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Spatial Distribution and Diversity of Bird Communities in District Mardan, Khyber Pakhtunkhwa, Pakistan

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Diversity, Urban, Agricultural, Water, Mardan

ABSTRACT

Maintaining biodiversity in urbanized landscapes is the top most conservation priority. Urban development results in an increase in local extinction rates and eliminates the majority of native species. The pattern of rainfall is changing and frequency of extreme events increasing due to urbanization and rapidly increasing average global temperature. These changes are having observable impacts on biodiversity at species level and ecosystem level, in terms of distribution, composition and function. Mardan district of Khyber Pakhtunkhwa has different habitats; it represents a useful ecological model to identify the effect of habitat heterogeneity on bird communities. We conducted the study to explore the local avian fauna and to compare its composition and diversity in different habitats. Bird species were identified employing point counts method in urban area; agricultural area with small forest chunk and water body. Twenty four point counts were plotted in three well-defined locations such that each location was divided into eight concentric rings of 10 m radius from 0-50 m with an onward interval of 50 m. Thirty five avian species belonging to 23 families and 10 orders were recorded. However, One Way Analyses of Variance (ANOVA) indicated significant ($P < 0.05$) differences in distribution of avian species among habitats. Results suggest that urban area fails to maintain high bird diversity than the adjacent agricultural area. The agricultural area showed the lowest proportion of exclusive species compared to urban area and water body, even though the heterogeneous aspects of the area favor local species richness.

INTRODUCTION

Land development and various processes associated with urbanization present a major threat to biodiversity. Decline of urban biodiversity is often associated with alteration of habitats caused by urbanization (Laurance *et al*., 2011). Urbanization affects wildlife diversity by decreasing the provision of important resources related to food and habitat for shelter (Ferna´ndez-Juricic and Telleri´a, 2000). The heterogeneous uniqueness of natural environment is one of the important factors that have resulted in an increase in avian diversity (Damen *et al*., 2017).

South American avifauna is predominantly well known for its high bird diversity, with more than 3000 species (Bierregaard, 1998). Indian subcontinent is very rich in avian diversity. Out of more than 9000 birds of the world, the Indian subcontinent has about 1,300 species (Grimmett *et al*., 2016).

Many ornithological studies have been performed in various parts of the world however; data from research on urban bird species are scattered and scarce. Most urban studies compared the avian population in the city center with the periphery of a single town. The results have shown that richness and diversity of bird species decline with increasing urbanization; the richness of bird species also tends to increase with decrease in urbanization (Schutz and Schulze, 2015).

Nuorteva (1971) compared the bird population of city center, neighboring agricultural lands and uninhabited forest in Finland. He recorded the highest number of avian species near rural houses and the lowest in the city. Muñoz-Sáez *et al*. (2017) recorded the highest population of granivorous and insectivorous species during winter in an agro ecosystem in central Chile. They found that overall bird species richness was favored by non-crop structure such as hedgerows.

If urbanization is eventually unavoidable at a given moment and place, city planners may manage artificial landscapes such as urban parks, so that they can attract a diverse range of ecologically important bird species. In this context and because of heterogeneous nature, Mardan district of Khyber Pakhtunkhwa (KP) represents a good model. We explored the local avian fauna as it was neglected for years and compared its composition and

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diversity in different habitats while focusing on ecological changes.

MATERIALS AND METHODS

Study area

Field data were collected from three different locations of Mardan district, located in Khyber Pakhtunkhwa Province of Pakistan. For field survey we chose three well defined environments: (1) Urban Area: The area is the part of Mardan city (34° 11' 28.1688'' N, 72° 4' 15.2652'' E), the area is well paved and densely populated with scant vegetation. Populus, Eucalyptus and Bakain are the main trees planted along the sides of the road. Besides that, fruit trees and ornamental trees are also present that provide food and nesting sites for bird species. The ground flora of herbs and shrubs is less developed compared to agricultural area and water body (Supplementary Table I). (2) Agricultural Area: The area is referred to cultivated lands located (34° 18' 46.6488'' N, 72° 9' 1.1304'' E) at a distance of 10 km from Mardan city. The area is the part of Gujrat Union Council bordering with Kata Khat Union Council and Bakhshali town. The area is not highly developed and populated and has more natural vegetation compared to urban area. Agricultural landscape includes two components viz., agricultural crops and tree species both local indigenous trees and ornamental trees that provide foraging and nesting habitat for many bird species. Besides that, ground flora of shrubs and herbs is present that also becomes the food of birds. The 20 acres Eucalyptus and Populus plantation, is also included in agricultural area (Supplementary Table I). (3) Water body: Ballar stream is the main water body of the area which is the combination of two streams Lund Khwar and Wach Khwar flowing from northeast to southwest which converge at Kamargai (34° 16' 55.6716'' N, 72° 10' 7.7664'' E). The stream flows along the Gujrat and Bakhshali town and discharges into Nala Kalpani (at Mardan). Nala Kalphani is a canal originating from river Swat. The banks of water body are surrounded by trees mainly Populus and Eucalyptus as well as ground flora of herbs and shrubs that make the source area for water birds (Supplementary Table I).

Survey method

For data collection bird surveys were conducted from August 2017 to August 2018. All twenty four sampling sites were explored by point counts method (Buckland *et al*., 2001). Eight sampling plots of 10-m radius from 0 to 50 m were drawn in each of three well defined environments; urban area (U), Agricultural area (A) and Water body (W). Counts were made early in the morning from 08:00-10:00 hours. Each sampling plot was surveyed twice a month. An onward distance of 50 m was maintained between all the sampling positions. Bird activity was observed for a period of 20 min at each sampling plot. Bird species observed or recorded outside the sampling points were not counted in order to minimize data-dependent problems. All the species were recorded by direct observation or by songs or calls within the habitat. Surveys were performed in breeding and non- breeding period till the appearance of spring and summer migrants. Bird counting was avoided in rainy and cloudy weather. The classification of bird species into trophic guilds was based on Manhaes and Loures-Ribeiro (2005) and Anderies *et al*. (2007) and field observations. The bird species were categorized into forest dependent, forest semi dependent and forest independent based on their degree of forest dependence which was established according to Anderies *et al*. (2005), da Silva (2015) and field observations.

Statistical analysis

Diversity and species richness in different habitats was calculated by Shannon-Weiner diversity index (Magurran, 1988). One way analyses of variance (ANOVA) were used to test the significant differences in distribution of avian population in different habitat types.

RESULTS

In total 35 bird species belonging to 23 families and 10 orders were recorded in all habitats of Mardan. Passeriformes was the main order, representing 47.82% families (n=11) and 51.42% species (n=18). Families representing leading number of species were Columbidae (n=4), Sturnidae (n=3) and Motacillidae (n=3) (Table I).

The agricultural habitat showed the highest species richness. Three migratory species white wagtail (*Motacilla alba),* white browed wagtail *(Motacilla maderaspatensis)* and Indian roller *(Coracias benghalensis)* were documented during breeding season that improved number of exclusive species and total species richness of agricultural area. Agricultural area had the lowest percentage 28.1% (n=9) of exclusive species. The percentage of exclusive species present in urban habitat was slightly larger 33.3% (n=7) than agricultural habitat (Table II). The species found in this area were dependent on human dominated environments, especially common myna (*Acridotheres tristis),* house sparrow *(Passer domesticus),* rock pigeon *(Columba livia)* and turtle dove *(Streptopelia turtle).* Exclusive species comprised 60% (n=21) of total avifauna. The water body was the habitat with highest percentage of exclusive species n=5 (41.6%) (Table II). The avian fauna of this particular habitat was the year round resident except little egret (*Egretta garzetta),* Indian pond heron *(Ardeola grayii),* white wagtail,white-browed wagtail and

Table I. Avifauna of District Mardan.

Order/Family	Common name	Scientific name	U/A/W	*P*	Fd	TG
Order: Passeriformes						
Family: i. Corvidae	House crow	*Corvus splendens*	68/64/0	**	S	O*
	Rufous treepie	*Dendrocitta vagabunda*	18/38/0	*	D	O*
ii. Pycnonotidae	Red vented bulbul	*Pycnonotus cafer*	20/32/0	***	D	Fr
iii. Dicruridae	Black drongo	*Dicrurus macrocercus*	12/25/0	*	D	In
iv. Sturnidae	Common myna	*Acridotheres tristis*	52/32/0	**	S	O*
	Jungle myna	*Acridotheres fuscus*	12/16/0	NS	D	O*
	Bank myna	*Acridotheres ginginianus*	16/25/22	NS	S	O*
v. Passeridae	House sparrow	*Passer domesticus*	62/16/0	***	S	O*
	Eurasian tree sparrow	*Passer montanus*	12/25/0	*	D	O*
vi. Laniidae	Long tail shrike	*Lanius schach erythronotus*	4/22/0	***	S	In
vii. Leiothrichidae	Afghan babbler	*Argya huttoni*	0/20/0	***	D	In
viii. Motacillidae	White wagtail	*Motacilla alba*	9/22/17	NS	S	In
	White browed wagtail	*Motacilla maderaspatensis*	12/18/6	NS	I	In
	Grey wagtail	*Motacilla cineria*	0/0/15	***	I	In
ix. Muscicapidae	White tailed stonechat	*Saxicola leucurus*	0/10/0	***	S	In
x. Hirundinidae	Barn swallow	*Hirundo rustica*	36/22/0	*	I	A*
	Bank swallow	*Riparia riparia*	44/24/48	NS	I	A*
xi. Alaudidae	Oriental skylark	*Alauda gulgula*	0/14/0	***	I	In
Order: Columbiformes						
Family: i. Columbidae	Collar dove	*Streptopelia decaocto*	8/16/0	***	D	Gr
	Laughing dove	*Spelopelia senegalensis*	11/25/0	*	D	Gr
	Feral pigeon	*Columba livia*	42/11/0	**	S	Gr
	Turtle dove	*Streptopelia turtur*	36/0/0	**	I	Gr
Order: Bucerotiforme						
Family: i. Upupidae	Eurasian hoopoe	*Upupa epops*	4/23/0	NS	D	In
Order: Strigiformes						
Family: i. Strigidae	Spotted owlet	*Athene brama*	0/9/0	***	D	In/C
Order: Charadriiformes						
Family: i. Charadriidae	Red wattled lapwing	*Vanellus indicus*	0/22/15	*	I	In
ii. Scolopacidae	Common greenshank	*Tringa nebularia*	0/0/21	***	I	In
Order: Pelecaniformes						
Family: i. Ardeidae	Little egret	*Egretta garzetta*	0/18/30	NS	S	C/In
Order: Accipitriformes						
Family: i. Accipitridae	Black kite	*Milvus migrans*	64/9/0	***	S	C
Order: Gruiformes						
Family: i. Rallidae	Water hen	*Amaurornis phoenicurus*	0/0/19	***	I	In
Order: Anseriformes						
Family: i. Anatidae	Duck	*Anas platyrchynchos*	0/19/32	*	I	In
Order: Coraciiformes						
Family: i. Coraciidae	Indian roller	*Coracias benghalensis*	0/26/0	***	D	In
ii. Meropidae	Green bee-eater	*Merops orientalis*	6/24/5	NS	D	A*
iii. Alcedinidae	Kingfisher	*Halcyon smyrensis*	0/15/20	*	S	C/In
	Pied kingfisher	*Ceryle rudis*	0/0/34	***	I	C

ANOVA results: NS, non-significant ($P > 0.05$); significant (*) $P < 0.05$, (**) $P < 0.01$, (***) $P < 0.05$: U/A/W Number of observations in the urban/agricultural/water habitats. Fd, degree of forest dependence; independent, S, semi-dependent; D, dependent; TG, trophic guilds; In, insectivore; Cr, carnivore; Fr, frugivores; Gr, granivore; O*, omnivore; Cr/In, carnivore/insectivore; A*, aerial insectivore.

bank swallow (*Riparia riparia)*. The bank myna (*Acridotheres ginginianus)* was recorded in large flocks only during the breeding season, colonizing the cavities on the bank of water body. The bank swallow showed a gradual decline in numbers from winter to summer season.

Insectivorous and omnivorous species were the dominant trophic guilds of agricultural habitat (Fig. 1). Omnivorous species distributed equally in agricultural and urban habitats, whereas the ratio of insectivorous species considerably declined in urban area. In water body the dominant trophic guilds were insectivore (invertebrate eaters). The bird species preying upon small birds and insects were recorded equally in agricultural area and water body. In agricultural habitat spotted owlet (*Athene brama)* preyed upon small birds and also included insects in its diet as a major food source. Due to the cutting of

trees in agricultural area the spotted owlet disappeared from further observations. Aerial insectivores moved equally between agricultural habitat and urban habitat but their preferred nesting sites were located in urban habitat and banks of water body. Granivorous species were the predominant trophic guild of urban habitat, the ratio of this guilds considerably decreased in agricultural habitat (Fig. 2).

Table II. Species richness and exclusive species.

Habitat	Total species	Exclusive species	Percentage (%)*	Percentage (%)**
Urban	21	7	60	33.3
Water	12	5	34.2	41.6
Agricultural	32	9	91.4	28.1

(%)* Percentage in relation to total number of species; (%) ** Percentage of exclusive species in relation to the total number of species in each habitat.

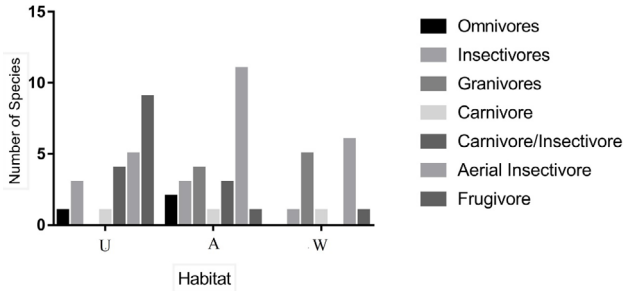

Fig. 1. Distribution of bird trophic guilds at Mardan habitats. U, urban; A, agricultural; W, water body.

All 35 avian species were analyzed by one way analysis of variance in which 26 species showed significant ($P < 0.05$) differences in distribution of avian population among habitats. (Table I). The frequency of forest dependent species was higher in agricultural habitat due to the presence of small forest fragments. Forest independent species reached the highest proportion in water body such as pied kingfisher (*Ceryle rudis*), water hen *(Amaurornis phoenicurus)* and common greenshank (*Tringa nebularia*) recorded exclusively in water body. The percentage of forest semi dependent species considerably decreased from 48% in agricultural area to 20% in water body (Fig. 2). Two species white wagtail and white browed wagtail recently expanded their range to urban habitat. On the other hand green bee-eater (*Merops orientalis*), Eurasian hoopoe (*Upupa epops*), little egret, bank swallow, white wagtail, white browed wagtail, jungle myna and bank myna did not show significant difference ($P > 0.05$) in distribution pattern among habitats. Agricultural area was far most stable in degree of forest dependence (Fd) (Fig. 2). The agricultural area showed the highest species richness VPi (3.07), followed by the urban area VPi (2.5). The lowest species richness VPi (2.41) was documented in the water body.

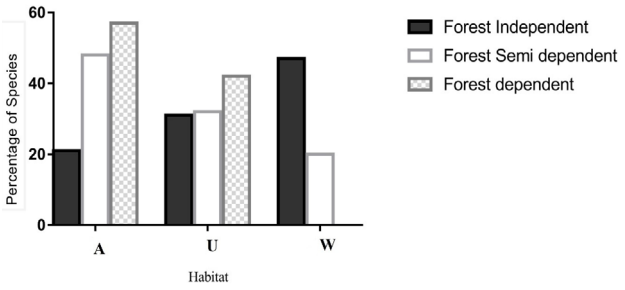

Fig. 2. Percentage of bird species in different habitats, according to the degree of forest dependence (Fd). A, agricultural; U, urban; W, water body.

DISCUSSION

Thirty five bird species were recorded; at least 25 were recorded in more than one habitat. Bird communities in different existing landscapes were dominated by only a few bird species. Many species recorded in the study area were of low frequency, due to their small population size. The results are similar to reported by Godoi *et al.* (2016) from riparian forest in western Brazil where the study area had been severely affected by human activities and had lower bird wealth and abundance. Similarly, in the present study small forest plantation in agricultural area was substantially reduced by human activities. Old trees were cut down due to which spotted owlet was not recorded in subsequent surveys. Hostetler and Knowles-Yanez (2003) reported that urban expansion contributed to the loss of biodiversity due to the proportional decrease in vegetation structure. Melles *et al.* (2003) investigated that forest fragments near urban landscape provided resource area for many alien birds and were the home to many resident birds. In Mardan city surroundings small forest fragments still exist that provide nesting sites and other food resources for urban bird communities, especially for the birds that do not reproduce in the city as the case with Afghan babbler and jungle myna that reproduce outside the city of Mardan.

All habitats of Mardan have specific characteristics to attract avian species. The agricultural area maintained the natural features in the district. Although the area is currently bounded by man-made landscape or by developed areas. The 20 acres forest plantation had given the advantage to most forest dwelling species and

facilitated the exchange of these species to adjacent areas, mainly in the neighborhood of water body.

Generalist bird species were predominant in the urban area. Evan *et al*. (2011) found that generalist species that feed on different resources were comparatively better supported by urban habitats than specialist species nesting on the ground. Since less specialized omnivores and insectivores were also higher in number, studies revealed that these trophic guilds were more successful in urban areas where natural habitats had been substantively impacted by urbanization (Fernández-Juricic*et al*., 2000; Dum *et al*., 2009) that resulted in an increase in developed areas (Arroyo-Solís *et al*., 2013).

Manhaes and Loures-Ribeiro (2005) reported the lowest percentage of exclusive species in urban area (14.3%) while the water body showed the highest percentage of exclusive species in southeast Brazil. During the present study water body supported the highest percentage of exclusive species (41.6%) whereas the lowest percentage of exclusive species was documented in agricultural area.

Urban area supported more resident species that used nesting sites year after year. Washburn *et al*. (2016) studied bird diversity and composition in Chicago and found that avian species were more common in top roof habitat in urban area as the green roof habitat with native vegetation offered foraging sites to most bird species.

Similarly, agricultural area shared many species with urban area and also provided refuge and food sources to many urban bird species. Thus, agricultural area had the lowest percentage of exclusive species.

The study confirms that the maintenance of trees, bushes and grass seeds in agricultural area and in the surroundings of water body serves to be a haven for bird communities in Mardan district. Burghardt *et al*. (2009) reported that in southeastern Pennsylvania native plants and landscapes positively influenced the avian and lepidopteran carrying capacity and provided a mechanism for reducing biodiversity losses in human-dominated landscapes. Therefore, enrichment of vegetation structure within an urban area shall enhance diversity and abundance of avian communities.

CONCLUSION AND RECOMMENDATIONS

The urban area does not support high bird diversity compared to the nearby agricultural environment, because heterogeneity in the habitat supports local species richness. Therefore, to maintain high bird diversity in the city, it is necessary to develop more natural sites and to encourage tree plantation and green areas. The Government of Khyber Pakhtunkhwa should initiate conservation policies to promote awareness in general public and to discourage habitat destruction, cutting of large indigenous trees and improving the vegetation structure in all habitats. Such decisions will be helpful in the maintenance of these habitats for conservation of avifauna.

Supplementary material

There is supplementary material associated with this article. Access the material online at: https://dx.doi.org/10.17582/journal.pjz/20200307110312

Statement of conflict of interest

The authors have declared no conflict of interest.

REFERENCES

Anderies, J.M., Katti, M. and Shochat, E., 2002. Living in the city: Resource availability, predation, and bird population dynamics in urban areas. *J. Theor. Biol*., **247**: 36-49. https://doi.org/10.1016/j.jtbi.2007.01.030

Andrade, R.D. and Marini, M.Â., 2002. Bird species richness in natural forest patches in southeast Brazil. *Lundiana,* **3**:141-149.

Arroyo-Solís, A., Castillo, J.M., Figueroa, E., López-Sánchez, J.L. and Slabbekoorn, H., 2013. Experimental evidence for an impact of anthropogenic noise on dawn chorus timing in urban birds. *J. Avian Biol*., **44**: 288-296. https://doi.org/10.1111/j.1600-048X.2012.05796.x

Bierregaard, R.O., 1998. Conservation status of birds of prey in the South American tropics. *J. Raptor Res.,* **32**: 19-27.

Burghardt, K.T., Tallamy, D.W. and Gregory Shriver, W., 2009. Impact of native plants on bird and butterfly biodiversity in suburban landscapes. *Conserv. Boil.*, **23**: 219-224. https://doi.org/10.1111/j.1523-1739.2008.01076.x

Buckland, S.T., Anderson, D.R., Burnham, K.P., Laake, J.L., Borchers, D.L. and Thomas, L., 2001. *Introduction to distance sampling: Estimating abundance of biological populations*. Oxford University Press, Oxford, UK.

Damen, M., Rahbek, C., Zimmermann, N.E. and Guisan, A., 2017. Spatial predictions at the community level: from current approaches to future frameworks. *Biol. Rev*., **92**: 169-187. https://doi.org/10.1111/brv.12222

Dum, R.P., Levinthal, D.J. and Strick, P.L., 2009. The spinothalamic system targets motor and sensory areas in the cerebral cortex of monkeys. *J. Neurosci*., **29**: 14223-14235. https://doi.

org/10.1523/JNEUROSCI.3398-09.2009

Evans, K.L., Chamberlain, D.E., Hatchwell, B.J., Gregory, R.D. and Gaston, K.J., 2011. What makes an urban bird? *Glob. Change Biol*., **17**: 32-44. https://doi.org/10.1111/j.1365-2486.2010.02247.x

Fernández-Juricic, E.S.T.E.B.A.N. and Tellería, J.L., 2000. Effects of human disturbance on spatial and temporal feeding patterns of blackbird Turdusmerula in urban parks in Madrid, Spain. *Bird Study*, **47**: 13-21. https://doi.org/10.1080/00063650009461156

Godoi, M.N., Souza, F.L., Laps, R.R. and Ribeiro, D.B., 2016. Composition and structure of bird communities in vegetational gradients of Bodoquena Mountains, western Brazil. *An. Acad. Bras. Ciênc*., **88**: 211-225. https://doi.org/10.1590/0001-3765201620140723

Grimmett, R., Inskipp, C. and Inskipp, T., 2016. *Birds of the Indian Subcontinent: India, Pakistan, Sri Lanka, Nepal, Bhutan, Bangladesh and the Maldives*. Bloomsbury Publishing.

Hostetler, M. and Knowles-Yanez, K., 2003. Land use, scale, and bird distributions in the Phoenix metropolitan area. *Landsc. Urban Plann.*, **62**: 55-68. https://doi.org/10.1016/S0169-2046(02)00096-8

Laurance, W.F., Camargo, J.L., Luizão, R.C., Laurance, S.G., Pimm, S.L., Bruna, E.M. and Van Houtan, K.S., 2011. The fate of Amazonian forest fragments: a 32-year investigation. *Biol. Conserv*., **144**: 56-67. https://doi.org/10.1016/j.biocon.2010.09.021

Muñoz-Sáez, A., Perez-Quezada, J.F. and Estades, C.F., 2017. Agricultural landscapes as habitat for birds in central Chile. *Rev. Hist. natl*., **90**: 3. https://doi.org/10.1186/s40693-017-0067-0

Manhães, M.A. and Loures-Ribeiro, A., 2005. Spatial distribution and diversity of bird community in an urban area of Southeast Brazil. *Braz. Arch. Biol. Technol*., **48**: 285-294. https://doi.org/10.1590/S1516-89132005000200016

Melles, S., Glenn, S. and Martin, K., 2003. Urban bird diversity and landscape complexity: species–environment associations along a multiscale habitat gradient. *Conserv. Ecol*., **7**: 1-22. https://doi.org/10.5751/ES-00478-070105

Magurran, A.E., 1988. *Ecological diversity and its measurement*. Princeton University Press. https://doi.org/10.1007/978-94-015-7358-0

Nuorteva, P., 1971. The synanthropy of birds as an expression of the ecological cycle disorder caused by urbanization. In *Annls Zool. Fenn. Soc. Biol. Fennica Vanam*. pp. 547-553.

da Silva, J.M.C., 1995. Avian inventory of the Cerrado region, South America: Implications for biological conservation. *Bird Conserv. Int.,* **5**: 291-304.

Schütz, C. and Schulze, C.H., 2015. Functional diversity of urban bird communities: Effects of landscape composition, green space area and vegetation cover. *Ecol. Evolut.,* **5**: 5230-5239.

Silva, C.P., García, C.E., Estay, S.A. and Barbosa, O., 2015. Bird richness and abundance in response to urban form in a Latin American city: Valdivia, Chile as a case study. *PLoS One*, **10**: e0138120. https://doi.org/10.1371/journal.pone.0138120

Washburn, B.E., Swearingin, R.M., Pullins, C.K. and Rice, M.E., 2016. Composition and diversity of avian communities using a new urban habitat: Green roofs. *Environ. Manage*., **57**: 1230-1239. https://doi.org/10.1007/s00267-016-0687-1