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Research Article

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ABSTRACT

Soundscape describes all sounds, those of biophony, geophony, and anthrophony, emanating from a given landscape which creates unique acoustical patterns across a variety of spatial and temporal scales. Development of rapid, cheap and efficient biodiversity measurements methods is considered very essential for biodiversity conservation. This study aims at comparing Soundscape and point count methods of biodiversity measurements. Both methods were implemented at Akrotiri and Ayia Napa, Cyprus for two days in each site for a period of 3 hours per day between 6:00-9:15. A total of 45 species were recorded from the entire survey in combination of point count and Soundscapeaural identification. Species recorded only from point count and not identified by any other survey method were 21 species and 5 species were identified by only Soundscape method. Species identified equally by both point count and Soundscape methods were 19 species. Acoustic Richness (AR) revealed significantly higher species richness in Akrotiri than Ayia Napa. However, both sites where not significantly dissimilar based on the Acoustic Dissimilarity index. This study provides evidence of high difference between Soundscape and point count methods of biodiversity measurement. Thus, a complementary technique involving both methods is highly recommended for more accurate biodiversity measurements relative to the employment of the methods individually.

INTRODUCTION

Sound is a vibration that propagates as an audible waves of pressure and displacement through a solid, liquid or gaseous medium. Sound waves are generated by different sources which creates vibrations in the surroundings and these are propagated away from the source at the speed of sound. The pressure, velocity and displacement of the waves vary in space and time, indicating their spectral and temporal properties (Guastavino, 2007). Sound reception among organisms with hearing capability is restricted within the range of frequencies (Feng & Schul, 2006). Humans have the ability to hear sounds within 20 Hz and 20000 Hz (20kHz), with the upper limit decreasing with age as the hearing organs get weak (Hartmann, 1997). Other species have the capability of hearing at different ranges necessary for detection of danger, navigation, predation and acoustic communication (Kroodsma *et al.*, 1982). The earth's atmosphere, water bodies, fire, rain, wind, landslides and earth movements produce unique sounds (Swanson *et al.*, 1988). Living organisms such as insects, birds, reptiles, fishes, marine and terrestrial mammals also have organs for sound production (Marler & Slabberkoorn, 2004). Human activities, equipment, electronics and machines also contribute to the numerous sounds we hear in our environment (Botteldooren *et al.*, 2004; Raimbault & Dubois, 2005).

Soundscape refers to the acoustic environment at a given time, which is a combination of all sounds within a specific location (Pijanowski *et al.*, 2011). This depends on the premise that the integration of the sounds reflect important ecosystem processes and human activities over space and time. The study of sound in landscapes provides the potential to understand how sound from different sources portray the status of the environment across varying spatial and temporal scales. The diversity of the sound sources include biophony, geophony and anthrophony. Biophony refers to sounds produced by all organisms such as

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plants, animals and humans; geophony are sounds emanating from the geophysical natural processes which includes water, thunderstorm, earth movement and wind; while anthrophony consists of sounds produced by man-made machines, equipment and electronics such as vehicles, sound systems, explosives and airplanes.

Pijanowski *et al*. (2011a) defined soundscape ecology as all sounds, those of biophony, geophony, and anthrophony, emanating from a given landscape to create unique acoustical patterns across a variety of spatial and temporal scales. However, for the purpose of the present study, I will define soundscape ecology as the study of the totality or pattern of interrelationship between organisms and their acoustic environment as a means of ecosystem processes and dynamic studies across time and space for the purpose of conservation and sustainable management of the ecosystem. The general behaviour of animal species is impacted by the unique characteristics of their soundscape, thereby constituting an important component of complex interactions between biological, geological and anthropogenic dynamics. The soundscape of specific location changes with time of the day, time of the year which is highly associated with natural cyclical processes. Studying the dynamics of soundscapes have the potential to contribute immensely to our knowledge of ecosystem processes, interactions and effects of disturbances on the activities of the animal species in their habitats.

Some of the relevant ecological hypotheses associated with soundscape include morphological adaptation hypothesis (MAH), acoustic adaptation hypothesis (AAH), and acoustic niche hypothesis (ANH). MAH and AAH are complementary in nature, describing how ecological feedback mechanisms give rise to changes in animal signals. ANH describes how these feedback mechanisms creates a complex arrangement of signals in the soundscape. The MAH posits that the physical attributes of an organism influence its acoustic signal properties (Bennet-Clark, 1998). Therefore, such a large bird as a heron and a goose with a relatively longer trachea would produce sounds at lower frequencies than a smaller bird with a shorter trachea such as a finch or a thrush. The AAH (Daniel & Blumstein, 1998) postulates that some group of organisms adjust the attributes of their sounds to maximize the propagation of their acoustic signals (Morton, 1975).

Daniel and Blumstein (1998) found no correlation between signal composition and habitat while Brown *et al*. (1995) reported that the acoustic properties of an environment has the potential to influence vocalizations. Thus, support for the AHH has been of the mixed type. Krause (1987), observed that both the morphological and the behavioural adaptations described by the MAH and the AAH can be influenced by interspecific interference when the call of one species is closely related to the frequency and time attributes of another species in the same habitat. Having frequently observed complex arrangements of no overlapping signals from soundscape recordings in different habitat types he postulated that such interspecific competition for auditory space would influence species to adjust their signals to vacant niches in the auditory spectrum as a means of reducing spectral and temporal overlaps in interspecific vocalizations. Flycatchers (*Empidonax minimus*) at Lake Itasca, Minnesota were observed to insert their shorter songs between the longer songs of red-eyed vireos (*Vireo olivaceus*) in occasions where the two species share the same habitat (Ficken *et. al*., 1974). Consequently, ANH predicts that less-disturbed habitats with its species composition intact will exhibit higher levels of coordination between vocalizations relative to a more disturbed habitat, whose species composition is greatly altered. Alteration in natural acoustic partitioning could be indication of the presence of an invasive species, creating biophonic disturbance in the habitat. Furthermore, on the premise that the theories of acoustic niches and habitat filtering are potential drivers of acoustic diversity, reconstructing the phylogeny of vocalizing species could be of great help in understanding the emergence of song parameters taking into consideration molecular and morphological data.

Many methods exist for avian ecological researches. Generally, classified into three types: counts, nest monitoring and capturing and marking methods. Also, in the present study we are including soundscape ecology as a method in avian ecological studies. Counts could be implemented through a line transect method or a point count method. Line transect method involves taking a count of the birds species while moving at a slow speed along a specified route within a specified distance in length and width of the study route. Point counts constitute one of the simplest methods in bird census in which a trained observer records all the birds seen and heard from a specified point count station within a specified period of time. Such counts can be carried across seasons or years for population dynamics studies for conservation purposes and related intents. Bibby *et al*. (2000) described in detail the various bird census methods.

The general aim of this study is to assess the effectiveness of soundscape analysis in the measurement of biodiversity. Specifically, to test for variation between visual observation (Point count) and soundscape methods in determining the biodiversity of selected sites in Cyprus. I hypothesis that Soundscape analysis will be more effective relative to conventional Point count biodiversity measurement method. This is based on the extensive spatiotemporal capabilities inherent in soundscape method as a rapid survey technique for biodiversity appraisal.

MATERIALS AND METHODS

The study was carried out at two locations: Ayia Napa and Akrotiri, Cyprus. Soundscapes were recorded using two Song Meter SM3 Bioacoustics recorders (Wildlife Acoustics Monitoring Systems). The recorders were placed at a distance of 350m apart within the study site. Two days of 3hrs continuous recordings were carried out in each location between 6:00 - 9:15 am. The soundscape was recorded as a stereo two channels of 16bits at 44100Hz sampling frequency and saved in wave format. Garmin GPS was used in recording of the coordinates of the recording and point count stations. Binoculars were used for proper identification of the birds during the point count. Raven was used for the acquisition, visualization, measurement, and analysis of sounds developed by the Cornell Laboratory of Ornithology. Seewave version 2.0.2 (Sueur *et al*. 2008a) implemented within R environment was used the for analysing, manipulating, displaying, editing and synthesizing time waves (particularly sound). This package was used in temporal analysis, spectral content and entropy, 2D and 3D spectrograms analyses. Species recorded were identified by visualizing the song's spectrograms with the assistance of experts in bird songs recognition.

Point counts were carried out simultaneously with the recording within the same recording site. Birds seen and heard were recorded at 6 points of 70m spacing between the positions of the recorder. Maximum of 10 minutes were spent at each point for bird observation and recording within 35m radius.

Statistical Analysis

The total number of birds recorded by that are unique to soundscape (N_s) and point count (Np) methods were estimated. This is to account for the differences in the total number of species recorded using the individual methods. Other indices computed from the sound files per study site include: Acoustic Entropy Index (H), Temporal Entropy (H_t), Spectral Entropy (H_f) and Acoustic Dissimilarity Index (D) between sites. These were computed based on the methods and procedures described in Sueur *et al* (2008b).

The temporal entropy was computed using the formula below:

$$H_t = -\sum_{t=1}^{n} A(t) \times \log_2 A(t) \times \log_2 (n)^{-1}; H_t \in [0,1]$$

Where ***A(t)*** is the amplitude envelope
t is time and
n is the length of time series
Spectral entropy was computed using the relationship:

$$H_f = -\sum_{f=1}^{n} S(f) \times \log_2 S(f) \times \log_2 (N)^{-1}; H_f \in [0,1]$$

Where ***S(f)*** is the mean spectrum
N is the frequency length

Acoustic Entropy Index (H) was then computed as:

$$H = H_f \times H_t ; H \in [0,1]$$

The Acoustic entropy is a valued between 0 and 1 such that H tends to 0 for a single pure tone and increases as the number of frequency bands and amplitude modulations and tends towards 1 for a random noise. This implies that H index increases with the number of singing species.

Acoustic Dissimilarity Index (D) was estimated as the compositional dissimilarity between the two study sites based on temporal and spectral acoustic data. Temporal dissimilarity between two signals x1(t) and x2(t) of the same duration digitized at the same sampling frequency was estimated by computing the difference between their envelope probability mass functions divided by 2 to get values between 0 and 1 using the relationship below:

$$D_t = \frac{1}{2}\sum_{t=1}^{n} |A_1(t) - A_2(t)|; D_t \in [0,1]$$

Likewise, Spectral dissimilarity was computed by the relationship:

$$D_f = \frac{1}{2}\sum_{f=1}^{n} |S_1(f) - S_2(f)|; D_f \in [0,1]$$

The Acoustic Dissimilarity Index was calculated as the product of spectral and temporal dissimilarities:

$$D = D_f \times D_t ; D \in [0,1]$$

All statistics were done within the statistical environment R version 3.2.2 with the packages "seewave", (Sueur *et al*. 2008a), "tuneR", "ade4" and "vegan" (website, CRAN). Normally distributed variables were analysed using one way Analysis of Variance (ANOVA) while variables that did not show normality were analyzed using Kruskal-Wallis rank sum test, while statistical significance within variables were tested by Single-Sample t-test at 95% confidence intervals.

RESULTS

A total of 24.25 hours of recording was achieved from the two sites (Akrotiri and Ayia Napa), with each site having at least 12 hours of soundscape recording. The soundscape for the two sites were recorded for 3 hours for two days in each of the two sites. 24 bird species were identified by aural method based on listening and visualizing the recording's spectrograms. From point count survey method, 40 species were identified across the study sites. A total of 45 species were recorded from the entire survey in combination of point count and soundscape aural identification. Species recorded only from point count and not identified by any other survey method were 21 species and 5 species were identified by only soundscape method. Species identified equally by both point count and soundscape methods were 19 species (Figure 2, Figure 3).

Figure 1 Locations in Cyprus where the survey was carried out.

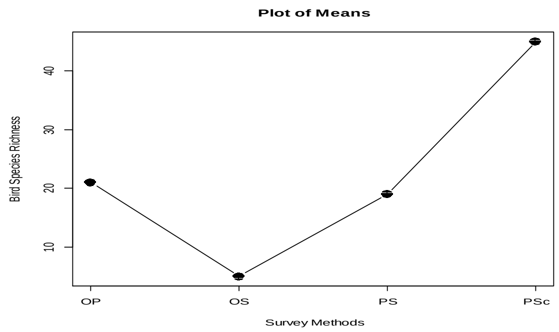


Figure 2 Number of species detected by different survey techniques with OP (Pointcount only), OS (Soundscape only), PS (Pointcount/Soundscape), PSc (Pointcount Soundscape complement) techniques.

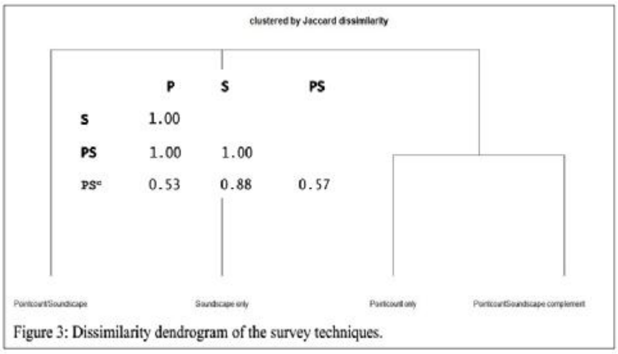


Figure 3: Dissimilarity dendrogram of the survey techniques.

Acoustic Complexity Index (ACI) was not statistically different between sites (F = 0.1473, p = 0.7047), with Akrotiri having ACI value of 154.4769±4.8750 and Ayia Napa having 153.7863±4.0398. Variation in ACI among days and across sites was not significant (F = 0.5457, p = 0.4675; Day1 = 154.7780±4.9190, Day2 = 153.460±3.8904). Variation in ACI across hours of the survey was not statistically significant (F = 0.4832, p = 0.6975). ACI did not differ significantly at Akrotiri between days (F = 2.413, p = 0.149) and survey hours (F = 0.249, p = 0.86). Significant variation was observed within the survey hours and days (Table 1, Figure 4).

Table 1 Variation in Acoustic Complexity Index within hours and days across sites.

Variable	Akrotiri			Ayia Napa		
	df	t-value	p-value	df	t-value	p-value
6:00-6:59	3	92.826	**<0.00001**	3	93.512	**<0.00001**
7:00-7:59	3	105.51	**<0.00001**	3	89.723	**<0.00001**
8:00-8:59	3	37.602	**<0.00001**	3	52.38	**<0.00001**
Day1	6	70.686	**<0.00001**	5	119.59	**<0.00001**
Day2	5	156.29	**<0.00001**	5	76.438	**<0.00001**

p values in **bold** indicate statistical significance

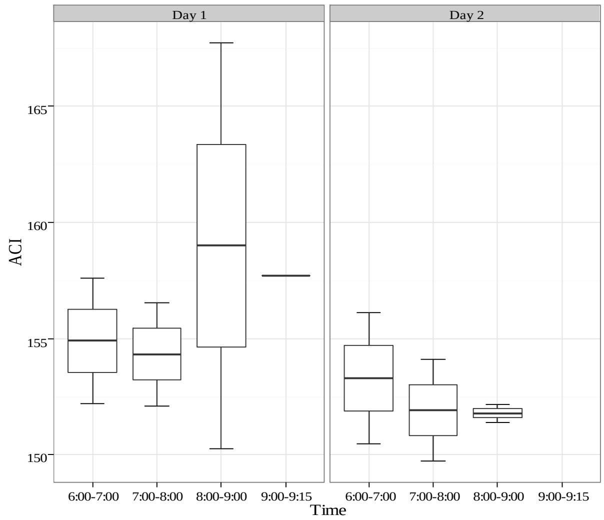


Figure 4 Acoustic Complexity Index variation within survey hours across days based on the length of the error bars.

Shannon Index (H) estimated from the total entropy of the soundscape indicated Akrotiri to be higher (0.6444±0.0926, n = 13) relative to Ayia Napa (0.5962±0.1341, n = 12). However, this difference in H between the two sites was not statistically significant (F = 1.108, df = 1, p = 0.303). No significant variation was observed among the hours of the survey (F = 0.37, df = 3, p = 0.776) and days (F = 0.046, df = 1, p = 0.832). Computing only for Akrotiri indicated lack of significant differences in hours of survey (F = 0.259, df = 3, p = 0.853) and between days (F = 0.677, df = 1, p = 0.428). At Ayia Napa H did not vary between days (F = 0.831, df = 1, p = 0.383) and hours of survey (F = 0.163, df = 2, p = 0.852). Within survey hour and day's variation in H at the two sites showed high significance (Table 2, Figure 5, and Figure 6).

Table 2 Variation in Shannon Index within hours and days across sites.

Variable	Akrotiri			Ayia Napa		
	df	t-value	p-value	df	t-value	p-value
6:00-6:59	3	9.6516	**0.0023**	**3**	8.1963	**0.0038**
7:00-7:59	3	20.341	**0.0002**	3	6.8363	**0.0064**
8:00-8:59	3	14.047	**0.0007**	**3**	10.427	**0.0018**
Day1	6	17.017	<**0.00001**	**5**	9.7419	**0.0001**
Day2	5	18.72	<**0.00001**	**5**	11.991	<**0.00001**

p values in **bold** indicate statistical significance

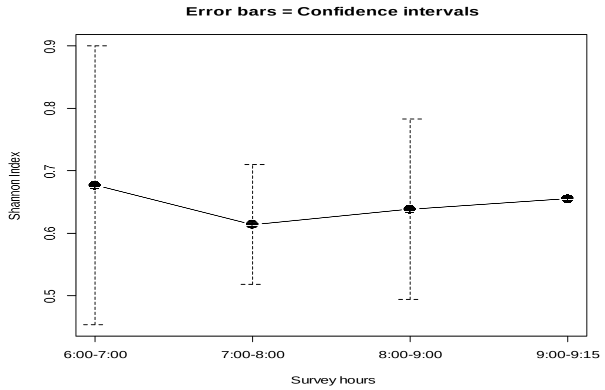


Figure 5 Shannon Index variation within survey hours based on the length of the error bars.

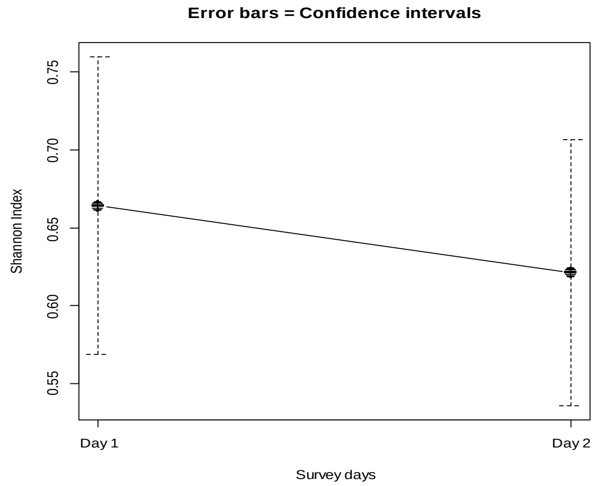


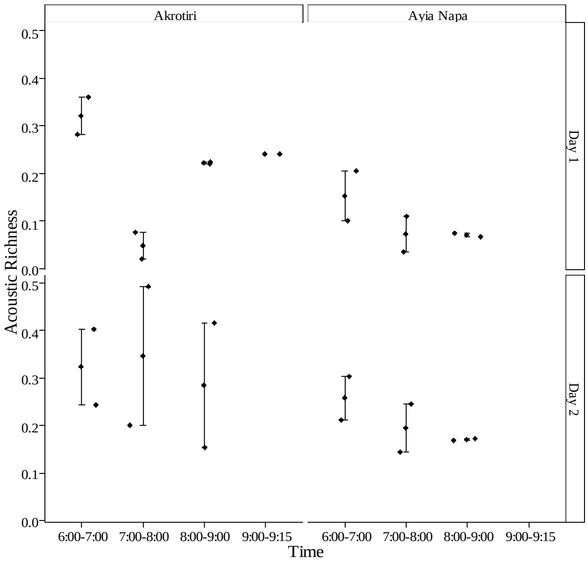
Figure 6 Shannon Index variation within survey days based on the length of the error bars.

Acoustic Richness was significantly higher in Akrotiri (0.2563±0.1349, n = 13) than in Ayia Napa (0.1529±0.0798, n = 12) (F = 5.318, df = 1, p = 0.030). No significant difference was observed in AR among survey hours (F = 0.983, df = 3, p = 0.42), while AR was significantly higher in the second day (0.2628±0.1160) than the first day (0.1549±0.1059) across the survey sites (F = 5.899, df = 1, p = 0.0234). In Akrotiri no significant difference was observed in AR between days (F = 2.656, df = 1, p = 0.131) and among the survey hours (F = 0.502, df = 3, p = 0.69). Acoustic Richness was significantly higher in the first day relative to the second day in Ayia Napa (F = 10.34, df = 1, p = 0.0092), while no significant difference was observed among the survey hours (F = 1.406, df = 2, p = 0.294). Significant variation was observed within survey hours and days in both sites with exception of 7:00-7:59 in Akrotiri (Table 3, Figure 7).

Table 3 Acoustic Richness variation within survey hours and days

Variable	Akrotiri			Ayia Napa		
	df	t-value	p-value	df	t-value	p-value
6:00-6:59	3	8.8519	**0.003**	**3**	4.941	**0.0159**
7:00-7:59	3	1.8769	0.1572	3	3.0578	**0.055**
8:00-8:59	3	4.4874	**0.0206**	**3**	4.1641	**0.0252**
Day1	6	4.6018	**0.0036**	**5**	4.1315	**0.009**
Day2	5	5.6844	**0.0023**	**5**	8.5865	**0.0003**

p values in **bold** indicate statistical significance



The differences in spectral entropy was not significant between sites (F = 1.29, df = 1, p = 0.268), days (F = 0.014, df = 1, p = 0.907) and survey hours (F = 0.293, df = 3, p = 0.83). In Akrotiri no significant difference was observed in spectral entropy between days (F = 1.101, df = 1, p = 0.317) and survey hours (F = 0.177, df = 3, p = 0.91). The trend in Akrotiri was the same for Ayia Napa between days (F = 0.889, df = 1, p = 0.368) and survey hours (F = 0.161, df = 2, p = 0.854). Significant variation was observed within the survey days and hours both in Akrotiri and Ayia Napa (Table 4, Figure 8).

Table 4 Spectral entropy variation within survey hours and days

Variable	Akrotiri			Ayia Napa		
	df	t-value	p-value	df	t-value	p-value
6:00-6:59	3	9.5561	**0.0024**	**3**	8.2201	**0.0037**
7:00-7:59	3	20.756	**0.0002**	3	6.8405	**0.0063**
8:00-8:59	3	14.411	**0.0007**	3	10.742	**0.0017**
Day1	6	17.809	**<0.0001**	5	9.972	**0.0001**
Day2	5	19.191	**<0.0001**	5	11.926	**<0.0001**

p values in **bold** indicate statistical significance

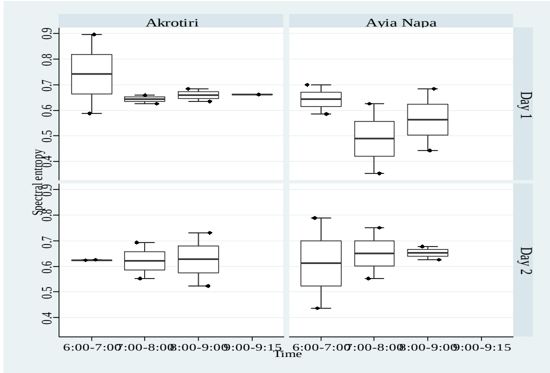


Figure 8 Spectral entropy across survey hours and days grouped in sites.

Temporal entropy was not significantly different between sites (X^2 = 0.1450, df = 1, p = 0.7034), days (X^2 = 1.068, df = 1, p = 0.3014) and survey hours (X^2 = 0.76615, df = 3, p = 0.8575). Considering Akrotiri specifically, no significant difference in temporal entropy was observed between days (X^2 = 2.4694, df = 1, p = 0.1161) and survey hours (X^2 = 0.7417, df = 3, p = 0.8633). Also, at Ayia Napa's spectral entropy was not significantly different between survey days (X^2 = 0.1025, df = 1, p = 0.7488) and among survey hours (X^2 = 0.15385, df = 2, p = 0.926). Variation in spectral entropy was significantly different within the survey hours and days both in Akrotiri and Ayia Napa (Table 5, Figure 9).

Table 5 Temporal entropy variation within survey hours and days

Variable	Akrotiri			Ayia Napa		
	df	t-value	p-value	df	t-value	p-value
6:00-6:59	3	739.14	**<0.0001**	**3**	485.11	**<0.0001**
7:00-7:59	3	67.424	**<0.0001**	3	300.02	**<0.0001**
8:00-8:59	3	354.64	**<0.0001**	**3**	267.59	**<0.0001**
Day1	6	115.8	**<0.0001**	**5**	330.17	**<0.0001**
Day2	5	665.1	**<0.0001**	**5**	627.74	**<0.0001**

p values in **bold** indicate statistical significance

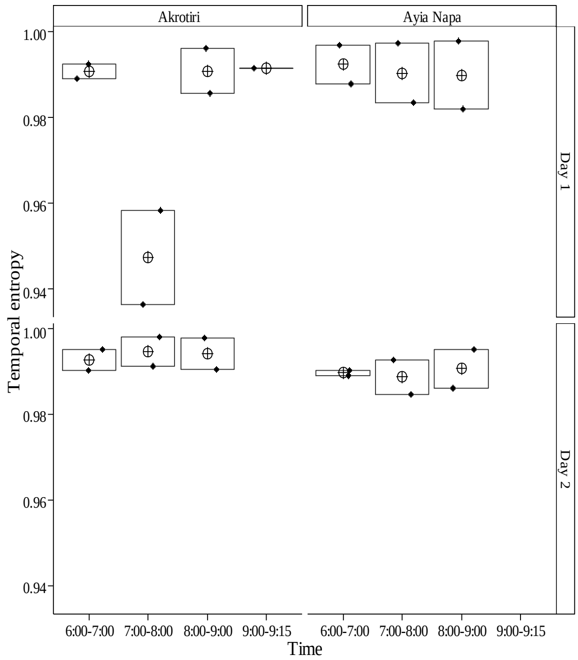


Figure 9 Temporal entropy variation within survey hours and days based on the height of the boxes.

Acoustic dissimilarity did not vary significantly across the survey hours (F = 1.9, df = 2, p = 0.205) and days (F = 1.057, df = 1, p = 0.328). The same was the case for spectral dissimilarity (X^2 = 2.4231, df = 2, p = 0.2977) and temporal dissimilarity (X^2 = 3.7308, df = 2, p = 0.1548) paired by survey hours. Pairing based on survey days also followed the same trend both for spectral dissimilarity (X^2 = 1.641, df = 1, p = 0.2002) and temporal dissimilarity (X^2 =0.1025, df = 1, p = 0.7488) (Figure 10).

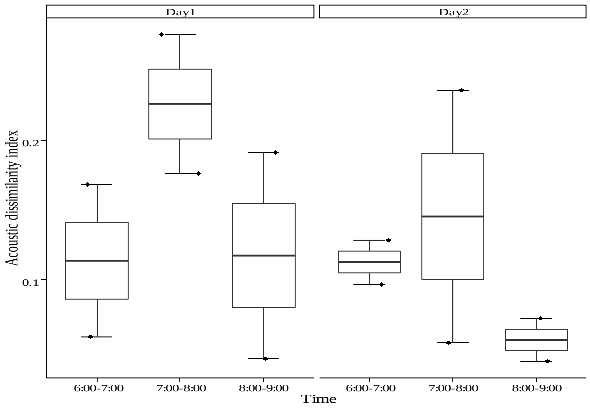


Figure 10 Acoustic dissimilarity based on time pairs grouped by day.

DISCUSSION

More species being identified by point count method could be attributed to its additional potential of visual identification to identification by sound techniques. This is such that the soundscape recording technique relies only on the sounds made by the bird species, which is not always the case for some less vocal bird species. Birds that made use of the habitat without the need for vocalization would not be identified by the soundscape technique but would certainly be seen by the observer during the point count. It is pertinent to mention that a complementary technique from both methods identified more species as twice as the number identified equally by point count and soundscape (Figure 2). This suggests strongly for complementary use of both methods instead of replacement of one method with the other for better results in bird species surveys. Considering the extent of dissimilarity among the techniques suggests pointcount_soundscape complement technique is not equivalent to point count technique by 53% and soundscape technique by 88%, while point count technique turned out to be 100% different from soundscape technique (Figure 3). By this, the hypothesis of soundscape technique being more effective relative to point count method seem not to hold. However, the probable effect of the small sample from the present study need not to be overlooked, as the story could be better told with larger samples.

The Acoustic Complexity Index (ACI) as a direct quantification of the complex biotic songs based on the variability of the intensities registered in audio-recordings (Pieretti *et al*., 2011), irrespective of constant human-generated-noise represents a useful tool to determine changes in behaviour and composition of a vocalizing community for better monitoring of bird dynamics in a quick way (Acevedo & Villanueva-Rivera, 2006). It not being significantly different between sites, days and among survey hours suggests that the bird community explores the habitats in likely the same pattern (Table 1, Figure 4). However, the significant variation within the days and hours suggests that all bird species are not exploring the habitats at the same time (Farina *et al*, 2011). This may include periods of more activity and periods of less or no activity in the respective habitats.

No significant difference in Shannon Index (H) between sites, days and among survey hours is an indication that the diversity of bird species assemblages does not differ based on sites, days or among hours (Table 2, Figure 5, and Figure 6). As such the likely usual pattern of making use of the habitat patch is obtainable both in Akrotiri and Ayia Napa. Significant variations within days and survey hours provides the information that the bird species assemblage is not constant within the hours and days (Sueur *et al*., 2008b). This suggests that different species compositions make use of the habitats at the different times within the hour, but consistently in their pattern of exploration between days. Furthermore, this reveals a kind time partitioning by the bird species in their pattern of habitat utilization.

The number of species in Akrotiri was significantly higher than at Ayia Napa as indicated by the Acoustic Richness (AR). The number of species seemed to be consistent among survey hours, which taking into consideration no significant difference in ACI suggests the same species make use of the habitats in the same temporal pattern. Significant difference in AR between days implies differences in the number of bird species that make use of the habitats in different days (Figure 7). This may be explained by variations in anthropogenic and environmental conditions of the habitats, as they seem to decide where to go based on the prevailing environmental conditions of the day or human activities. Significant variation in AR within hours and day provides the information that great deal of different bird species make use of the habitat at different duration within the hours and days (Table 3). This is important for conservation purposes as no few species dominate the use of the habitats (Depraetere, 2012). No significant variation in the hour 7:00-7:59 in Akrotiri suggests a sort of interference or disturbance within that hour, probably due to human activity in the site.

Temporal and spectral entropy not being significant between days and among survey hours suggests consistency in the pattern of habitat utilization both in space and time within the vocal spectrum (Table 4, Table 5, Figure 8, and Figure 9). This also indicates high level of maintenance in the soundscape, coupled with usual variation in activities within the hours and days (Han, Muniandy and Dayou, 2011). Acoustic dissimilarity between the sites not being significantly different indicates high level of similarity in the soundscape of the two sites (Figure 10). This is consistent with lack of statistical significance both in temporal and spectral dissimilarities.

CONCLUSION

Based on the analysis from this mini research project, soundscape method of biodiversity measurement should not be considered as a replacement for point count method nor be discarded. Complementary technique involving both methods provides more accurate biodiversity measurements relative to the employment of the methods individually.

This study has shown higher species richness at Akrotiri relative to Ayia Napa which could be explained by the observed high level of anthropogenic activities, as Ayia Napa is the most visited sites on the island with a great deal of movements and traffic during the peak period of tourism in Cyprus within which period the survey was carried out. Naturally, Acoustic Dissimilarity (D) should have shown the same trend as AR between sites, but inability to synchronize the surveys between the two sites at the same time may have played a role in obscuring the differences between the two soundscapes.

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References

Acevedo, M. A. and Villanueva-Rivera, L. J. (2006). Using automated digital recording systems as effective tools for the monitoring of birds and amphibians. *Wildlife Society Bulletin*, 34, pp. 211–214.

Bennet-Clark, H. C. (1998). Size and scale effects as constraints in insect sound communication. *Philosophical Transactions of the Royal Society*, B 353, pp. 407–419.

Botteldooren, D., Coensel, B., and De Meur, T. (2004). The temporal structure of the urban soundscape. *Journal of Sound Vibration*, 292(1–2), pp.105–123.

Brown, C. H., Gomez, R., and Waser, P. M. (1995). Old world monkey vocalizations: Adaptation to the local habitat? *Animal Behaviour*, 50, pp. 945–961.

Bibby, C. J., Burgess, N. D., Hill, D. A. and Mustoe, S. H. (2000). Bird census techniques. 2nded. New York: Academic Press.

Chapin, F. S., Zavaleta, E. S., Eviner, V. T., Naylor, R. L., Vitousek, P. M., Reynolds, H. L., Hooper, D. U., Lavorel, S., Sala, O. E., Hobbie, S. E., Mack, M. C. and Diaz, S. (2000). Consequences of changing biodiversity. *Nature*, 405(6783), pp. 234–242.

Daniel, J. C., Blumstein, D. T. (1998). A test of the acoustic adaptation hypothesis in four species of marmots. *Animal Behaviour*, 56, pp.1517–1528.

Depraetere, M., Pavoine, S., Jiguet, F., Gasc, A., Duvail, S. and Sueur, J. (2012). Monitoring animal diversity using acoustic indices: implementation in a temperate woodland. *Ecological Indicators*, 13, pp. 46-54.

Farina, A., Pieretti, N. and Piccioli, L. (2011). The soundscape methodology for long-term bird monitoring: a Mediterranean Europe case-study. *Ecological Informatics*, 6, pp. 354-363.

Feng, A. S. and Schul, J. (2006). Sound processing in real-world environments. In: Narins PM, Feng AS, Fay RR (eds) Hearing and sound communication in amphibians. Springer, NY.

Ficken, R. W., Ficken, M. S. and Hailman, J. P. (1974). Temporal pattern shifts to avoid acoustic interference in singing birds. *Science*, 183, pp. 762–763.

Fisher, J. A. (1998). What the hills are alive with: In defence of the sounds of nature. *Journal of Aesthetics and Art Criticism*, 56, pp. 167–179.

Guastavino, C. (2007). Categorization of environmental sounds. *Canadian Journal of Experimental Psychology/Revue canadienne de psychologie expérimentale*, 61(1), pp.54-63.

Han, N., Muniandy, S. and Dayou, J. (2011). Acoustic classification of Australian anurans based on hybrid spectral-entropy approach. *Applied Acoustics*, 72(9), pp.639-645.

Hartmann, W. M. (1997). Signals, sound and sensation. American Institute of Physics, NY.

Krause, B. (1987). Bioacoustics, habitat ambience in ecological balance. *Whole Earth Review*, 57, pp. 14–18.

Kroodsma, D. E., Miller, E. H., and Oullet, H. (1982). Acoustic communication in birds: production, perception and design features of sounds Academic Press, New York.

Louv, R. (2008). Last child in the woods: saving our children from nature-deficit disorder. Algonquin Books, Chapel Hill.

Marler, P., and Slabberkoorn, H. (2004). Nature's music: the science of birdsong. Elsevier Academic Press, San Diego, CA.

Miller, N. P. (2008). US national parks and management of park soundscapes: a review. *Applied Acoustics*. 69, pp. 77–92.

Morton, E. S. (1975). Ecological sources of selection on avian sounds. *American Naturalist*, 109, pp. 17–34.

Pieretti, N., Farina, A., and Morri, F. D. (2011). A new methodology to infer the singing activity of an avian community: the Acoustic Complexity Index (ACI). *Ecological Indicators*, 11, pp. 868-873.

Pijanowski, B. C., Villanueva-Rivera, L. J., Dumyahn, S. L., Farina, A., Krause, B., Napoletano, B. M., Gage, S. H. and Pieretti, N. (2011a). Soundscape ecology: the science of sound in the landscape. *BioScience*, 61(3), pp. 203–216.

Pijanowski, B. C., Farina, A., Dumyahn, S. L., Krause, B. L. and Gage, S. H. (2011b). What is soundscape ecology? An introduction and overview of an emerging new science. *Landscape Ecology*, 26(9), pp. 1213–1232.

Raimbault, M. and Dubois, D. (2005). Urban soundscapes: experiences and knowledge. *Cities* 22(5) pp. 339–350.

R Development Core Team, 2015. The R Project for Statistical Computing. http://www.r-project.org/ (accessed 02.07.15.).

Sueur, J., Aubin, T., Simonis, C., (2008a). Seewave: a free modular tool for sound analysis and synthesis. *Bioacoustics*, 18 pp. 213–226.

Sueur, J., Pavoine, S., Hamerlynck, O., and Duvail, S. (2008b). Rapid Acoustic Survey for Biodiversity Appraisal. *PLoS ONE*, 3(12): e4065. doi:10.1371/ journal.pone.0004065

Swanson, F. J., Kratz, T. K., Caine, N., and Woodmansee, R. G. (1988). Landform effects on ecosystem patterns and processes. *BioScience*, 38(2), pp. 92–98.

Vitousek P. M., Mooney H. A., Lubchenco J, and Melillo J. M. (1997). Human domination of Earth's ecosystems. *Science*, 277, pp. 494–499.

Wrightson K. (2000). An introduction to acoustic ecology soundscape. *Journal of Acoustic Ecology*, 1, pp. 10–13.

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