Efficiency, accuracy and utility of a sound monitoring tool in bird monitoring programs. Identifications by BirdNET and humans are compared

BY BO KAYSER

Abstract

Danish bird observatories have been monitoring changes in the number of migrating birds for decades using standardized migration counts and ringing. It can be difficult and costly to find people to do this work. Hence, I wanted to investigate whether electronic listening tools could be used as a supplement or a replacement for some of these monitoring tasks.

For this purpose, I compared identifications by the BirdNET neural network (Cornell Lab of Ornithology and Chemnitz University of Technology) of bird sounds obtained with a PUC digital sound recorder (https://www.birdweather.com), with simultaneous identifications by ear by a person standing near the PUC. The studies were carried out in an area with gardens, fields and forests in Stensby near the coast of Southern Zealand.

During all the ten-minute recordings combined, the person identified 9,888 and the PUC 1,564 bird sounds. The efficiency of the PUC in relation to the person was thus 16%. It was predominantly distant and weak sounds that PUC did not recognize.

When checking 2,500 of the PUC recordings by ear, a full 98% of identifications were judged to be correct, while 1% were judged to be incorrect and for 1%, I was unsure about the species identification due to poor sound quality.

For a wide range of vocally active bird species the PUC was considered suitable for monitoring changes in species composition and relative abundance at the study site.

Introduction

There is a widespread need to record bird occurrences around the globe (Anon. 2022). However, the number of competent bird monitors is limited, as is the time they can spend recording data in specific areas. Consequently, there is a desire to supplement human data collection with data gathered by autonomous recording units (ARUs) like the BirdWeather PUC.

The main objective for BirdLife Denmark with the bird observatories in Blåvand, Gedser and Skagen is that the bird observatories shall monitor changes in the number of migratory birds passing through the country and publish the results in an easily accessible way and do so for decades.

For many years migrating birds have been counted at spits along the coast (Meltofte 1993, Jenni 2003, Thorup 2007, Kayser & Pagh Jensen 2022) and caught for ringing using standardized monitoring practices (Tøttrup 2006, Kayser 2021, Ranke 2022, Uijl 2024).

Other methods can be used to record the number of migratory birds. This can be done, for example, by using standardized registration of bird sounds. In the long term, bird observatories can stop using, for example, ringing and switch to a combination of other monitoring tools. For BirdLife Denmark, it is important that the monitoring can be made for a long period of time for a large number of bird species. The recorded numbers of units differ—for example, between the number of ringed birds and the number of recorded bird sounds. To compare changes recorded using different methods, it is appropriate to present the changes as index values.

Over the past 10–15 years, several studies have been conducted comparing recordings made using Passive Acoustic Monitoring (PAM) like the PUC with those made by humans (Sedláček *et al.* 2015, Leach *et al.* 2016, Darras *et al.* 2018, Doohan *et al.* 2025, Fathoni *et al.* 2026). Typically, the aim has been to determine the number of species, the number of individuals of each species, and the composition of the bird communities. Researchers have often used point counts to record the birds present (Sedláček *et al.* 2015, Leach *et al.* 2016). Human observers in the field are generally better at estimating the number of individuals than PAM (Sedláček *et al.* 2015).

PAM appears to be a good supplement to surveys conducted by humans. By using listening equipment with high-quality microphones, results comparable to those obtained by human observers can be achieved with PAM (Darras *et al.* 2018).

The results presented in this article are part of a series of studies documenting the usefulness of bird sound recording using a BirdWeather PUC listening device (BirdWeather 2026), called the PUC, to monitor changes in the number of migratory birds passing through an area over time.

This article is the first in a series of at least three publications in which the results are presented. This article presents results on how effective a PUC is in recording bird sounds compared to a person standing nearby. In addition, results are presented on the accuracy of the species identification provided by the PUC. Finally, an analysis is presented of how well the changes in numbers over time that PUC records correspond to the changes that a person standing nearby registers.

The next step in the analysis is to gain knowledge when comparing ringing, migration counting and electronic bird sound recording record over time for the three methods (Kayser 2026).

The third step will be a supplementary study of which types of bird sounds that are recorded in spring and autumn, respectively. Is it singing (breeding-related sounds), migration calls or other sounds?

The results are expected to be summarized with an overview of bird species for which sufficient data is collected at Gedser Bird Observatory to follow the changes over the years and of which of the three monitoring methods that are most suitable for the individual species.

Starting in the autumn of 2025, the results from the PUC bird sound recordings were included in the reporting done by Gedser Bird Observatory on bird migration in the Gedser area and in the calculation of changes in bird numbers.

Materials and methods

The recordings of bird sounds were made in Denmark in the village Stensby (54.980°N, 12.049°E) in a large garden surrounded by fields and forests and about 2 km from the coast.

Recordings were made during each halfmonth from November 2024 to October 2025. Recordings were made with the PUC (see picture), during 24 hours from midnight to midnight. Tool settings: Recording time: 9 sec. Probability: 5%. Confidence: 75%. This means that the recordings analyzed by BirdNET are 9 s long, that the probability of a species being in the area by BirdNET has been estimated to be at least 5% and that BirdNET has estimated that the probability that the identification is correct is at least 75%.

The BirdWeather PUC listening tool.

The human identifications by ear were made by the author from an hour before sunrise to an hour after sunset. Records were made for 10 minutes each hour. For each minute all the bird species heard were recorded. Birds that were only seen but not heard were not recorded.

The efficiency of the identifications made by the PUC was found by comparing its identifications with those of the human listener. This was done by comparing the number of minutes of the 10 minutes in which bird sounds of each species had been recorded by the PUC and by the author.

The correctness of the bird sound identifications made by the PUC was estimated by the author by listening to a series of 500 recordings made by the PUC and comparing the bird species identified by the PUC BirdNET solution with those identified by the author. Such a comparison was made in five different months. The author is experienced in identifying bird sounds, has some degree of age-related hearing loss and is using hearing aids.

I also investigated whether the PUC records showed the same patterns in bird occurrences (sounds) during predefined periods as the data collected by the human observer. Here, I compared the identification of species of bird sounds made by ear for 10 minutes each hour with those identifications made by the PUC in the same 10-minute period from an hour before sunrise to an hour after sunset. Recording was not made during the night, because very few bird sounds were detected during the night in the 24-hours PUC surveys.

A priori, I noticed that the number of bird sounds tended to rise during the spring (first half of the year) and subsequently fell during the autumn (second half of the year). Similarly, the number of bird sounds tended to increase during the morning and forenoon, only to decrease again during the afternoon and evening. Such temporal changes in activity patterns may be difficult to model, and hence, I analyzed the bird occurrences separately in six-month periods (January to June and July to December) broken into half-month intervals and in 12-hour periods (separated at noon) broken into hourly intervals. Furthermore, I compared the bird recordings across the two methods directly independent of time to analyze, if the human and the PUC recorded many/few birds in the same time intervals.

All analyses were carried out as Spearman rank correlation tests as the assumptions of parametric tests were transgressed in several cases.

Results

The efficiency of the PUC BirdNET identifications

The study showed that the PUC BirdNET solution identified only about one-sixth of the bird sounds that a human standing beside the PUC did (Tab. 1). It was mostly the many weak sounds and remote birds that were missed by the PUC.

Tab. 1. Number of identifications made by the author and the PUC and percentage of number of identifications made by the PUC compared to the auther.
Antallet af artsbestemmelser foretaget af forfatteren og af PUC'en samt den procentvise andel.

	Number of identifications *Antal bestemmelser*		**Percentage** *Procent*
	Human *Person*	**BirdNET** *BirdNET*	**BirdNET to human** *BirdNET til person*
Bird sound identifications (all species) *Fuglelydsbestemmelser (alle arter)*	9888	1564	16

The precision of the identifications of bird species made by BirdNET

The author listened to a series of 500 recordings made by the PUC and compared the identification of the species made by BirdNET and those of the author (Tab. 2).

Tab. 2. The number of identifications made by BirdNet and the author that were equal, different or where the author was unsure.
Antallet af artsbestemmelser foretaget af BirdNET og forfatteren som var enten ens, forskellige eller hvor forfatteren var usikker på arten.

Date *Dato*	**Equal** *Ens*	**Different** *Forskellige*	**Unsure** *Usikker*	**Total** *I alt*
01-12-2024	492	5	3	500
02-01-2025	487	5	8	500
16-02-2025	494	2	4	500
01-04-2025	487	11	2	500
03-06-2025	497	3	0	500

The precision of the PUC BirdNET solution was high. About 98 percent of the sounds identified were the same. However, the PUC had also some strange identifications too. E.g. the PUC identified most calls from Hooded Crow *Corvus cornix* as being Carrion Crow *Corvus corone* (often classified as the same species, *Corvus corone.* (Cramp *et al.* 1994)). Some songs of Common Wood Pigeon *Columba palumbus* were identified as Eurasian Collared Dove *Streptopelia decaocto*. Remote European Herring Gulls *Larus argentatus* were identified as Eurasian Bittern *Botaurus stellaris*. The zipper in my coat was identified as Mute Swan *Cygnus olor*.

Bird groups suitable for this monitoring tool

Only bird species that make sounds regularly can be monitored using the PUC. It can be vocal like call notes and song, or mechanical like the drumming of woodpeckers or the wing flaps of Mute Swans. For groups that are mostly silent during migrating like raptors, divers and grebes, the tool will not be relevant.

During this study it was possible to record species from the following groups: geese, ducks, swans, gamebirds, doves and pigeons, cranes, gulls, owls, woodpeckers and passerines.

Tab. 3. The number and percentage of recorded bird sounds from the different species groups made by the author and by the PUC.
Antallet og procentdelen af registrerede fuglelyde fra de forskellige artsgrupper, registreret af henholdsvis forfatteren og en PUC'en.

	Human *Person*		**PUC *PUC***	
Group of birds *Gruppe af fugle*	**Number *Antal***	**Percent *Procent***	**Number *Antal***	**Percent *Procent***
Geese *Gæs*	613	6	119	8
Pigeons *Duer*	1571	16	132	8
Non-passerine birds (other) *Ikke-spurvefugle (andre)*	647	7	27	2
Corvids *Kragefugle*	2132	22	323	21
Tits *Mejser*	525	5	86	5
Warblers *Sangere*	849	9	230	15
Thrushes *Drosler*	1673	17	269	17
Sparrows *Spurve*	705	7	45	3
Finches *Finker*	362	4	71	5
Other passerines *Andre spurvefugle*	811	8	262	17
Total *I alt*	**9888**	**100**	**1564**	**100**

In general, the human and the PUC recorded the same composition of bird sounds across different bird groups (Tab. 3). However, the proportion of pigeons in the total number of recordings was twice as big for the human as for the PUC. This may be because the PUC only records loudly singing Wood Pigeons close by, while the person can hear the more distant song, which may be heard almost all day long.

Changes and trends recorded by the tool compared to changes and trends recorded by a human listener

The total numbers of records made by the human and by the PUC were very different (Tab. 3). Thus, when comparing the relative number of recorded bird sounds over time the percentages of registrations for each of the two methods (human and PUC) was used.

Tab. 4. Multiperiod changes in number of bird sounds for halfmonths in the first and the second half of year. Results from recordings made by the author and the PUC are compared. Spearman rank correlation test. Rho is the Spearman correlation coefficient.
Flerperiode ændringer i antallet af fuglelyde for halvmåneder i første og anden halvdel af året. Resultater for registreringer udført af forfatteren og PUC'en er sammenlignet. Spearman rank correlation test. Rho er Spearman korrelationskoefficienten.

	Halfmonth *Halvmåned* 01-h1 to *til* 06-h2				**Halfmonth *Halvmåned* 07-h1 to *til* 12-h2**			
	Human *Person*		**PUC *PUC***		**Human *Person***		**PUC *PUC***	
	Rho	**P-value**	**Rho**	**P-value**	**Rho**	**P-value**	**Rho**	**P-value**
All species *Alle arter*	0.867	<0.001	0.937	<0.001	-0.797	<0.01	-0.347	0.269
Wood Pigeon *Columbo palumbus*	0.909	<0.001	0.820	<0.001	-0.937	<0.001	-0.863	<0.001
Rook *Corvus frugilegus*	-0.690	<0.05	-0.814	<0.01	0.344	0.273	0.361	0.248
Chiffchaff *Phylloscopus collybita*	0.885	<0.001	0.827	<0.001	-0.669	<0.05	-0.293	0.355
Blackbird *Turdus merula*	0.748	<0.01	0.788	<0.01	-0.319	0.317	-0.430	0.163

Tab. 5. Multiperiod changes in number of bird sounds for hours in for the first and the second half of the day. Results from recordings made by the author and the PUC are compared. Spearman rank correlation test.
Flerperiode ændringer i antallet af fuglelyde for timer i første og anden halvdel af døgnet. Resulter for registreringer udført af forfatteren og PUC'en er sammenlignet. Spearman rank correlation test.

	Hour *Time* 3 to *til* 11				**Hour *Time* 12 to *til* 22**			
	Human *Person*		**PUC *PUC***		**Human *Person***		**PUC *PUC***	
	Rho	**P-value**	**Rho**	**P-value**	**Rho**	**P-value**	**Rho**	**P-value**
All species *Alle arter*	0.912	<0.001	0.912	<0.001	-0.790	<0.01	-0.790	<0.01
Wood Pigeon *Columbo palumbus*	0.735	<0.01	0.521	0.082	-0.272	0.391	-0.356	0.257
Rook *Corvus frugilegus*	0.928	<0.001	0.879	<0.001	-0.959	<0.001	-0.859	<0.001
Chiffchaff *Phylloscopus collybita*	0.924	<0.001	0.909	<0.001	-0.516	0.086	-0.515	0.087
Blackbird *Turdus merula*	0.879	<0.001	0.367	0.240	-0.455	0.137	-0.186	0.563

Tab. 6. Comparison for each halfmonth of the number of registrations made by the author and by the PUC for all halfmonths throughout the year from November 2024 to October 2025. The rankings of the values for the human and the PUC, respectively, are compared. The same comparison was made for each hour. Spearman rank correlation test.
Sammenligning for hver halvmåned af antal registreringer af forfatteren og PUC'en for alle halvmåneder i året fra november 2024 til oktober 2025. Rang af værdier for henholdsvis personen og PUC'en er sammenlignet. Den samme sammenligning blev lavet for hver time. Spearman rank correlation test.

	Halfmonth *Halvmåned*		**Hour *Time***	
	Rho	**P-value**	**Rho**	**P-value**
All species *Alle arter*	0.851	<0.001	0.949	<0.001
Wood Pigeon *Columbo palumbus*	0.859	<0.001	0.792	<0.001
Rook *Corvus frugilegus*	0.789	<0.001	0.952	<0.001
Chiffchaff *Phylloscopus collybita*	0.860	<0.001	0.967	<0.001
Blackbird *Turdus merula*	0.914	<0.001	0.382	0.066

In the following figures the variation in sound activity during the year and during the day (24 hrs.) is shown. In early January and late December recordings were obtained for 10 hours. In late June and early July recordings were collected for 20 hours. So even if the number of bird sounds per hour had been the same throughout the year the recorded numbers would increase during the first half of the year and decrease during the second half of the year.

All species

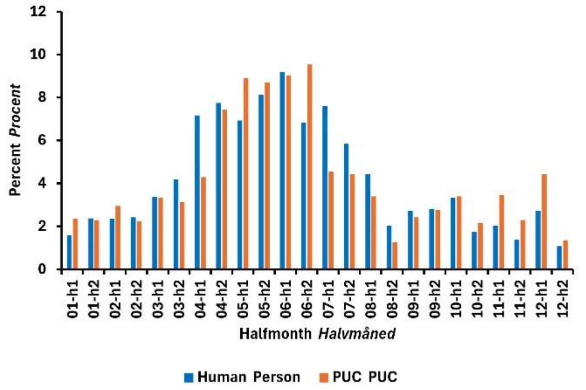

Fig. 1. Number of recorded sounds in each halfmonth for all species made by the author and the PUC.
Antal lyde registreret af forfatteren og PUC'en i hver halvmåned for alle arter.

For both the human and the PUC the number (and percentages) of recorded sounds correlated significantly with time during the first half of the year. During the second half of the year the numbers were generally decreasing over time indicated by the inverse correlations, although only significant for recordings made by the human (Tab. 4 and Fig. 1).

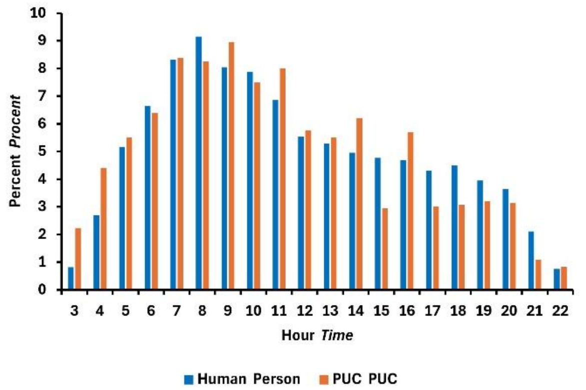

Fig. 2. Number of recorded sounds in each hour for all species made by the author og the PUC.
Antal lyde registreret af forfatteren and PUC'en i hver time for alle arter.

For both the human and the PUC there was a significant increase in the number of recorded sounds during the first half of the day. During the second half of the day the numbers decreased. For recordings made by the human as well as by the PUC the decrease was significant (Tab. 5 and Fig. 2).

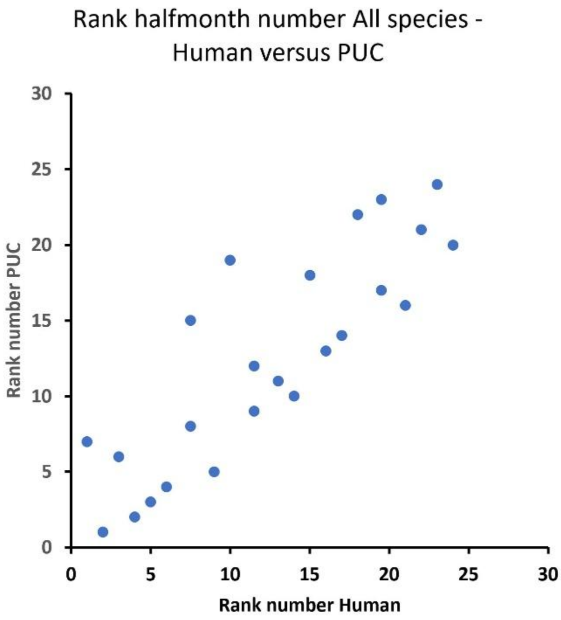

Fig. 3. Comparison for each halfmonth of the number of bird sound registrations made by the author and by the PUC for all halfmonths throughout the year. The rankings of the values for the person and the PUC, respectively, are compared. Spearman rank correlation test.
Sammenligning for hver halvmåned af antal af fuglelyde registreret af forfatteren og PUC'en for alle halvmåneder i året. Rang af værdier for henholdsvis person og PUC er sammenlignet. Spearman rank correlation test.

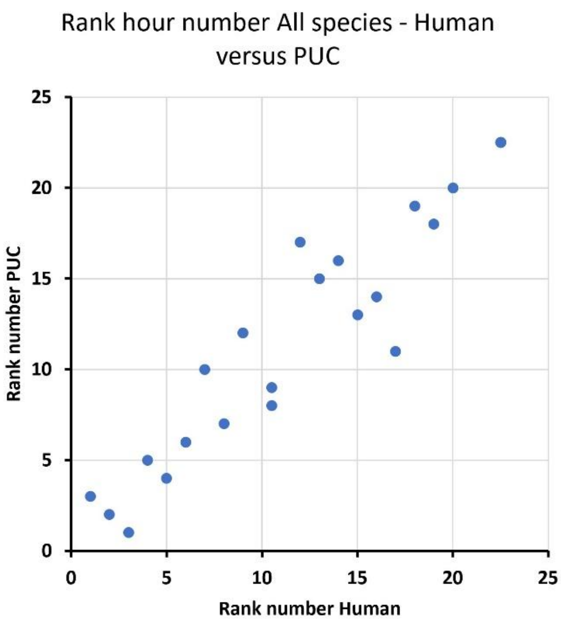

Fig. 4. Comparison for each hour of the number of bird sound registrations made by the author and by the PUC for all hours throughout the day. The rankings of the values for the person and the PUC, respectively, are compared. Spearman rank correlation test.
Sammenligning for hver time af antal fuglelyde registreret af forfatteren og PUC'en for alle timer i døgnet. Rang af værdier for henholdsvis person og PUC er sammenlignet. Spearman rank correlation test.

There was a close correlation between the number of sounds recorded by the author during a halfmonth and the number of sounds recorded by the PUC during the same period. Comparing the rankings of the recorded numbers for the human and the PUC, respectively, reveals a significant correlation ($P<0.001$). The same applies to a similar comparison regarding the number of sounds recorded per hour ($P<0.001$) (Tab. 6).

Wood Pigeon

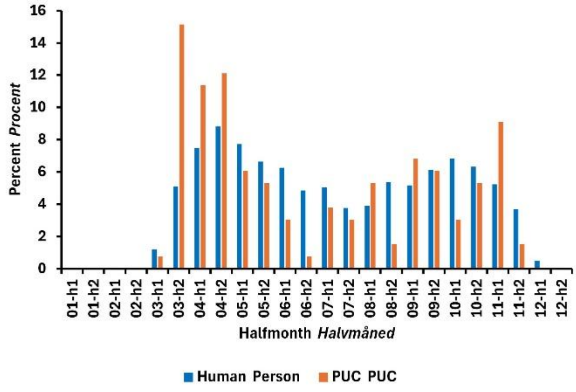

Fig. 5. Wood Pigeon. For explanation see Fig 1.
Ringdue. For forklaring se Fig. 1.

The Wood Pigeons sang from March to November, with the highest number of records from late March to late May, but also many in the autumn, from September to November.

For both the human and the PUC there was a significant increase in the number of recorded sounds during the first half of the year. During the second half of the year the numbers were significantly decreasing for both the human as well as by the PUC (Tab. 4 and Fig. 5).

The wood pigeons sang all day long, from early morning until late in the evening. Most recordings were made during the morning hours, but there were also many in the late afternoon and early evening.

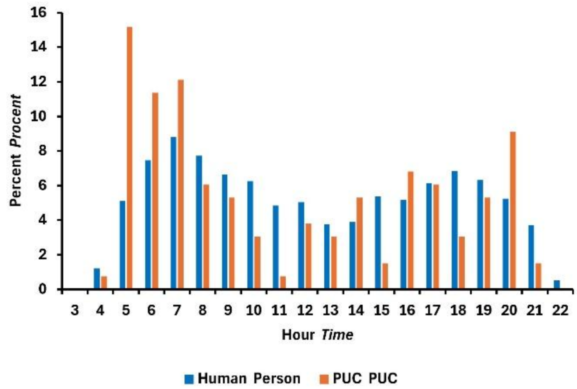

Fig. 6. Wood Pigeon. For explanation see Fig 2.
Ringdue. For forklaring se Fig. 2.

For both the human and the PUC there was a non-significant increase in the number of recorded sounds during the first half of the day. During the second half of the day there was a non-significant decrease for human and PUC (Tab. 5 and Fig. 6).

There was a significant correlation between the number of sounds recorded by a human during a halfmonth and the number of sounds recorded by the PUC during the same period. The same applies to a similar comparison regarding the number of sounds recorded per hour (Tab. 6).

Rook

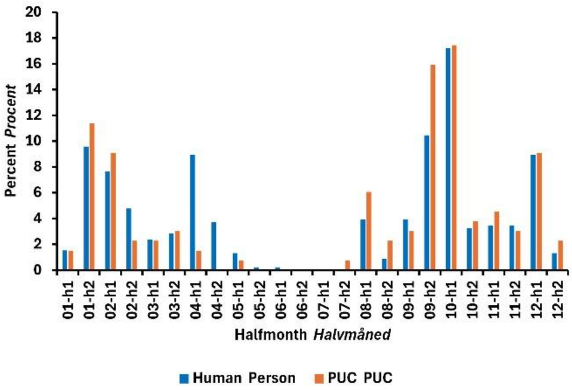

Fig. 7. Rook. For explanation see Fig 1.
Råge. For forklaring se Fig. 1.

Rooks were recorded particularly during autumn, winter, and early spring.

For both the human and the PUC there was a significant decrease in the number of recorded sounds during the first half of the year. During the second half of the year the numbers were increasing. For recordings made by the human as well as by the PUC the increase was non-significant (Tab. 4 and Fig. 7).

Rooks were heard from mid-morning until early evening.

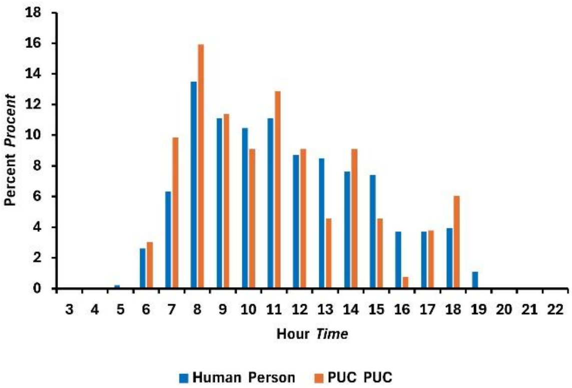

Fig. 8. Rook. For explanation see Fig 2.
Råge. For forklaring se Fig. 2.

For both the human and the PUC there was a significant increase in the number of recorded sounds during the first half of the day. During the second half of the day there was a significant decrease for human and PUC (Tab. 5 and Fig. 8).

There was a close and significant correlation between the number of sounds recorded by a human during a halfmonth and the number of sounds recorded by the PUC during the same period. The same applies to a similar comparison regarding the number of sounds recorded per hour (Tab. 6).

Chiffchaff

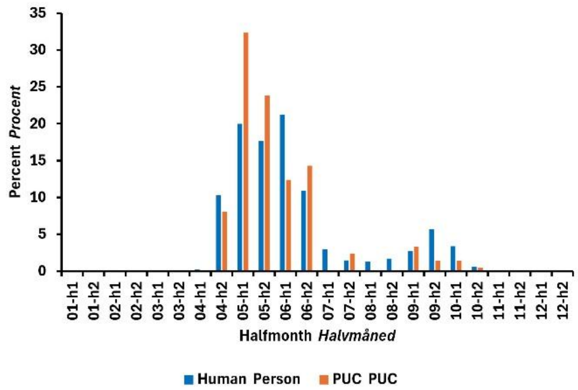

Fig. 9. Chiffchaff. For explanation see Fig 1.
Gransanger. For forklaring se Fig. 1.

The highest numbers of Chiffchaffs were recorded from the second half of April to late June. The last birds were heard in October.

For both the human and the PUC there was a significant increase in the number of recorded sounds during the first half of the year. During the second half of the year the numbers were decreasing. For recordings made by the human as well as be the PUC the decrease was significant (Tab. 4 and Fig. 9).

Chiffchaffs were heard from early morning until quite late in the evening, with lower vocal activity in the mid-afternoon.

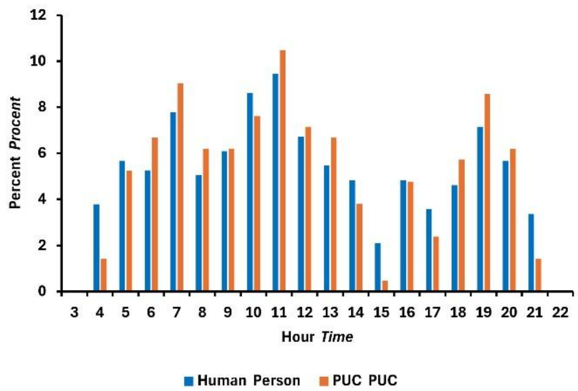

Fig. 10. Chiffchaff. For explanation see Fig 2.
Gransanger. For forklaring se Fig. 2.

For both the human and the PUC there was a significant increase in the number of recorded sounds during the first half of the day. During the second half of the day there was a non-significant decrease for human and PUC (Tab. 5 and Fig. 10).

There was a close and significant correlation between the number of sounds recorded by a human during a halfmonth and the number of sounds recorded by the PUC during the same period. The same applies to a similar comparison regarding the number of sounds recorded per hour (Tab. 6).

Blackbird

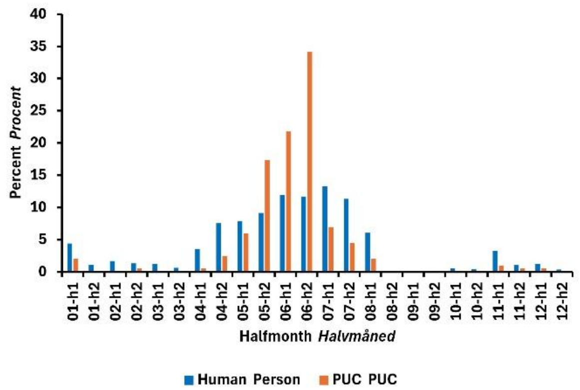

Fig. 11. Blackbird. For explanation see Fig 1.
Solsort. For forklaring se Fig. 1.

The Blackbirds were heard particularly from April through August, but were also recorded during the rest of the year.

For both the human and the PUC there was a significant increase in the number of recorded sounds during the first half of the year. During the second half of the year the numbers were decreasing. For recordings made by the human as well as by the PUC the decrease was non-significant (Tab. 4 and Fig. 11).

The blackbirds were heard from very early in the morning until very late in the evening and were vocal throughout the day.

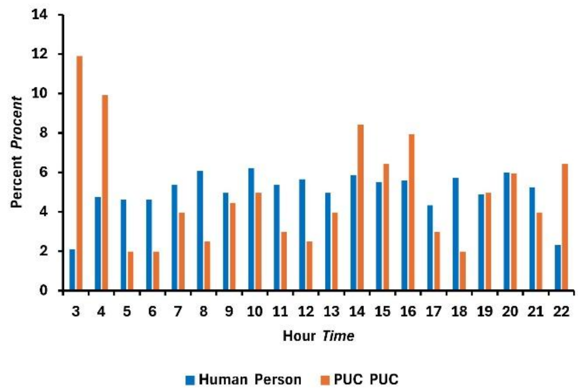

Fig. 12. Blackbird. For explanation see Fig 2.
Solsort. For forklaring se Fig. 2.

For both the human and the PUC there was a increase in the number of recorded sounds during the first half of the day. For the human the increase was significant. During the second half of the day there was a non-significant decrease for human and PUC (Tab. 5 and Fig. 12.).

There was a close and significant correlation between the number of sounds recorded by a human during a halfmonth and the number of sounds recorded by the PUC during the same period. For a similar comparison regarding the number of sounds recorded per hour the correlation was non-significant (Tab. 6).

Discussion

In other studies, the aim typically has been to determine the number of species, the number of individuals of each species, and the composition of the bird communities (Sedláček *et al.* 2015, Leach *et al.* 2016, Darras *et al.* 2018, Doohan *et al.* 2025, Fathoni *et al.* 2026).

This study examines only the degree of correlation between multi-period counts of individuals performed by the author and by the PUC. Some of the problems described in the other studies associated with recording both all the species present and their number are thus avoided.

In this survey the PUC only recorded about one-sixth of the bird sounds that a author recorded. However, this may not be a major problem, as the tool is intended to be used to record changes and trends, not actual numbers. Results for efficiency are in the same range as shown in other studies comparing human recordings and the PUC device. (Cole *et al.* 2022).

The results from this study show that the PUC BirdNET solution is suitable for monitoring changes in numbers and long-term trends for a wide range of bird groups. It is well suited for monitoring changes during the day (24 hrs.), and as well during the year. It is probably well suited for monitoring changes over many years too.

The BirdWeather solution did identify a very large proportion of the bird sounds it registered correctly according to parallel identification by the author. In the checks conducted it was about 98 percent. The result for accuracy is higher than in other studies (Cole *et al.* 2022).

This does not mean that the PUC does not make incorrect identifications. But it does not matter when the purpose of using the tool is to follow changes in the number of individuals of abundant bird species and when thousands of sound identifications are used.

Human listeners are not perfect either. Not all audible birds are recorded, and some are misidentified.

One of the purposes of the study was to find out whether the PUC found the same multi-period changes in the number of birds and the same trends in long-term changes as a human listener did, which is necessary, if the tool is to be used as a supplement or even as a replacement of some of the monitoring work that bird observatories currently carry out manually (Meltofte 1993, Kayser 2021, Kayser & Pagh Jensen 2022, Uijl 2024). The study showed that the tool registered approximately the same changes and trends in the number of birds as a human listener.

By using the BirdWeather PUC BirdNET solution, Gedser Bird Observatory and other monitoring sites will be able to continuously record bird sounds in the area - something human observers can only do for limited periods. The BirdNET solution automatically identifies the species of the recorded sounds and provides us with easy online access to these identifications. Consequently, we spend very little time converting the recorded sounds into usable count data. But as mentioned, the BirdNET solution can serve as a supplement to rather than a replacement for bird recordings made by people. For one thing, the BirdNET solution cannot detect silent birds.

In the current version of the BirdNET solution, we lack an indication of the type of sound for each recording—whether it is a song (sounds associated with the breeding season), a migration call, or another type of sound. Consequently, we have had to rely on manual classification to categorize the recordings from the spring and autumn seasons.

Conclusion

The PUC recorded much fewer sounds than the author, but the human observer and the PUC recorded very similar changes in multi-period comparisons. All species combined and four individual species were analyzed based on both halfmonth and hourly data, resulting in a total of 20 comparisons (Tab. 4 and 5). All showed changes in the same direction. In 11 cases, the changes were significant for both the human observer and the PUC. In five cases, the change was non-significant for both, while in four comparisons, it was significant for the human observer but non-significant for the PUC.

Similarly, analyses of whether the human and the PUC recorded many or few sounds at the same time revealed that they did so for both halfmonth periods and for hours (Table 6). A significant correlation was found in 9 out of the 10 comparisons, while the tenth showed a near-significant correlation.

Acknowledgements

I would like to express my sincere thanks to Johnny Kahlert and Lars Dinesen for the improvements to the manuscript they proposed over several rounds of review. This applies to both the precision of the text and, not least, the statistical analysis of the results.

Resumé

Effektivitet, korrekthed og anvendelighed af fuglelydsregistreringsudstyr til bestandsovervågning af fugle

På danske fuglestationer har man i årtier fulgt ændringer i antallet af trækkende fugle ved hjælp af standardiseret træktælling og ringmærkning. Det kan være vanskeligt at finde personer til at udføre dette arbejde, og det er ret omkostningstungt. Ved bl.a. Gedser Fuglestation har vi derfor ønsket at undersøge, om elektronisk lytteudstyr kan anvendes som et supplement til eller en erstatning for nogle af disse overvågningsopgaver.

Til det formål er der blevet gennemført en sammenligning af artsbestemmelse af de fuglelyde, som en BirdWeather PUC lytteenhed forbundet med det neurale netværk BirdNET, herefter betegnet PUC'en, og en person ved siden af har registreret. Undersøgelserne er blevet gennemført i et område med haver, marker og skove i Stensby på Sydsjælland. Fra november 2024 til oktober 2025 er det i hver halvmåned blevet registreret i hvert af ti minutter i hver time fra timen før solopgang til timen efter solnedgang, hvilke fuglearter som blev identificeret af henholdsvis PUC'en og af artiklens forfatter. Fugle, som blev set, men ikke hørt, blev ikke registreret. Forfatteren, har stor erfaring med genkendelse af fuglelyde, har moderat aldersbetinget høretab og anvender høreapparater.

Ved de nævnte timinutters registreringer blev 9.888 fuglelyde registreret af forfatteren og 1.564 af PUC'en. PUC'en effektivitet i forhold til personen var dermed 16% (Tab. 1). Det var især fjerne og svage lyde, som ikke blev registreret af netværket. På Gedser Fuglestation ønsker vi at anvende PUC'en til at følge ændringer i antallet af almindeligt forekommende arter. At PUC'en kun identificerede omkring en sjettedel af de lyde, som en person gjorde, gør den ikke dårligere til at følge antalsændringer over tid. Det vigtige er de relative ændringer, ikke de absolutte størrelser.

I hver af fem halvmåneder gennemførte forfatteren en kontrol af 500 af de artsbestemmelser af fuglelyde, som PUC'en havde identificeret (Tab. 2). Af de 2.500 bestemmelser var hele 98% efter forfatterens bedømmelse korrekte, mens 1% var bestemt forkert, og for 1% var forfatteren usikker på artsbestemmelsen på grund af dårlig lydkvalitet. Korrektheden af BirdWeather løsningens artbestemmelse af fuglelyde er altså meget høj og helt tilstrækkelig til at følge antalsændringer.

De flerperiode ændringer, her timer og halvmåneder, som netværket og forfatteren registrerede, var stort set ens (Tab. 4-6, Fig. 1-12). Det gjaldt både for ændringerne fra halvmåned til halvmåned og fra time til time. Den menneskelige observatør og PUC'en registrerede meget ensartede ændringer i sammenligninger på tværs af perioder. Der blev foretaget analyser af alle arter samlet samt af fire enkelte arter på grundlag af både halvmånedlige data og timedata, hvilket resulterede i i alt 20 sammenligninger (Tab. 4 og 5). Alle viste ændringer i samme retning. I 11 tilfælde var ændringerne signifikante for både den menneskelige observatør og PUC'en. I fem tilfælde var ændringen ikke-signifikant for begge parter, mens den i fire sammenligninger var signifikant for den menneskelige observatør, men ikke-signifikant for PUC'en. Ligeledes viste analyser af, hvorvidt mennesket og PUC'en registrerede mange eller få lyde samtidigt, at dette var tilfældet for både halvmånedlige perioder og timer (tabel 6). Der blev fundet en signifikant korrelation i 9 ud af de 10 sammenligninger, mens den tiende viste en næsten signifikant korrelation.

De resultater understøtter, at PUC'en giver sammenlignelige relative antalsændringer over tid i forhold til en persons registreringer, og dermed kan indgå som et supplement til de øvrige fugleregistreringer. PUC BirdNET løsningen er altså velegnet til at følge flerperiodeændringer i fugleantal uanset om der er tale om timer eller halvmåneder og antagelig også for år.

Det er naturligvis kun antalsændringer hos fuglearter, som regelmæssigt afgiver lyde, som kan følges med elektronisk lytteudstyr. Det omfatter fx flere arter af svaner, andefugle, duer, traner, ugler, spætter og mange arter af spurvefugle.

References

Anon. 2022: Birds are very useful indicators for other kinds of biodiversity. BirdLife: https://datazone.birdlife.org/articles/birds-are-very-useful-indicators-for-other-kinds-of-biodiversity

BirdWeather 2026: BirdWeather - a living library of bird vocalizations. BirdWeather PUC home page: https://www.birdweather.com/

Cole, J. S., N. L. Michel, S.A. Emerson & R. B. Siegel 2022: Automated bird sound classifications of long-duration recordings produce occupancy model outputs similar to manually annotated data. – The Condor: Ornithol. Appl. 124: 1-15.

Cramp S., C.M. Perrins, D.J. Brooks, E. Dunn … and M.G. Wilson 1994. Handbook of the Birds of Europe, the Middle East and North Africa. The Birds of the Western Palearctic. Volume VIII. – Oxford University Press.

Darras, K., P. Batáry, B. Furnas, A. Celis-Murillo, S.L. Van Wilgenburg, Y. A. Mulyani & T. Tscharntke 2018: Comparing the sampling performance of sound recorders versus point counts in bird surveys: A meta-analysis. – J. Appl. Ecol. 55: 2575–2586.

Doohan, B., S. Hoefer, S. Allen-Ankins & L. Schwarzkopf 2025: Passive acoustic monitoring predicts higher avian diversity metrics than traditional bird surveys across multiple Australian bioregions. – Ecol. Indic. 182: 114533.

Fathoni, A.S., Susilohadi, T. Haryoko, M.A. Ghazi & A.A. Purwanto 2026: Comparison of Visual Count Survey and Passive Acoustic Monitoring for Avifauna Diversity in Purwosari Village, Girimulyo, Kulonprogo. - J. Trop. Biodivers. Biotechnol. 11: jtbb12602.

Jenni, L. & M. Kéry 2003: Timing of autumn bird migration under climate change: anvances in long-distance migrants, delays in short-distance migrants. – Proc. R. Soc. Lond. 270: 1467-1471.

Kayser, B. 2021: Ændringer i fænologi, antal og ynglesucces blandt rastende småfugle ved Gedser Fuglestation 2007-19 *(Trends in phenology and breeding success among staging passerine migrant at Gedser Bird Observatory 2007-2019)*. – Dansk Orn. Foren. Tidsskr. 115: 197-204.

Kayser, B. & F. Pagh Jensen 2022: Efterårstræk af havdykænder ved Gedser Odde 2009-20 *(Autumn migration of sea-ducks at Gedser Odde 2009-2020)*. – Dansk Orn. Foren. Tidsskr. 116: 9-16.

Kayser, B. 2026: Elektronisk lytteenhed som supplement til registrering af fugletræk. – Dansk Orn. Foren. Tidsskr. 120: 66-68.

Leach, E.C., C.J. Burwell, L.A. Ashton, D.N. Jones & R.L. Kitching 2016: Comparison of point counts and automated acoustic monitoring: detecting birds in a rainforest biodiversity survey. – Emu - Austral Ornithol. 116: 305–309. https://doi.org/10.1071/MU15097.

Ranke, P.S. 2022: Tidsmessige endringer og forløb av tugletrekket om høsten – Rapport. BirdLife Norge.

Meltofte, H. 1993: Vadefugletrækket gennem Danmark. De involverede bestande, deres træktider og trækstrategier. - Dansk Orn. Foren. Tidsskr. 87: 1-180.

Sedláček O., J. Vokurková, M. Ferenc, E.N. Djomo, T. Albrecht & D Hořák 2015: A comparison of point counts with a new acoustic sampling method: a case study of a bird community from the montane forests of Mount Cameroon. – Ostrich 2025:1-8.

Thorup K., A.P. Tøttrup & C. Rahbek 2007: Patterns of phenological changes in migratory birds. - Oecologia 151:697–703.

Tøttrup A.P., K. Thorup & C. Rahbek 2006. Changes in timing of autumn migration in North European songbird populations. - Ardea 94: 527-536.

Uijl, M.D. 2024: Changes in the phenology of spring migrating passerines at Blåvand Bird Observatory, Denmark, 1984-2021. - Dansk Orn. Foren. Tidsskr. 118: 142-148.

The author's address:

Bo Kayser, Pilevej 2, Stensby, 4773 Stensved, Denmark (bo.kayser@gmail.com)