Putrescible Waste Landfills as Bird Habitats in Urban Cities: A case from an Urban Landfill in the Colombo District of Sri Lanka

S.S. Marasinghe[1], P.K.P.Perera[1*], P.N. Dayawansa[2]

[1]*Department of Forestry and Environmental Science, University of Sri Jayewardenepura, Nugegoda, Sri Lanka*
[2] *Department of Zoology and Environment Sciences, University of Colombo, Sri Lanka*

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Abstract

As putrescible waste landfills are reliable and rich sources of food, these man-made habitats can support large populations of avifauna composed of different feeding guilds. Unusually high population inflations of few opportunistic species of birds could impose a severe impact on the overall ecological balance. We studied the bird community in an open waste dump located in a highly urbanised area in the Colombo District, Sri Lanka. Bird census were performed using block counts in two contrasting sites of the landfill i.e., active dumping area and inactive dumping area between April 2015 and March 2016. Abundance and density of birds were significantly higher in the active dumping area than in the inactive area. The inactive dumping area accounted for the highest avifaunal richness, diversity and evenness. *Bubulcus ibis* and *Corvus splendens* were the dominant species at the active dump, and their foraging and social behaviors probably discouraged other bird species from exploiting food resources in the dump despite belonging to different feeding guilds. The forging bird community at the landfill exhibited seasonal variations in abundance and other interspecific interactions. Since the influx of large numbers of birds to landfills can potentially cause numerous environmental issues in urban areas, the current study highlights the importance of study of the seasonal patterns of bird communities in relation to location and management of landfills.

Keywords: *urban landfills, feeding guilds, cattle egret, house crow, nuisance birds, waste management*

1. Introduction

Amidst the ever escalating human population and urbanization, effective management of municipal solid waste has become one of the major concerns in urban environs (Hoornweg and Bhada-Tata, 2012). In many developing countries, the issue of solid waste management in cities is rapidly becoming an environmental and economic catastrophe as cities are centers of garbage production (Sharholy et al., 2008). Tons of municipal solid waste, mainly comprising of nonhazardous garbage, rubbish and trash from homes, institutions, and industrial facilities often end-up in urban landfills.

Landfill construction for solid waste disposal not only removes suitable habitats for certain wildlife species but also enhances certain other human-wildlife interactions. Such interactions may have both positive as well as negative impacts on wildlife populations. Some common ecological repercussions of landfills include alteration/loss of wildlife habitats, increased behavioral disturbances including habituation and functioning as food subsidies for certain species, thus the abnormal increase in a few species causing ecological imbalance (Patton, 1988; Blanco, 1996; Elliott et al., 2006).

**Correspondence: priyan@sjp.ac.lk*
Tel: +94 112758411, Fax: +94 112803470
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Among different faunal species, avifauna has been specifically used as a biological indicator in studying anthropogenic influences on animals because of their well-known taxonomy (O'Connell et al., 2000; Gregory and Strien, 2010; Perera et al., 2017), ecology (Padoa-Schioppa et al., 2005), links among bird communities, vegetal associations and territories (Keast, 1990; Petty and Avery, 1990), coverage of different levels of ecological pyramids in most environments (Bunce et al., 1981; Burrough, 1986) and ease of detection that allows rapid data collection on presence/ absence or abundance (Haila, 1985; Wiens, 1989; Perera et al., 2017).

Putrescible waste landfills in urban settings are known to support high abundance of birds. Putrescible waste is "solid waste that contains organic matter capable of being decomposed by microorganisms and of such a character and proportion as to cause obnoxious odors and to be capable of attracting or providing food for birds or animals'' (Argonne National Laboratory). Such landfills provide reliable and rich sources of food as well as potential to support large communities of avifauna representing different feeding guilds (Belant et al., 1995; Jackson et al., 1999; Restaniet al., 2001; Turrin et al., 2015). Previous studies have identified putrescible waste landfills as the primary cause for increased abundance of certain bird species on a local and regional scale, as the carrying capacity reached new levels due to ample availability of food within landfills.

On the other hand, with the concomitant decline in many natural habitats, human modified habitats such as landfills are increasingly becoming important habitats for numerous avian species. As birds adapt to an environment increasingly dominated by humans, their social behavior and demography is likely to change, and species that rely on anthropogenic foods may form stable social organisations with consistent dominance hierarchies in places such as putrescible waste landfills (Saalfeld et al., 2013). Furthermore, less-stable assemblies of vagrant bird species may also form periodically.

Although birds on landfills perform valuable ecological functions (Whelan et al., 2008), unusually high populations of a few bird species with low species richness can have negative impacts on the overall proportions of certain species (Mills et al. 1989; Cam et al., 2000). Conditions in landfills may favor aerial insectivores, granivores and ground foraging insectivores (Allen and O'Conner, 2000; Ciach and Kruszyk, 2010). On the other hand, birds may cause conflicts with human interest with respect to noise, birds carrying litter off site, possible transmission of pathogens in bird droppings, pollution of water near roosting sites due to droppings, increased risks of bird-strikes/collisions and affecting the day to day site operations at landfills (Jackson et al., 1999; Burger, 2001; Dolbeer, 2006; Cook et al., 2008; Martin, 2012). As such, control and management of landfill birds has been recognized as an important aspect in urban landfill management (Cook et al., 2008; Martin, 2012).

In the Sri Lankan context, the severity of the solid waste management issue is rising with the rapid economic development and urban expansion. Open dumping or landfilling are the most common ways of disposing solid waste in Sri Lanka, mainly due to the high cost involved with advanced technologies of landfilling, lack of technical capacity, and lack of knowhow (Bandara and Hettiaratchi, 2010). Several large-scale landfills/open dumps are currently in operation in major cities and suburbs where the majority of them are in association with wetlands, thus replacing the urban wetland ecosystems.

Open dumps function as important foraging grounds for numerous urban wildlife species. Large populations of crows and cattle egrets commonly occupy these landfills along with other species which are less abundant. As any major changes in waste management and disposal practices such as changing from landfilling to incineration can potentially have sizeable impacts on bird populations depending on landfills, better understanding of the extent and patterns of daily use of landfills by birds and their seasonal dynamics in abundance is highly important. Such ecological information would be useful for regulatory agencies and local governments in decision making pertaining to the management of landfills. However, limited or no studies in literature have investigated the effects of landfills on the spatial and temporal distribution of birds and other wildlife species foraging at landfills in Sri Lanka. Hence there is a dearth of knowledge about landfills and their interaction with wildlife thus, this study was designed to bridge this existing literature gap. The study assessed the diversity and abundance of birds at the

Karadiyana Landfill in the Colombo District; the largest operating landfill in Sri Lanka. It further examined the temporal changes and functional diversity of the bird community via analysing feeding guild structures to assess the importance of putrescible waste landfills as a source of food for different avian feeding guilds.

2. Materials and Methods

2.1 Study site

This study was conducted at the Karadiyana landfill site (6°48'44.97"-6°49'0.76"N, 79°54'4.60"-79°54'20.78"E) located in the Colombo District, Sri Lanka (Figure 1). The entire landfill is approximately 10.12ha in extent, which over the years, has replaced a natural marshland ecosystem.

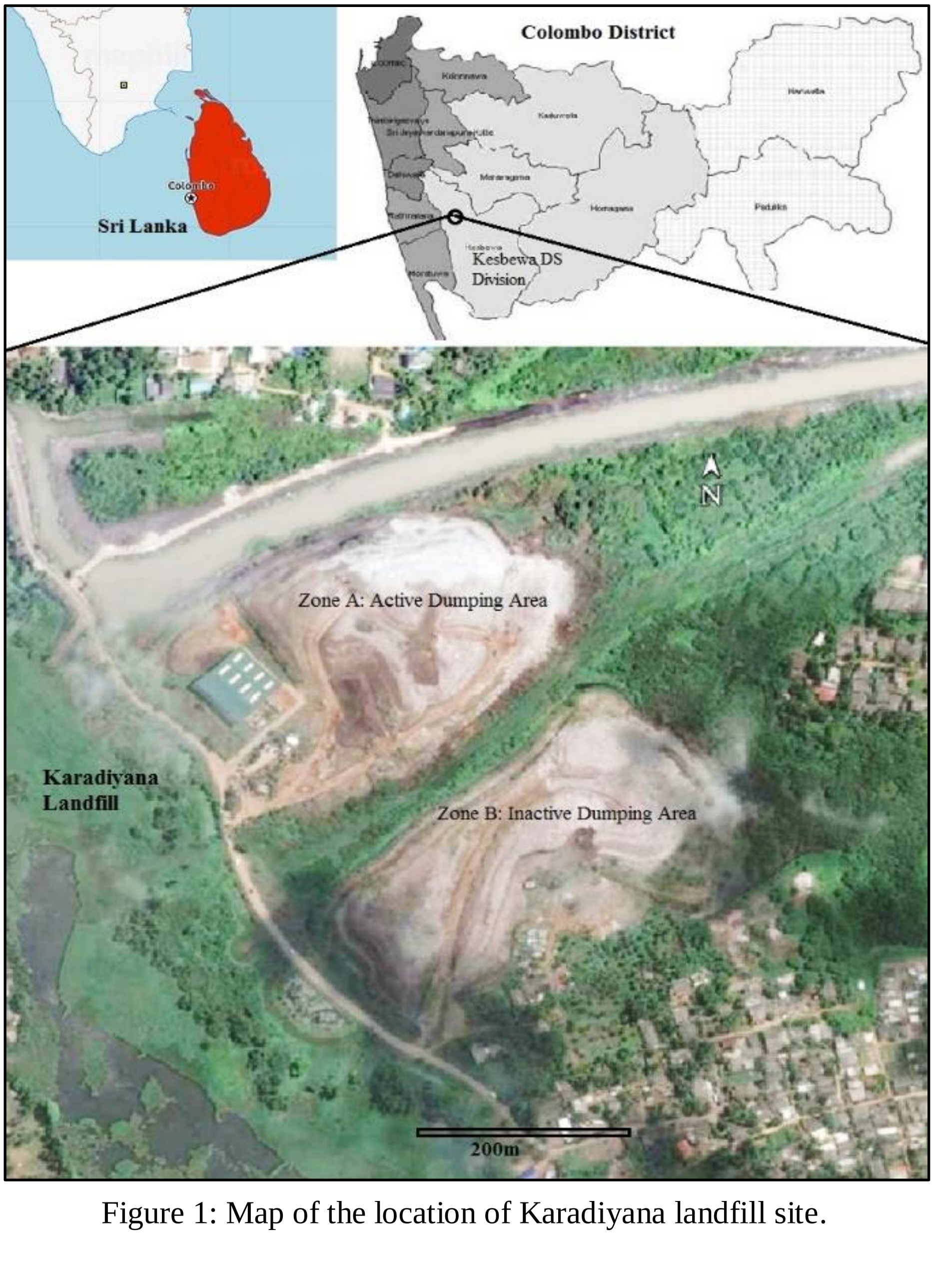

Figure 1: Map of the location of Karadiyana landfill site.

The average annual rainfall in the study area is over 2000 mm, while the temperature ranges from 27 to 31^{o} C (Punyawardena 2008). Municipal waste, domestic waste and industrial waste from seven local authorities are dumped into this landfill. Daily waste dumping activities are generally carried out from 6.30 am to 6.30 pm in a 12-hour shift. The landfill comprises of two major management zones: Zone A which is the active dumping/operating site and Zone B which is an inactive area (Figure 1). The active dumping site is approximately 4.85 ha in extent, which consists of administrative office buildings, vehicle yards, composting yard with shelter, and the active dumping area. For this study, the active dumping area was defined as the area where daily dumping activities are carried out by workers and machinery. The extent of this active dumping area is estimated to be approximately 2.27 ha. Inactive site (Zone B) is approximately 5.27 ha in extent, where operations have not been carried out for the past five years. As no fresh garbage is dumped over this area, the surface is comparatively dry. The area also encompasses marshland, with some parts of the old dumping area being colonized by a mixed vegetation of *Annonaglabra*, *Cerberamanghas,* and *Melastoma* sp.

2.2 Bird census

During the preliminary field survey, it was found that the avian community foraging in active and inactive dumping areas is different in terms of species composition and abundance of assemblages. This is owing to the heterogeneity in resource availability (food and cover) at the two sites. To capture the diversity of birds occupying the entire landfill, both active and inactive dumping sites were sampled. Block count method (Norton-Griffiths, 1978) was used to conduct the census of birds. Blocks were demarcated by locating random points in space with reference to the physical features present on the ground of the landfill. Only birds those were directly foraging on active or inactive dumping surfaces and the birds restricted to the fringes of the dump i.e. the dumpsite-wetland interface and dumpsite-built-up area interface were counted.

Data collection lasted for a period of 12 months from April 2015 to March 2016. Bird counts were conducted in each zone in 6 different time slots of the day from 0600h (dawn) to 1800h (dusk), i.e., 0600h-0800h, 0800h-1000h, 1000h-1200h, 1200h-1400 h, 1400h-1600h and 1600h-1800h, each month. About 15 minutes were spent in each study site and block count session/bird census was conducted. Different bird species inhabiting each site were identified and the number of individuals representing each bird species was recorded. A Nikon©Aculon 10x50 binocular was used to facilitate bird identification and counting as necessary. The species those were difficult to identify at the location, were photographed and identified by using published descriptions/ field guides.

The counting was conducted as quickly as possible to avoid any bias associated with multiple counting that may occur due to the movement of individuals from one area to another. Birds that move from a counted block to uncounted one (or vise-versa) were noted and the final block counts were adjusted accordingly. Two consecutive counts of birds on each block were made to improve accuracy and the average was calculated. A total of 144 counts were completed during the study period, i.e. 72 counts at both the active and inactive dumping site respectively.

Observer bias was minimised as block counts of birds was conducted by the same field observer throughout the study period. While conducting the census, vehicles used for daily waste dumping operations were used for transportation inside the landfill site to minimise additional disturbances to birds as these species were found to be habituated to the vehicles.

2.3. Data analysis

Relative Abundance of each species and each feeding guild (carnivore, omnivore, granivore and insectivore) in the two main habitat types, species richness, species diversity and evenness indices were used to explore the complexity of avifaunal community inhabiting different habitats of the dumping site. Accordingly, Shannon-Weiner diversity index (H´) (Tramer, 1969), Margalef's index of species richness (Margalef, 1958) and Pielou's evenness index (e) (Pielou, 1966) were used to describe the ecology of avifauna. Jaccard Coefficient of community similarity was used to contrast the community distinctiveness between the active dumping site and inactive dumping site (Whittaker, 1960).

For all the recorded bird species, data at individual species level were insufficient to proceed with subsequent statistical analysis to explore temporal patterns of variation in their occurrence. Hence, the detection probability of greater than 25% for a species (calculated by dividing the counts where the species was present by total number of counts) was used as the screening criterion to investigate species-level dynamics (Alwiset al., 2016). All collected data were pooled together as there was no considerable difference in bird abundance between different time slots of the day. Hypothesis testing was performed using non-parametric statistical techniques in PASW© v.18. Mann-Whitney U Test (at α=0.05 level) was used to examine whether individual species abundance differ significantly between active and inactive dumping surfaces.

3. Results

3.1. Diversity of birds at the landfill

During 144 counting sessions conducted over the period of 12-months, a total of 61,293 individual birds belong to 24 species and 15 families were recorded foraging in the landfill (Appendix 1). Avian community at the Karadiyana landfill site were dominated by Cattle egret (*Bubulcus ibis*), House crow (*Corvus splendens*), Feral pigeon (*Columba livia*) and Common myna (*Acridotheres tristis*). Cattle egret, House crow, Common myna, Feral pigeon, Red-rumped swallow (*Cecropis hyperythra*), Indian pond heron (*Ardeola grayii*), Black-headed ibis (*Thresironis melanocephalus*), Brahminy kite (*Haliastur indus*), and Black-crowned night heron (*Nycticorax nyticorax*) used both active and inactive dumping surfaces for foraging. House sparrow (*Passer domesticusindicus*), Yellow wagtail (*Motacilla thumbeigi*), Red-wattled lapwing (*Vanellus indicus*) and Paddy field pipit (*Anthus rufulus*) were recorded foraging in the inactive dumping site while Little egret (*Egretta garzetta*) and Great egret (*Casmerodius albus*) predominantly used the active dumping site as a foraging site. The highest species richness was recorded from the inactive dumping site (Table 1).

Table 1: Species richness in the two habitat types.

Habitat Type	No. of Species	Margalef's species richness
Active dumping site	11	0.674
Inactive site	14	1.430
Entire site	16	1.412

Highest Shannon- Weiner diversity index was recorded from the inactive dumping site (Table 2). Although the abundance of bird species was comparatively low in the active dumping site, this habitat accommodates a greater diversity of species. In contrast, the active dumping site was less diverse; however the density of birds was much higher. Pielou's evenness was highest in the inactive dumping site (Table 2). The active dumping area was dominated by the Cattle egret and House crow, while other species were recorded in low numbers. This resulted in low evenness at the active dumping area.

Table 2: Species diversity and evenness of two habitats.

Habitat	Species diversity (H')	Species evenness (e)
Active dumping site	1.0423	0.4291
Inactive site	1.9068	0.7225
Entire site	1.3952	0.5032

Active and inactive dumping areas represent two different resource patches for birds. Thus, the species composition and abundance are likely to differ between the two sites. Mann- Whitney U Test on abundance of bird species with a detection probability of 0.25 found that, the abundance of Cattle egret, House crow, Feral pigeon, Indian pond heron, Black-headed ibis and Brahminy kite varied significantly (p<0.05) between the active and inactive dumping surfaces (Table 3).

Table 3: Comparison of the abundance of birds between active and inactive dump surfaces.

No	Common Name	Scientific Name	Mean rank		Z	P value
			Active site	Inactive site		
1	Cattle egret	*Bubulcus ibis*	89.88	42.24	-7.157	0.000
2	House crow	*Corvussplendens*	99.40	36.54	-9.371	0.000
3	Feral pigeon	*Columba livia*	71.52	45.66	-4.066	0.000
4	Common myna	*Acridotherestristis*	64.24	59.08	-1.258	0.208
5	Red-rumped swallow	*Cecropishyperythra*	44.10	36.40	-1.430	0.153
6	Indian pond heron	*Ardeolagrayii*	68.19	50.57	-2.823	0.005
7	Black headed ibis	*Thresironismelanocephalus*	17.89	25.87	-2.134	0.033
8	Brahminy kite	*Haliasturindus*	61.93	25.13	-5.818	0.000

Statistical significance at $\alpha=0.05$ level.

3.2. Temporal changes in the abundance of dominant landfill birds

Cattle egrets were the dominant species at the active dumping site. They tend to dominate the active dumping area from November to April. However, their numbers substantially declined during the period of May to October, possibly due to migratory behaviour (Figure 2A). Their numbers in the inactive dumping area also showed a similar trend in abundance with time. In contrast, the House crow population at the active dumping area was low during the period of November to April. In the absence of Cattle egrets, the House crow population showed a substantial increase during the period of May to October (Figure 2B). Abundance of Feral pigeon and Common myna also increased in the active dumping site in the absence of Cattle egrets (Figure 2C and 2D). The abundance of Black-headed ibis markedly increased in June and July, though their actual numbers were comparatively low (Figure 2G). Red-rumped swallow, Indian pond heron and Brahminy kite populations at the landfill did not show marked fluctuations throughout the study period. (Figure 2E, 2F, and 2H).

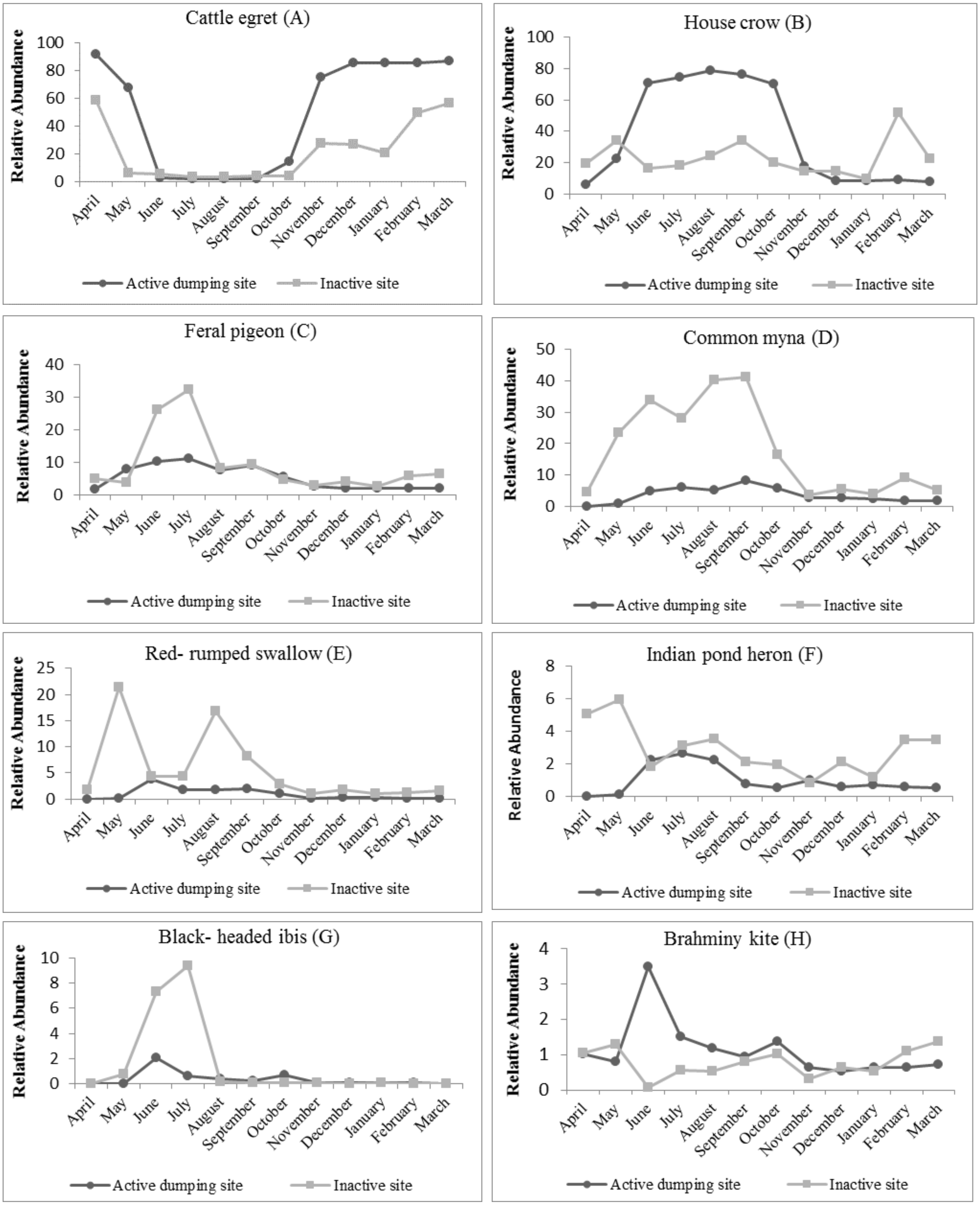

Figure 2: Monthly Relative Abundance of (A) Cattle egret, (B) House crow, (C) Feral pigeon, (D) Common myna, (E) Red- rumped swallow, (F) Indian pond heron, (G) Black- headed ibis and (H) Brahminy kite.

3.3. Feeding guild structure and composition

Bird census identified four feeding guilds at the landfill site; carnivore, omnivore, granivore and insectivore (Figure 3). The Most abundant feeding guild at the active dumping site was carnivores followed by omnivores, granivores and insectivores. The most abundant guild at the inactive site was omnivores. Carnivore feeding guild in the active dumping site was mainly represented by Cattle egret, Indian pond heron, Black-headed ibis, and Brahminy kite while the House crow and Common myna represented the omnivore feeding guild. Omnivore feeding guild at the inactive dumping site was mainly represented by the House crow and Common myna, while the Red-rumped swallow, Barn swallow and Feral pigeon comprised the insectivore feeding guild. When considered the feeding guild assemblage at the Karadiyana landfill site, carnivore was the dominant feeding guild. This was followed by feeding omnivore and insectivore feeding guilds.

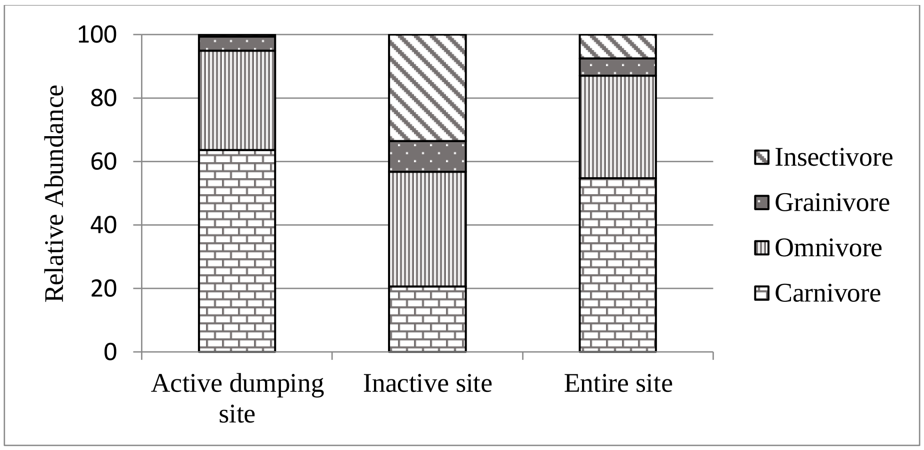

Figure 3: Relative abundance of feeding guilds in active dumping site, inactive dumping site and entire landfill.

The null hypothesis of “Abundance of birds belonging to each feeding guild does not differ between the active and inactive dumping surfaces” was statistically tested. Results revealed that the abundance of carnivore, omnivore and granivores varied significantly between the two sites. Abundance of carnivores and omnivores were significantly high at the active dumping surface.

Table 4: Mann-whitney U test analysis results of the feeding guilds

No	Feeding Guild	Mean		t	p value
		Active	Inactive		
1	Carnivore	211.36	173.62	-3.317	0.001
2	Omnivore	159.95	101.62	-6.264	0.000
3	Granivore	71.52	45.66	-4.066	0.000
4	Insectivore	44.10	36.40	-1.430	0.153

Statistical significance at α=0.05 level

4. Discussion

Karadiyana landfill is located in a marshy land and is of close proximity to the Bolgoda Lake. Hence the surrounding area naturally supports considerable bird diversity. However, the human-modified urban landfill site harbors a high abundance and low diversity of birds. During block counts, 24 bird species were recorded inside the landfill. Those species directly depended on various food resources available at the landfill. Among those, 11 species were observed at the active dumping site where the daily dumping activities were carried out, and 14 species were observed at the inactive site. By far, the three most abundant species foraging on the landfill included Cattle egret, House crow and Common myna, suggesting that these species are the major exploiters of food resources at the landfill.

4.1 Landfill resource utilization patterns by birds

Composition, quality and quantity of the garbage, level of human interferences and waste management/site operation activities were substantially different at the two habitats, thus providing unique environmental conditions and foraging opportunities to birds. The highest species richness and diversity were recorded at the inactive dumping site. The area was predominantly comprised of plastics, polythene, non-biodegradable materials and other biodegradable materials that decompose at a slower rate. Organic food items in the form of garbage were less abundant at the inactive dumping site. However, the inactive dumping surface provides ideal breeding grounds for a variety of insects, and as a result, numerous other species such as lizards, small snakes etc. could be found here. As such, the inactive dumping area allows variety of foraging opportunities for birds. This is evident from the feeding guild analysis which revealed omnivores and insectivores dominating the inactive dump site. Common myna and House crow were the dominant omnivores occupying the inactive landfill site. Apart from directly consuming food items available at the site, these omnivores also use the inactive dump site as a place with less interference to consume food items picked up from the active dump site where the disturbances from other birds and humans were more persistent. Insectivores such as the Red-rumped swallow, Paddy field pipit, and Yellow wagtail were predominantly dependent on insects available at the inactive site. Large flocks of migrant Barn swallow were also recorded foraging at the inactive dump site. Members of the carnivore feeding guild i.e. Cattle egret and Brahminy kite mainly utilised the inactive dump site for resting, although opportunistic foraging was evident. In contrast, other members of the carnivore feeding guild such as Little egret, Indian pond heron, Black-crowned night heron, Great egret, Gray heron and Purple heron seemed to be actively exploiting food resources available at the inactive dump, in the form of small vertebrates, insects and snails.

Species richness and species diversity were comparatively lower at the active dumping surface than at the inactive site. Few dominant species displaced the others from foraging on the active dumping surface. The most abundant species in the active dumping site as well as in the entire landfill, the Cattle egrets are known as cosmopolitan due to their ability to adapt to different habitats and spread over anthropogenic habitats such as lawns and landfill sites (Seedikkoya et al., 2007; Abigail et al., 2013). Reliable and abundant food availability may be the primary reason for birds such as Cattle egrets to become attracted to landfills. For instance, a recent study investigated the foraging success and efficiency of Cattle egrets in three habitat types (grassy areas, silted drain, and landfill sites) and found that the foraging efficiency is highest at the landfill sites (Abigail et al., 2013). As pray species are readily available, the birds can substantially cut-down the energy budget on foraging activities. As a consequence, the population levels can surge as more energy could be reserved for breeding (Siegfried, 1971).

In Sri Lanka, there are migrating and resident breeding populations of Cattle egrets (Henry, 1998). According to field observations, Cattle egrets were absent from June to September, which may resemble their movement pattern. Interestingly, the abundance of House crow at the active dumping site was drastically increased with the absence of Cattle egrets in the landfill. This increased abundance could be due to reduced competition. The realised niche of House crows will extend to the larger fundamental niche of open dumping site in the absence of the competitor. This change further indicates a shift in dominant feeding guild from carnivore to omnivore.

House crow of omnivore feeding guild was the second most abundant in both active and inactive dumping zones that forage on fresh garbage. House Crows are opportunistic and inventive breeders (Ryall, 2003). According to Soh et al. (2002), reproductive success of Corvids can be higher in the urban areas than in local wild lands because of their positive association with urban environments.

4.2 Landfill Site Operations and Foraging behaviours of Birds

Site vehicles working in the dump affected the foraging behavior of birds to avariable extent, and the proximity to disturbance can affect the foraging behaviour of birds (Burger and Gochfeld, 1983;

Bellebaum, 2005). However, Burger and Gochfeld (1983) observed no such correlation with regard to Cattle egrets foraging in landfills. Field observations made in this study contradict Burger and Gochfeld (1983)'s observations as unusually high densities of Cattle egrets were observed near operating vehicles. Ground disturbances that occur during the operation of site vehicles expose maggots and worms just underneath the surface, and Cattle egrets were taking a greater risk by feeding earlier and closer to site vehicles mainly to avoid intra-specific competition. This is comparable to commensalism that Cattle egrets exhibit in other environments where they tend to forage in close association with cattle, and feed on insects disturbed from the grazing and movement of cattle. The House crow and Common myna also exhibited similar foraging behaviour to a certain extent where they took advantage of newly exposed edible items from daily site operations.

Feeding guild analysis revealed feeding overlaps among bird species, creating interspecific competition (Pohajdak, 1998). Larger numbers of House crows and Brahminy kites tend to concentrate at the usual time of the day where slaughter house waste is brought-in and dumped at the site. Intense competition for the same food source takes place during this time. Species relationships such as kleptoparasitism (Bolen and Robinson, 2002) were also evident in this man-made ecosystem where Brahminy kites were observed stealing food items picked up by House crows from the dump. Vise-versa of the same scenario was also observed occasionally where two or more House crows teamed-up to snatch food from Brahminy kites. Furthermore, the physical interferences due to the presence and foraging behaviors of large number of Cattle egrets probably discourage other species to exploit food on the active dumping zone even in the absence overlapping of diet with Cattle egrets. This is supported by the observation of the House crow, Common myna, and Feral pigeon (omnivore and insectivore feeding guilds) dominating the active dumping surface during the period of June to September, in the absence of Cattle egrets.

Among the 8 species which have sufficient data, the abundance of 6 species; Cattle egret, House crow, Feral pigeon, Red-rumped swallow, Indian pond heron and Brahminy kite were significantly different between the active and inactive dumping areas. This difference is mainly due to the availability and abundance of food types as well as the degree of human induced disturbances in the two habitats. In this study, it was observed that all landfill birds occupying the active dumping zone seem to be habituated to moving vehicles and human presence. Cattle egrets and House crows seem to tolerate greater disturbances. In contrast, members in the insectivore feeding guild showed less tolerance to human disturbances, hence confined to the inactive dumping zone where no major human disturbances are present.

Cattle egrets perform an important ecological role in the environment as a scavenger and a natural pest/insect controller (Blaker, 1969; Abigail et al., 2013). They are reported to exploit Housefly (*Musca domestica*) and Blue bottle fly (*Calliphora spp*.) maggots in landfills which are vectors of the pathogens that cause diseases such as typhoid, dysentery, cholera and poliomyelitis (Seedikkoya et al., 2007; Jayaratne et al., 2015). Although Cattle egrets are considered carnivores, it predominantly depends on an insectivorous diet with occasional scavenging for edible refuse at the dump. According to Seedikkoya et al. (2007), a Cattle egret can consume up to 100-150 g maggots per day. Despite their ecological role, breeding colonies of Cattle egrets may serve as vectors of zoonotic diseases and contribute to sanitation and aviation hazards in urban areas (Baxter, 2005; Pitt and Witmer, 2007; Abigail et al., 2013). Similarly, House crow is also an important scavenger in urban landscapes, but a vector of human pathogens such as *Cholera, Salmonella, Giardia, Shigella* and *Escherichia*. With their loud calls, social behaviour and aggressiveness towards other birds, House crows are further capable of displacing other birds from urban habitats, thus reducing the avian diversity (Suliman et al., 2011; Jayathilake and Chandrasekara, 2015). Hence, there is a need to manage landfill sites to control the populations of nuisance birds attracted to landfills. A common management practice in landfills/controlled dumps is the application of daily cover, which is necessary to abate odor and prevent the attraction of rodents and birds (Talyan et al., 2008). Water fog for repelling birds is also practiced in some countries (Nachtman et al., 2000).

Owing to the inherent nature of the study design, the findings of this study may have local applicability. Past studies suggest that species composition and seasonal abundance of birds can vary considerably even among similarly operated landfills in close proximity (Belant et al., 1995), and thebird use of landfill facilities is likely to be influenced by surrounding habitats or land-use (e.g. wetland, urban cities) than by the waste itself or onsite waste management activities (Gabrey, 1997). Therefore, site-specific studies may be necessary to assess the use of landfills by birds and align on-site waste management practices to control bird populations in landfills.

5. Conclusion

The constant and abundant availability of food at landfills can attract large number of birds. The foraging bird community at Karadiyana landfill site is characterised by low species diversity and richness, but high abundance and dominance of few species, especially Cattle egret and House crow. Presence of Cattle egrets and House crows in large numbers, their foraging and social behaviours probably discourage other bird species from exploiting food resources on the working area of the landfill, even when there are no overlaps in diet among them. Despite being a man-made urban ecosystem in a highly urbanised area, the forging bird community at the landfill exhibit complex ecological relationships among its members. Favorable welfare factors at the landfill can potentially cause ecologically unstable increases in populations of few species, while posing health and safety concerns to humans. Hence findings of this study stress the importance of considering the seasonal patterns of local and regional bird populations in relation to location and management practices of landfills.

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