signal parameters, including minimum and maximum frequency (Hz), minimum and maximum length of detection (s), and maximum inter-syllable gap (ms). These parameters were determined using 40 manually located cuckoo calls from the study area with Raven Pro 1.5 (Bioacoustics Research Program 2014). Kaleidoscope Pro's cluster analysis function was used, extracting the Discrete Cosine Transform coefficient (DCT) of the spectrum of candidate sounds. A Hidden Markov Model (HMM) was constructed using the vector of the DCT of each signal frame, and vectors were grouped based on K-Means clustering. Clusters were labelled as "cuckoo" or "other sounds" based on the first 50 events of each cluster. Each sound was visually/acoustically checked to determine classifier performance, including precision and recall rate.

Table 1. Signal parameters derived from Raven Pro were input into Kaleidoscope to detect common cuckoo calls.

Species	Min Freq (Hz)	Max Freq (Hz)	Min Length (s)	Max Length (s)	Intersyllable Gap (s)
Common Cuckoo	250	900	0.3	1	0.6

The recall rate was estimated by dividing the total number of calls detected by Kaleidoscope Pro by the total number of actual cuckoo vocalizations (determined by manual analysis). A total of 108, 15-minute recordings were randomly selected to determine the recall rate.

3. RESULTS

The common cuckoo was detected through the cluster analysis function within Kaleidoscope Pro at every recording location across the CEZ. The number of calls detected ranged from 2163 to 16,062. Kaleidoscope Pro reported a total of 128,527 events matching the signal parameters. These were divided into "other sounds" (29,437 events, 22.9%) and "cuckoo" (99,090 events, 77.1%).

The precision of the classifier was 95.1%, with a false positive rate of 3.3%. Most false positives were vocalisations from birds with similar frequencies, including the common woodpigeon (*Columba palumbus*), Eurasian hoopoe (*Upopa epops*), Eurasian collared dove (*Streptopelia decaocto*), and tawny owl (*Strix aluco*). The mean recall rate for the entire dataset was 61% (5058 calls detected out of 8363 calls annotated in the 108 recordings of the validation dataset), ranging from 40% to 100% for each recorder.

Table 2. Recall rate for each acoustic recorder used in this study. The number of manual annotations represents the number of calls detected through manually inspecting the validation dataset, whereas the number of calls detected through automated classification represents how many calls the classifier in Kaleidoscope Pro detected. The recall rate column expresses the percentage of calls correctly detected by the automated classifier in relation to the calls detected through manual annotations.

Recorder	No. of calls manual annotations	No. of calls automated classifier	Recall Rate
303715	1158	773	67%
303712	2087	1145	55%
303160	1074	434	40%
303727	403	205	51%
303719	302	265	88%
303724	331	178	54%
303137	563	298	53%
303138	25	25	100%

303736	794	614	77%
303183	548	271	50%
303146	425	379	90%
303139	653	471	72%

4. DISCUSSION

The classifier showed high precision (95.1%) and a low false negative rate (0.5%), indicating few misclassifications, mainly due to other bird species with similar frequencies. It performed well in detecting common cuckoo calls within the CEZ, achieving a recall rate of 61%, though this varied from 40% to 100% across different recorders.

Variations in recall rate were likely influenced by factors such as habitat structure, environmental noise, and the distance between the target species and the recorder. Habitat characteristics can affect sound transmission, leading to signal attenuation and impacting detectability. Environmental noise, especially during adverse weather conditions and high biophonic noise during the dawn chorus, can also challenge accurate detection. The distance between the target species and the recorder further affects the classifier's ability to detect vocalisations.

5. REFERENCES

[1] V. Jelínek, P. Procházka, M. Požgayová, and M. Honza: "Common Cuckoos Cuculus canorus change their nest-searching strategy according to the number of available host nests," Ibis, vol. 156, no. 1, pp. 189–197, 2014.

[2] R. B. Payne: The Cuckoos. New York: Oxford University Press, 2005.

[3] M. Honza, B. Taborsky, M. Taborsky, Y. Teuschl, W. Vogl, A. Moksnes, and E. Røskaft: "Behaviour of female common cuckoos, Cuculus canorus, in the vicinity of host nests before and during egg laying: A radiotelemetry study," Animal Behaviour, vol. 64, no. 6, pp. 861–868, 2002.

[4] J. Shonfield and E. M. Bayne: "Autonomous recording units in avian ecological research: current use and future applications," Avian Conservation and Ecology, vol. 12, no. 1, 2017

[5] J. Mei, S. M. Puswal, M. Wang, and F. Liu: "Diurnal and Seasonal Patterns of Calling Activity of Seven Cuculidae Species in a Forest of Eastern China," Diversity, vol. 14, no. 4, pp. 1–18, 2022.

[6] E. C. Knight, K. C. Hannah, G. J. Foley, C. D. Scott, R. M. Brigham, and E. Bayne: "Recommendations for acoustic recognizer performance assessment with application to five common automated signal recognition programs," Avian Conservation and Ecology, vol. 12, no. 2, 2017.

[7] C. Pérez-Granados and K. L. Schuchmann: "Monitoring the annual vocal activity of two enigmatic nocturnal Neotropical birds: the Common Potoo (Nyctibius griseus) and the Great Potoo (Nyctibius grandis)," Journal of Ornithology, vol. 161, no. 4, pp. 1129–1141, 2020.

[8] C. Pérez-Granados and K. L. Schuchmann: "Seasonal climate impacts on vocal activity in two neotropical nonpasserines," Diversity, vol. 13, no. 7, pp. 1–13, 2021.