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Anthropogenic noise reduces bird species richness and diversity along a Rur-urban gradient: A case study from a city in central India during nationwide lockdown amid COVID-19

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Abstract

Urbanization is increasing rapidly in all parts of the world to accommodate the increasing human population but it is having a drastic effect on native flora and fauna. The present study was carried out across a three stage urbanization gradient in and around the city of Bilaspur, Chhattisgarh. Observations were made from September 2019 to February 2021 at the selected three sites during COVID 19 pandemic. Point count method was used for bird surveys and Sound pressure (Noise) measurements were made across the three selected sites. The Avian diversity was measured by total species richness, Fisher's alpha diversity index and Shannon-Wiener diversity index. The Urban centre recorded the highest sound pressure and lowest Avian species richness but as we moved away from the urban centre the noise levels reduced and the avain species richness increased towards the rural areas. This is mainly due to many avian species avoiding urban areas because of increasing noise levels. We also found that the urban bird community is dominated by a few species whereas the rural bird community was much more diverse.

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Introduction

As the current world population keeps growing at a rapid rate, accompanied Parallelly by urbanisation more and more local biodiversity is being affected. A very few studies have been carried out to study the consequences of Urbanization on birds (Sengupta *et al.,* 2014) Earlier studies showed a high bird abundance in Indian cities which could be because of the food availability, vegetative cover and the Indian virtue of generosity towards all living forms (Galushin 1971). The past studies on Urban birds across the Indian subcontinent have shown a rich species diversity where 125 bird species were recorded in the urbanized habitats of Pauri District, Garhwal Himalaya, Uttarakhand State, 88 species on the Amravati University Campus and 76 species were recorded on a campus of the Punjabi University, Pakistan (Nathani *et al.,* 2012; Wadatkar 2001). But the most recent study from Kolkata, however, recorded only 48 bird species across different urban habitats where the higher species richness was towards the rural areas and species richness went down as they approached the city centre (Sengupta *et al.,* 2014).

Urban habitats are quite different from the natural areas, due to which the species dwelling in these areas face higher competition with exotic species, higher risk of predation and parasites, as well as stress due to chemical pollution and noise (Jokimäki 1999; Slabbekoorn 2008). Noise pollution in cities is a relatively recent phenomenon that birds now have to cope up with throughout much of the world. Whether a given avian species will be a "winner" (urban-adapted or urban-exploiter species) or "loser" (urban-avoiding species) is determined by an interaction between land use and life history traits of that particular species (McKinney *et al.,* 1999). Noise induced changes on birds include stress, flight, changes in foraging, louder calls and other reactions based on physical observations. This can ultimately result in permanent hearing loss in avian populations (Niemiec *et al.,* 1994). Loud sounds from urban sources like industries, vehicular traffic etc. damages sensory organs of birds as well as affect their reproductive success. Traffic noise had a negative effect on reproductive success on great tits (*Parus major*) with females laying smaller clutches in noisier areas (Halfwerk *et al.,* 2011). The urban avian community is greatly influenced by the land use changes and the life history traits of selected species as to whether they will adapt to the urban scenario or end up avoiding the habitat (Blair 2001).

Vehicles contribute the majority towards urban noise (Zannin *et al.,* 2002; Perillo *et al.,* 2017). Vehicular noise affects bird distributions, reducing density, richness and abundance in sites where noise pollution is intense (Rheindt 2003; Arévalo *et al.,* 2011; mc Clure *et al.,* 2013). Increased Noise Pollution has resulted in birds having to make louder calls.

Vocalization in birds is governed by Energy costs and body size in order to increase their amplitude to rise above background noise (Brackenbury 1979; Brumm 2004; Oberweger *et al.,* 2001). Sexual selection and social integration is birds is based on acoustic communication (Catchpole *et al.,* 2003). If birds must change their vocalization it might affects many facets of their life causing immense stress on them.

The present study was carried out with an aim to study the impact of increasing sound pressure (Noise) in urban areas on birds. Noise pollution has become a major problem in today world as human population is increases. Birds being a visible part of the ecosystem help in providing information on the overall condition like quality and changes in the environment as well as community composition therefore they are called as ecosystem health indicators. Such studies can help to predict the effect of anthropogenic noise in the current scenario.

Materials and methods

Study site

The study area Bilaspur, Chhattisgarh. It is located at 22.070 N Latitude and 81.140 E Longitude. The elevation above mean sea level is about 945 feet (288 meters). The climate remains moderate across the district all year round. In summer the Average temperature is 33° C whereas it falls to 130C in winter.

The average annual rainfall for the district varies between 600 to 750mm, out of which, over 80% occurs during June-September (Viswanath *et al.,* 2000). The Achanakmar Tiger Reserve lies to the North-west of the city with a mixed forest type mostly dominated with *Shorea robusta*.

The study was conducted in three zones of the urbanized gradient:

Zone 1: The forest area studied falls used the buffer zone of the Achanakmar Tiger reserve (N22022' E81057'). This area is densely forested area dominated by tree species like Sal (*Shorea robusta*), Tendu (*Diospyros melanoxylon*), Teak (*Tectona grandis*), Arjun (*Terminalia arjuna*), Mahua (*Madhuca indica*). There are small neighbouring forest villages and agriculture land owned by the local residents. This area was considered as a control for the study.

Zone 2: The peri-urban site Bhaisajhar (N 22°18' E8206') is a village forest on the periphery of Bilaspur city situated around 35 kms away from the city.

The village has a population of 893 residents and the area has a plantation area of Teak (*Tectona grandis*) and other tree species are Tendu (*Diospyros melanoxylon*) and Mahua (*Madhuca indica*).

Zone 3: The urban area of Bilaspur city (N2204' E82010') is densely populated; the study area is in the middle of the city with more than 50% of the surface covered with asphalt or buildings. The population of Bilaspur city is 2,663,629 residents.[9] There are sparce trees present which include Babool (*Acacia nilotica*), Mango (*Mangifera indica*), Gulmohar (*Delonix regia*), Neem (*Azadirachta indica*) etc.

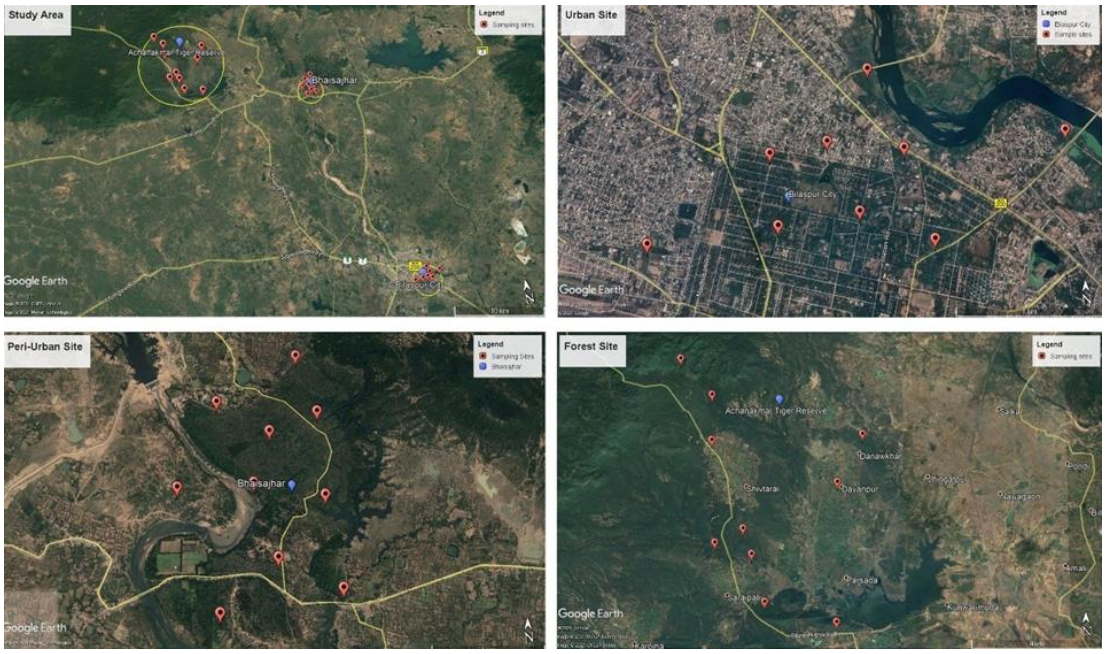

Fig. 1. a) Study sites b) Urban site (Zone 3) c) Peri-urban site (Zone 2) d) Forest site (Zone 1).

Bird counts

The recordings were done at 3 different sites i.e. Forest, Peri Urban forest and urban area. By establishing fixed sampling points, at a minimum distance of 200 m apart (Bibby *et al.,* 2000; De Moura *et al.,* 2010). This minimised the chances of recording the same individuals at more than one point and allowed detection of species. All field work was conducted by ornithologists with extensive experience of the avifauna of the region. All bird seen and heard were recorded and only birds using the landscape were counted, overflying birds were not considered as they were not using the area.

Birds were recorded in two phases; first phase in the morning 06:00 hrs to 09:00 hrs and second phase in

the evening 16:00 hrs to 18:00 hrs (Vishwakarma *at al.,* 2021). 28 sampling points were used in total during the study accounting to around 320 hours of fieldwork. Observations were made using binocular Nikon Aculon 10 x 50 and Camera's Canon 700D with 100-400 Tamron lens and Nikon P900 83X Zoom lens and for identification we referred Grimmett *et al.,* 2013.

Fig. 2. Map showing distance between sampling points.

Sound Pressure

While conducting the bird census we also recorded the sound pressure, for measuring sound pressure (i.e. noise) levels a Sound Level Meter (UNIT-T UT353BT Mini) was used mounted on a tripod stand with the microphone placed at a height of 1.5m from the floor of the measurement. The sound-level meter recorded the noise values in decibels per second, measurements were taken on different days of the week, excluding rainy and windy days. Before each noise measurement the instrument was calibrated (Konadath *et al.,* 2019).

Results

Bird Abundance and Richness

The total number of species recorded across all sites was 110 species. The highest species richness was recorded in the forest area. The highest number of individuals was recorded in the Forest area (108 species) followed by the peri-urban area (57 species) and the least number of species were recorded in the urban area (33 species). The number of individuals were also highest in the forest (2370 individuals) and the lowest species abundance was recorded in the Urban area (582 individuals). 22 avian species were similar across all 3 study sites.

Table. 1. Total number of species, families and the number of individuals observed.

Statistical analysis	Forest	Peri-urban	Urban
Species	108	57	33
Individuals	2370	1055	582
Dominance	0.02308	0.03083	0.04688
Shannon	4.169	3.74	3.228
Fisher alpha	23.32	12.91	7.579

The Rock pigeon (*Columba liva*) was the most dominant species in the urban area and Rose ringed parakeet (*Psittacula krameri*) was most dominant in the Peri-urban area and Forest.

Noise

Sound pressure (Leq) ranged from 32 to 64 dB and peak sound levels (L10) ranged from 39 to 77 dB (Table 2). The sound pressure (Noise) was negatively correlated with species richness across all 3 study sites. We observed that urban birds reacted less to noise on the contrary, birds in the forest and rural areas get highly disturbed by the slightest noise.

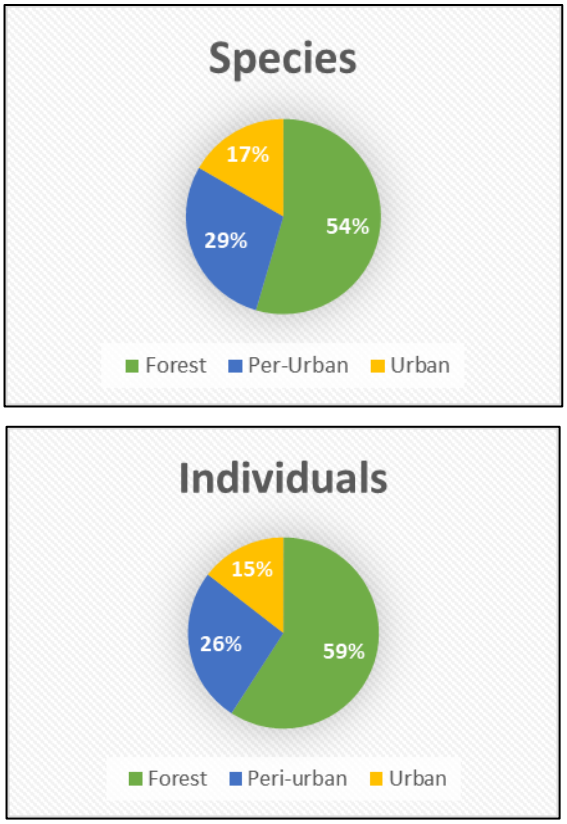

Fig. 3. a) Pie chart of species recorded across all sites b) Pie chart of number of individuals recorded across all sites.

Table. 2. Sound pressure recorded across the 3 study areas in Decibel.

Site	Sound Pressure (Decibel)	
	L_{eq}Ranges	L_{10} Range
Forest	32-37	39-43
Peri-urban	42-51	54-57
Urban	49-64	68-77

Leq = time averaged sound pressure levels; L10 = peak sound pressure levels.

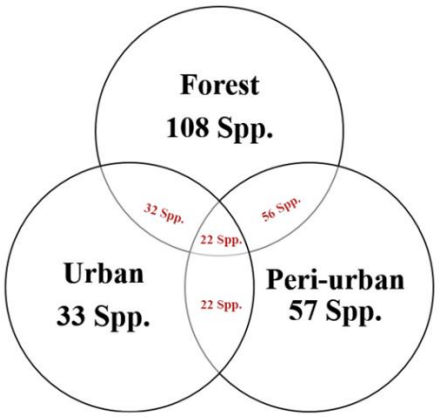

Fig. 4. A Venn diagram representing the association across all 3 sites.

Discussion

The present study documented 110 species across the three stage urbanization gradient which was higher compared to previous studies (Kale *et al.,* 2018; Sengupta *et al.,* 2014). But our results were consistent, with few studies that showed a lower bird species diversity in urbanized areas (Blair 1996; Blair 2001; Blair *et al.,* 1997; Marzluff 2001; Garaffa *et al.,* 2009). 22 bird species were common across all the three habitats and the avian communities in the urban area as well as the peri-urban area were a subset of the species pool of the forest area. But there was not much similarity between the avian communities of the Urban and peri-urban areas (Fig. 4).

Out of the 110 avian species recorded 13 species were migratory and mostly sighted in the forest and peri-urban areas, only a single migratory species was recorded in the urban area. Two IUCN red listed species, Grey headed fish eagle (*Haliaeetus ichthyaetus*, near threatened; IUCN, 2013) and Alexandrine parakeet (*Psittacula eupatria*, Near Threatened; IUCN, 2013) were recorded in the forest and peri-urban area which indicated the importance of these areas for the conservation of such species.

Bird species like Rock pigeon (*Columba liva*), Red Vented Bulbul (*Pycnonotus cafer*), Common myna (*Acridotheres tristis*) were the most common avian species in the city centre. They have adapted to living in urban areas with high fragmentation and minimal vegetation. These birds use buildings for roosting, foraging and nesting and are mostly unaffected by noise and human presence such species can be termed as urban exploiters (Mohring *et al.,* 2021). Rock pigeons are a menace in urban areas because of their preference to live in close proximity to human dominated landscapes. Their population begins to boom once they colonize any area as female pigeons can give birth to 48 squabs per year. Their faecal matter is highly acidic and may destroy buildings and monuments and also causing respiratory disease in humans (Gore *et al.,* 2016). On the contrary avian species like Common hawk cuckoo (*Hierococcyx varius*), Plain prinia (*Prinia ornata*),

Black redstart (*Phoenicurus ochruros*) were not frequently encountered in the urban centre but since there was less human movement due to the covid-19 lockdown these birds were recorded moving around in the city.

The urban areas of Bilaspur city are devoid of designated green space, parks or oxi-zones (Fig. 5) which is one of the major cause of loss or avian diversity in the urban area. Many green patches have been converted in concrete spaces which has escalated the urban heat island phenomenon within the city. Urban green spaces (UGS) are very important, especially in developing countries like India and China, where air pollution levels are extremely high. These green spaces not only help in purifying the air but also help in ground water retention, micro-climate regulation and also in mitigating the urban heat island phenomenon and Trees also act as a sound buffer in urban areas reducing the impact of noise not only on wildlife but also on humans at the same time. (Jennings *et al.,* 2016; Ramaiah *et al.,* 2019)

Fig. 5. Map showing densely populated areas of Bilaspur .

Urban noise has a myriad of effects on birds which includes hearing impairments in birds, induces stress, avoidance to specific areas, behavioural changes, changes in calls affecting vocal communication and also affects reproductive success in many bird spices which has been affecting urban bird population (Ortega 2012). Avian species which were closely linked to humans like House sparrow (*Passer domesticus*) and House crow (*Corvus splendens*) were not recorded in the urban area which could be due to reasons like Replacement of natural biotic cover to artificial substrate like Concrete, lawns and Asphalt (Turrini *et al.,* 2015), Competition for food with other species like Red Vented Bulbul and Rock pigeon, Loss of nesting opportunities as they cannot find suitable nest holes in modern buildings, Increased traffic disturbance and pollution from exhaust fumes which would be greater in city centres (Summers-Smith 2003). Although we need long term studies to understand why a few species have started to avoid urbanized areas and moved away from the cities.

During this study the human movement and noise pollution within the urban areas was reduced due to the covid-19 lockdown and an increase in avian species was noted although for a short duration but such efforts can have a positive effect in enhancing urban biodiversity.

This study in an initial step towards global collaboration to better understand avian responses by integrating a large number of data sets. Similar data from previous years and from years following the COVID-19 pandemic, will considerably strengthen inferences, helping to dissent angle anthropause effects from natural seasonal variation in animal biology. With this we can better understand the functioning of urban biodiversity and suggest methods for their conservation. Better planning is needed to reduce the losses caused by urbanization on wildlife in which Planners, developers, researchers and residents all play a vital role.

Fig. 6. (L TO R): a) Rock pigeon nesting in a building cavity b) Red vented bulbul with nesting material c) Indian grey Hornbill d) Indian Pitta e) Common Tailorbird f) Plum headed parakeet.

References

Arévalo JE, Newhard K. 2011. Traffic noise affects forest bird species in a protected tropical forest. Revista de Biología Tropical **59(2),** 969-980.

Bibby CJ, Burgess ND, Hillis DM, Hill DA, Mustoe S. 2000. Bird census techniques. Elsevier.

Blair RB, Launer AE. 1997. Butterfly diversity and human land use: Species assemblages along an urban gradient. Biological conservation **80(1),** 113-125.

Blair RB. 1996. Land use and avian species diversity along an urban gradient. Ecological applications **6(2),** 506-519.

Blair RB. 2001. Birds and butterflies along urban gradients in two ecoregions of the United States: is urbanization creating a homogeneous fauna? In Biotic homogenization (pp. 33-56). Springer, Boston, MA.

Brackenbury JH. 1979. Power capabilities of the avian sound-producing system. Journal of Experimental Biology **78(1),** 163-166.

Brumm H. 2004. The impact of environmental noise on song amplitude in a territorial bird. Journal of animal ecology **73(3),** 434-440.

Catchpole CK, Slater PJ. 2003. Bird song: biological themes and variations. Cambridge university press.

Census of India. 2011. Population Statistics. Directorate of Census Operations in Chhattisgarh, Census of India 2011.

De Moura LN, Vielliard JM, Da Silva ML. 2010. Seasonal fluctuation of the Orange-winged Amazon at a roosting site in Amazonia. The Wilson Journal of Ornithology **122(1),** 88-94.

Galushin VM. 1971. A huge urban population of birds of prey in Delhi India. Ibis **113(4),** 522-522.

Garaffa PI, Filloy J, Bellocq MI. 2009. Bird community responses along urban–rural gradients: Does the size of the urbanized area matter. Landscape and Urban Planning **90(1-2),** 33-41.

Halfwerk W, Holleman LJ, Lessells CKM, Slabbekoorn H. 2011. Negative impact of traffic noise on avian reproductive success. Journal of applied Ecology, **48(1),** 210-219.

Hunter P. 2007. The human impact on biological diversity: How species adapt to urban challenges sheds light on evolution and provides clues about conservation. EMBO reports **8(4),** 316-318.

Jennings V, Larson L, Yun J. 2016. Advancing sustainability through urban green space: Cultural ecosystem services, equity, and social determinants of health. International Journal of environmental research and public health **13(2),** 196.

Jokimäki J. 1999. Occurrence of breeding bird species in urban parks: effects of park structure and broad-scale variables. Urban Ecosystems **3(1),** 21-34.

Kale M, Ferrante M, Dudhe N, Kasambe R, Trukhanova IS, Ivanova T, Lövei GL. 2018. Nestedness of bird assemblages along an urbanisation gradient in Central India. Journal of Urban Ecology **4(1),** juy 017.

Konadath S, Mahadeva A, Chatni S. 2019. Noise measurement across different land-use patterns. Journal of Indian Speech Language & Hearing Association **33(2),** 55.

Marzluff JM, Bowman R, Donnelly R. 2001. A historical perspective on urban bird research: trends, terms, and approaches. In Avian ecology and conservation in an urbanizing world (pp. 1-17). Springer, Boston, MA.

McClure CJ, Ware HE, Carlisle J, Kaltenecker G, Barber JR. 2013. An experimental investigation into the effects of traffic noise on distributions of birds: avoiding the phantom road. Proceedings of the Royal Society B: Biological Sciences **280(1773),** 20132290.

McKinney ML, Lockwood JL. 1999. Biotic homogenization: a few winners replacing many losers in the next mass extinction. Trends in ecology & evolution **14(11),** 450-453.

McKinney ML. 2002. Urbanization, Biodiversity, and ConservationThe impacts of urbanization on native species are poorly studied, but educating a highly urbanized human population about these impacts can greatly improve species conservation in all ecosystems. BioScience **52(10),** 883-890.

Mohring B, Henry PY, Jiguet F, Malher F, Angelier F. 2021. Investigating temporal and spatial correlates of the sharp decline of an urban exploiter bird in a large European city. Urban Ecosystems **24(3),** 501-513.

Naithani A, Bhatt D. 2012. Bird community structure in natural and urbanized habitats along an altitudinal gradient in Pauri district (Garhwal Himalaya) of Uttarakhand state, India. Biologia **67(4),** 800-808.

Niemiec AJ, Raphael Y, Moody DB. 1994. Return of auditory function following structural regeneration after acoustic trauma: behavioural measures from quail. Hearing research **79(1-2),** 1-16.

Oberweger K, Goller F. 2001. The metabolic cost of birdsong production. Journal of Experimental Biology **204(19),** 3379-3388.

Ortega CP. 2012. Chapter 2: Effects of noise pollution on birds: A brief review of our knowledge. Ornithological monographs **74(1),** 6-22.

Pauchard A, Aguayo M, Peña E, Urrutia R. 2006. Multiple effects of urbanization on the biodiversity of developing countries: the case of a fast-growing metropolitan area (Concepción, Chile). Biological conservation **127(3),** 272-281.

Perillo A, Mazzoni L G, Passos LF, Goulart VD, Duca C, Young RJ. 2017. Anthropogenic noise reduces bird species richness and diversity in urban parks. Ibis **159(3),** 638-646.

Ramaiah M, Avtar R. 2019. Urban green spaces and their need in cities of rapidly urbanizing India: A review. Urban Science **3(3),** 94.

Rheindt FE. 2003. The impact of roads on birds: does song frequency play a role in determining susceptibility to noise pollution. Journal für Ornithologie **144(3),** 295-306.

Sengupta S, Mondal M, Basu P. 2014. Bird species assemblages across a rural urban gradient around Kolkata, India. Urban Ecosystems **17(2),** 585-596.

Slabbekoorn H, Ripmeester EAP. 2008. Birdsong and anthropogenic noise: implications and applications for conservation. Molecular ecology **17(1),** 72-83.

Summers-Smith JD. 2003. The decline of the House Sparrow: a review. British Birds **96(9),** 439-446.

Turrini T, Knop E. 2015. A landscape ecology approach identifies important drivers of urban biodiversity. Global change biology **21(4),** 1652-1667.

Vishwakarma A, Anthony FM, Tiwari S, Choubey S. 2021. Avifaunal Diversity of Winter Season in Kopra Reservoir of Bilaspur, Chhattisgarh, India. In Proceedings of the Zoological Society **(Vol. 74, No. 1,** pp. 118-126). Springer India.

Viswanath S, Nair PKR, Kaushik PK, Prakasam U. 2000. Acacia nilotica trees in rice fields: A traditional agroforestry system in central India. Agroforestry systems **50(2),** 157-177.

Wadatkar JS. 2001. Checklist of birds from Amravati University Campus, Maharashtra. Zoos' Print Journal **16(5),** 497-499.

Zannin PH, Diniz FB, Barbosa WA. 2002. "Environmental noise pollution in the city of Curitiba, Brazil," Applied Acoustics **63,** 351-358.