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The Feeding Behavior of Wild-birds on Waste Dumps: A Potential Pathogenic Threat to the Human Population in the Campus of Yaoundé University I, Centre Region, Cameroon

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Abstract
In most African countries including Cameroon, avian study, conservation and protection efforts are mainly focused on protected areas such as national parks. But, exploration and conservation of birds in urban areas particularly in waste disposal sites are neglected. Hence, the objective of this study was to assess wild-bird feeding activity on waste dumps in the campus of Yaounde University I. The research area was divided into four zones, north, south, east, and west zone. Four dumpsites were randomly selected from each zone and were visited twice a week for research data collection. On the dumps, observations were done from 7:00am – 6:00pm, and foraging activities of all the bird species observed were recorded on data sheets during the period. More so, the ecological conditions like the atmospheric changes, photo-period, weight estimate of dumps, proximity of dump to residential homes, major dump materials were recorded simultaneously. The study revealed a significance on bird species and dumpsite location X^2 = 14.485 df=9, P<0.05. Grey-headed sparrow (*Passer griseus*) 48% was the most abundant bird species on the dumpsites compared to village weaver (*Ploceus cucullatus*) 32%, little weaver-bird (*Ploceus luteolus*) 16%, and pied crow 4% respectively. The feeding rate of the birds showed a significance on atmospheric conditions X^2 = 82.674 df=4, P=0.000. Amongst these three activities rates, normal 41% was the most recorded compared to low 38%, and high 21% respectively. The cloudy atmospheric condition 3% almost halted feeding activity of the birds at the dumpsites compared to windy 72%, and sunny 25% respectively. Moreover, a significance was revealed by dump-weight and feeding rate X^2 =22.617 df=4, P=0.000. Though all the dumpsites received feeding and foraging activity of birds, 1-tonne dumps had the highest waste materials 45% while 2-tonne, and 3-tonne dumps had the least 31% and 24% respectively. Dump proximity to buildings and feeding rate were also significant X^2 = 27.640 df=6, P=0.000. Additionally, a significance was recorded between day-period and feeding rate X^2 = 83.271 df=4, P=0.000. This study observed high feeding and foraging rate during the morning period of the day 40% compared to afternoon and evening with 26% and 34% respectively. Solid dumps are rich in rodents, birds, reptiles, insects, domestic animals like cats, dogs, and pigs. These animals very much depend on these dump-subsidized-food source for their livelihood. Unfortunately, they could vector diseases like malaria, typhoid, and cholera, amongst many others into the human society. Though, waste management is given a little attention in the country, inability for waste segregation at dumpsites, together with cycling gaps has rather fuelled health problems to some people living some school campuses and cities. More waste management budget and training is needed if human-health improvement is expected in the country

Keywords: University, Waste materials, Bird species, Dump location, Ecological conditions
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INTRODUCTION

Food availability from rubbish dumps enhances population abundance, especially in birds but also in mammals and reptiles (Newsome et al., 2015). Many studies on different bird species as rooks (Olea and Baglione, 2008), turkey vultures (*Cathartes aura*) (Torres-Mura et al., 2015) and house crow (*Corvus splendens*) (Saiyad et al., 2015) show population increases when using organic waste as food resource. In the case of rooks, the population increase can be up to 3.7 times compared to birds not using waste (Olea and Baglione, 2008). Also, studies in gulls show that this kind of food is related to colonies expansion in different parts of the world (Duhem et al., 2008). However, some studies suggest that the importance of dumpsites may have been exaggerated because the presence of gulls not always implies foraging behaviour and the population growth could be due to other coexisting factors (Coulson, 2015).

Food resources from dumps are an important factor influencing animal movement (Tennent and Downs, 2008). Interestingly, this kind of food subsidies could cause changes in white stork migration patterns (Tortosa et al., 2002), and have facilitated the establishment of resident populations in Europe (Rotics et al., 2017, Gilbert

et al., 2016). In black vultures (*Coragyps atratus*) these sites determine their roost selection since close food resources reduce energetic cost of movement (Novaes and Cintra, 2013). Similarly, rubbish dumps are more used by bald eagles from closest communal roosts (Turrin et al., 2015). Crows and ravens have smaller home ranges near human settlement where they exploit organic waste (Marzluff and Neatherlin, 2006). Similarly island foxes, have smaller home ranges in urban landscapes than in rural populations due to food availability, especially refuse containers (Gould and Andelt, 2013). Also, the home range of refuse feeders banded mongooses is more concentrated than that of no refuse feeders groups (Gilchrist and Otali, 2002), and spotted hyenas and red foxes increased their home range after a change in waste availability (Bino et al., 2010). In reptiles as the desert monitor (Varanus griseus) the home range is affected by the presence of Tel Aviv municipal dump (Stanner and Mendelssohn, 1987). Therefore, these food subsidies alter vertebrate space use, particularly reducing their home ranges but also modifying migration behaviour. This change in the movement patterns can have different ecological consequences, like changes in pathogen distribution that those species carry (Mc Kay and Hoye, 2016).

The role of wild birds as disseminators of antibiotic-resistant bacteria between distant ecosystems is difficult to estimate (Báez et al., 2015; and Ahlstrom et al., 2019). White storks (Ciconia ciconia), like many other free-living migratory birds, can become long-distance vectors of CR E. coli. They feed nearby pastures and plowed fields, marshy wetlands, rice fields, and more recently on solid human waste disposal sites, and display long-distance movement patterns within and between continents (Bécares et al., 2019). Due to their mobility and contact with fecal contamination in pastures and surface waters, they may effectively acquire and spread disease and antimicrobial-resistant bacteria (Szczepanska et al., 2015) and become a potential source of CR E. coli for humans and farm animals (Keller et al., 2011). White storks may breed in open farmland with access to marshy wetlands but also, very often, they cohabit with humans, making use of man-made facilities such as roofs of buildings, telephone or electric power line poles, or other constructions for their nests. If such individuals acquire CR *E. coli* during feeding, they can act as potential reservoirs of resistant bacteria (Liakopoulos et al., 2016a, b).

There have been several studies reporting detection of *E. coli* in wild birds (Báez et al., 2015) and Alcalá et al. (2016) described for the first time the presence of *E. coli* in a white stork in Spain. However, to our knowledge this is the first study to analyze carriage of CR *E. coli* in white storks, in detail, in a large number of colonies subjected to different degrees of anthropic pressure with the aim of determining the epidemiology of CR *E. coli* in this species and their role as potential spreaders of CR *E. coli.*

The assessment of wild-bird feeding in the campus of Yaoundé University I was the major focus of this study. Organic waste-dumps in many cities in the world is facing a lot of challenges at the level of management. In the developed world the treatment waste materials start from the segregation of waste fragments at the road dumpsites before transported to cycling areas or landfills. However, the situation in some countries in the developing world is different, no waste segregation, poor waste management facilities at landfills, personnel training and salaries are among the problems affecting the waste management companies. Hence, the waste management disorder could result to illnesses, such as malaria, typhoid, cholera and many others vectored into the human society.

MATERIALS AND METHODS

Description of the study area

Yaoundé University I is one of the two state universities located in the capital city of Yaoundé, situated between latitude 3°7'and 3°9' N and longitude 11°4'and 11°6' E (Edmonds, 2015). With an estimated student population of about 40,000, the university is one of the best in Cameroon (fig.1). However, Yaoundé city covers over 256km^2 and experiences a typical equatorial climate, with abundant rainfall (1600mm/year) and an average temperature of 23^{0}C, it has two seasons, the rainy and dry seasons respectively (Edmonds, 2015). The hug human population in the city has made the university to have the highest student and staff population as compared to other universities in the country.

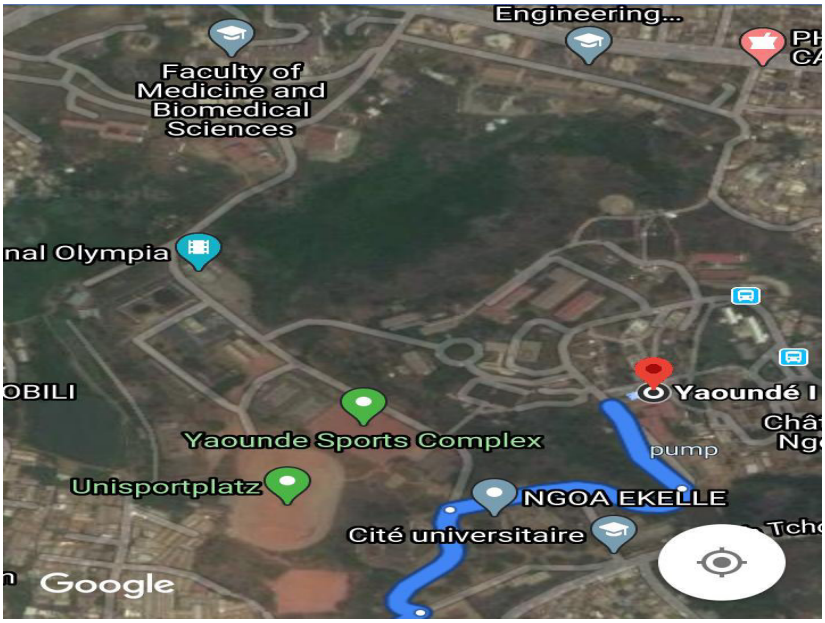

Fig.1: Map of Yaoundé I (Edmonds, 2015)

Methods of Data Collection

The field research started with a pilot study to test the methods to be used in the process. The exercise witnessed adjustment of some variables on the check-sheets not feasible in the field. Hence, the data collection program started in the month of March and ended in July. The research area was divided into four zones, north, south, east, and west. Research data were collected using point count techniques by selecting appropriate locations/observation points to in order to maximize the chances of observation following the method of Sidra et al.(2013). Four dumpsites were randomly selected from each zone and were visited twice a week for research data collection. At the dumps, observations were done from 7:00am – 6:00pm, and the activities of all the bird species observed on waste dumps were recorded during this period. Moreover, the ecological conditions like weather changes, photo-period, weight estimate of dumps, proximity of dump to residential homes, major dump materials were recorded simultaneously.

Research Data Analysis

The data was analyzed by using chi-square (X^2) and correlation (r) statistical models. The inferential and exploratory statistics helped to examine the variables against each other, and to understand their degree of association. The bird species and their activities were examined on dump weight, dump proximity to human residence, and the atmospheric changes.

RESULTS

This study showed a significance on bird species and dumps location $X^2 = 14.485$ df=9, $P<0.05$ (fig. 2). Yaounde University I is located at the heart of the city of Yaoundé, the capital of Cameroon, with a hug population, the university faces solid-waste-management challenges within and around the campus. The study made use of four dumpsite areas, north 32%, south 32%, west 20%, and east 16% respectively (fig.3). All the four locations had a high concentration of students' activity especially during the morning and mid-day periods of the working-week days. The hug dump concentration in the northern and southern areas of the campus might have been caused by human activities expected to be higher in the two locations compared to others. Grey-headed sparrow (*Passer griseus*) 48% was the most abundant bird species on the dumpsite compared to village weaver (*Ploceus cucullatus*) 32%, little weaver 16%, and pied crow 4% respectively (fig.4). Grey-headed sparrow has a hug population density in Cameroon, may be because its neither hunted nor nor a serious crop-pest. However, the inability to control the population of some of the city wild-birds has made them to be a nuisance to human residence, offices, streets, and dumpsites which attract their greatest population. The population of village weaver-bird (*Ploceus luteolus*) is also high in the campus because of the presence of oil palm, a source of nesting for nest-building.

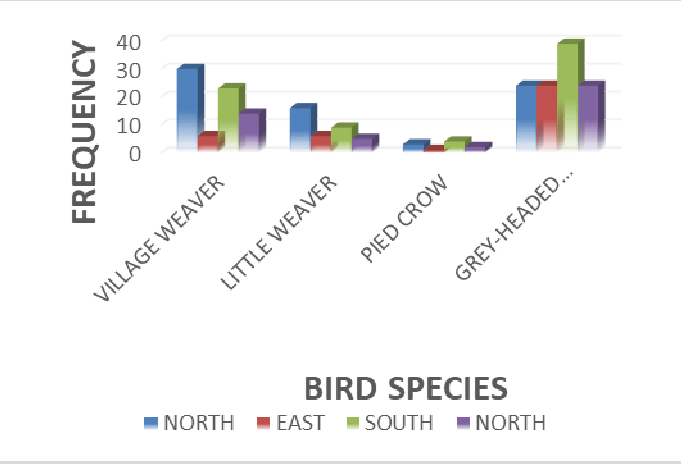

Fig.2: Bird species and waste dump location

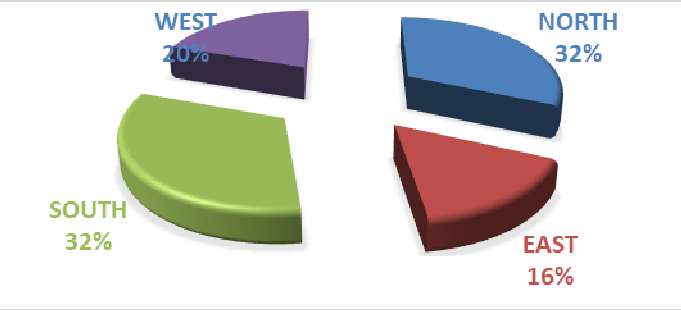

Fig.3: Waste dump location

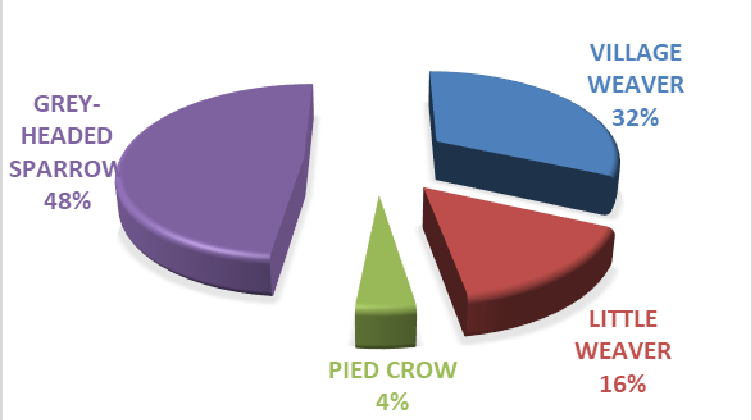

Fig.4: Bird species

The feeding rate of the birds on waste dumps showed a significance on atmospheric conditions $X^2 = 82.674$ df=4, P=0.000 (fig.5). Wildlife activity has often been influenced both positively and negatively by atmospheric conditions. Feeding has often been halted by heavy rainfall while the bright weather condition increases it. The study considered three bird-feeding rates on waste dumps, high, low, and normal. Amongst these three activities rates, normal 41% was the most recorded compared to low 38%, and high 21% respectively (fig.5). The cloudy atmospheric condition 3% almost halted the feeding activity of the birds at the dumpsites compared to windy 72%, and sunny 25% respectively (fig.6). A sunny atmosphere has been favorable to the feeding-activity increase in wildlife, however, waste-dumps feeding and in the campus of this university has shown the contrary.

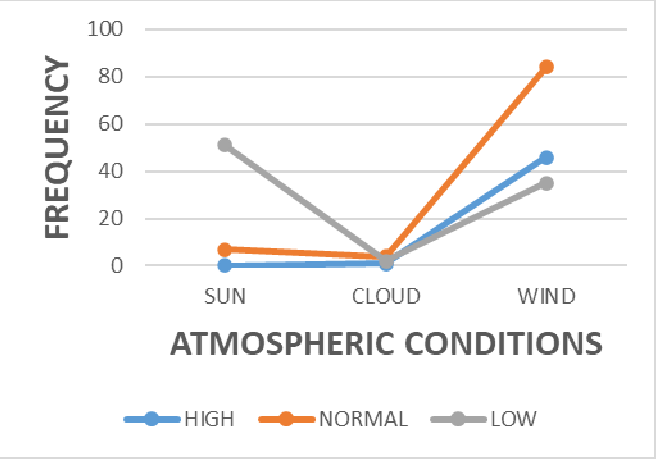

Fig.5: Feeding rate of the birds and meteorology

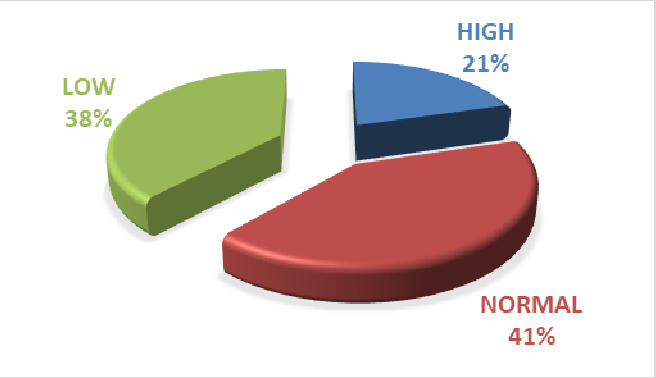

Fig.6: Bird feeding activity

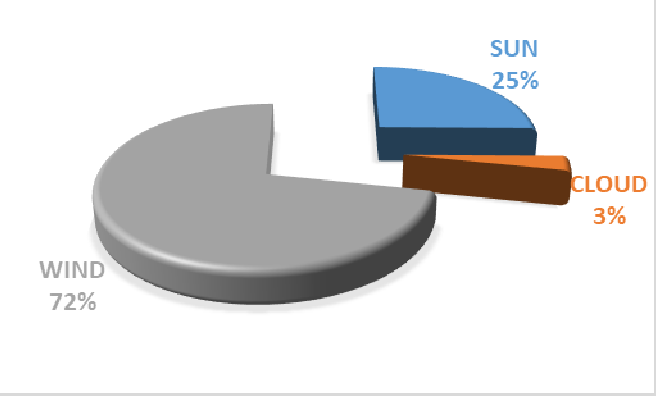

Fig.7: Atmospheric conditions

Bird species and dump-materials witnessed a significance $X^2 = 13.321$ df=9, $P<0.05$ (fig.8). Among the waste dump-materials, food fragments recorded highest frequency 90% compared to papers 7%, plastics 2%, and cloths 1% respectively (fig.9). The university hygiene management division must have adopted the policy of incinerating waste materials at dumpsites, papers, plastics, and cloths to prevent windblown waste materials from littering the campus compared to other campuses in the country. Unfortunately, solid waste like food fragments from campus restaurants and hostels cannot be incinerated easily, hence, dominates in dumpsites. Nevertheless, the inability to incinerate some food fragments on dumpsites favors the feeding ecology of birds and increasing their population in the campus.

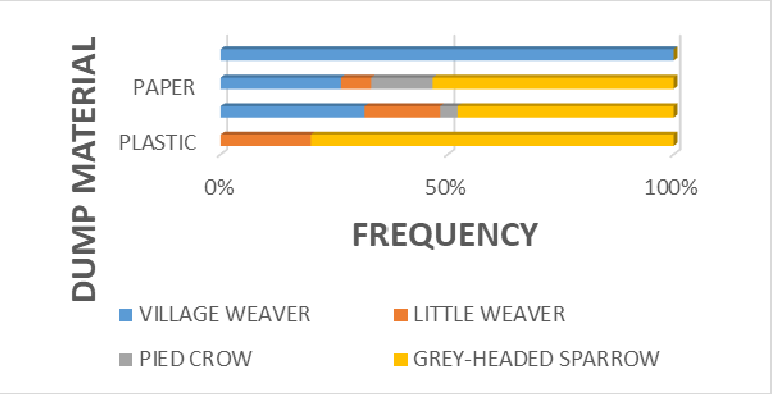

Fig.8: Dump material and bird species

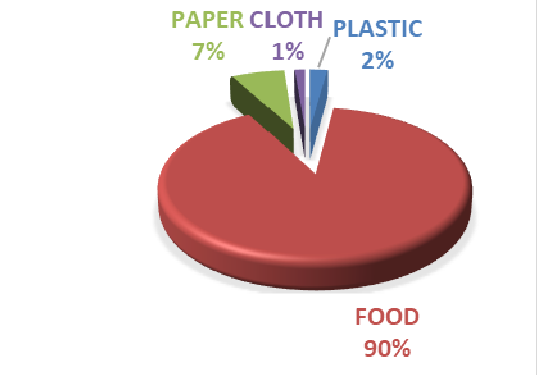

Fig.9: Dump materials

A significance was revealed by dump-weight and feeding rate X^2 =22.617 df=4, P=0.000 (fig.10). Though all the dumpsites received the feeding activity of birds, 1-tonne dumps had the highest waste materials concentration 45%, while 2-tonne, and 3-tonne waste dumps had the least materials 31% and 24% respectively (fig.11). Waste dumps with low weight estimate received fresh waste materials more than the larger older ones with less fresh food fragments.

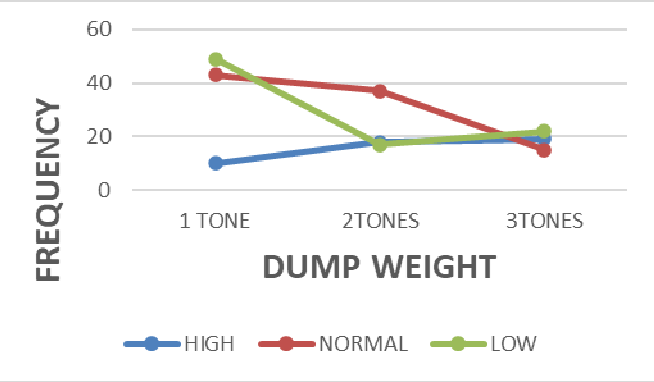

Fig 10: Dump-weight and feeding rate

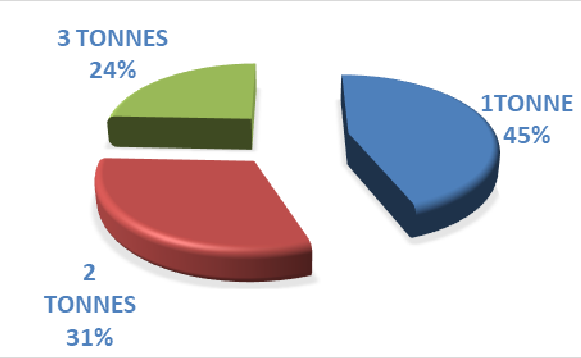

Fig.11: Dump-weight

Dump proximity to buildings and feeding rate were also significant $X^2 = 27.640$ df=6, P=0.000 (fig.12). Human social activity in the campus affected the feeding activity of birds, since they were observed giving attention concentration to people passing closer to the dumpsites. Humans hunt some bird species for consumption, hence, spotting them at close range could easily trigger their killing. Occasionally, even the species such as Grey-headed sparrow that people do not eat in Cameroon could be stone-killed for unclear reasons. 5-meter-range dumps (36%) had the highest proximity to buildings compared to 10-meter range (26%), 20-meter range (20%), and 15-meter range (18%) respectively (fig.13).

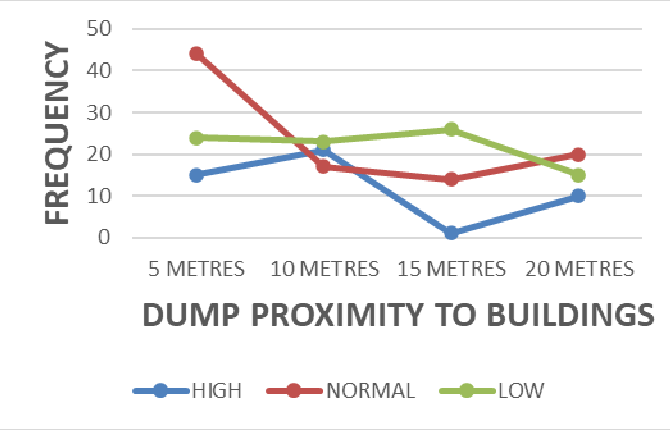

Fig.12: Dump proximity to buildings and bird-feeding rate

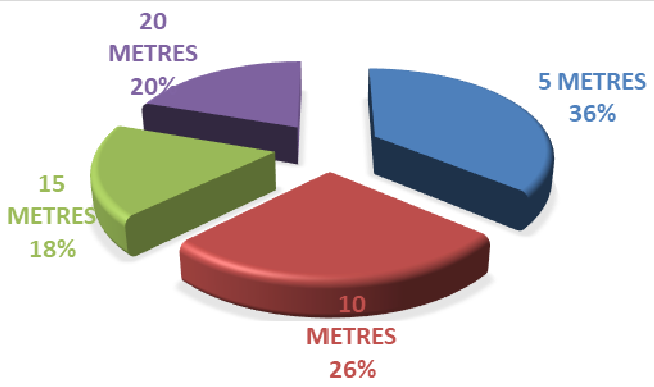

Fig.13: Dump proximity to buildings

Additionally, a significance was recorded between day-period and feeding rate $X^2 = 83.271$ df=4, P=0.000 (fig.14). This study observed high feeding rate during the morning period of the day 40% compared to afternoon and evening with 26% and 34% respectively (fig.15). Most studies have recorded wildlife feeding activity rate with this trend. The morning period increases diurnal wildlife feeding while the afternoon period receives a slowdown of feeding activity because the animals are believed to be less hungry during this period, while the evening period receives a gradual feeding activity increase to prepare themselves for the night-sleep.

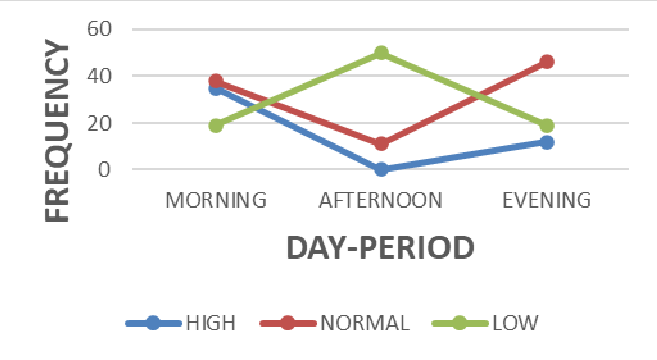

Fig.14: Feeding rate and day-period

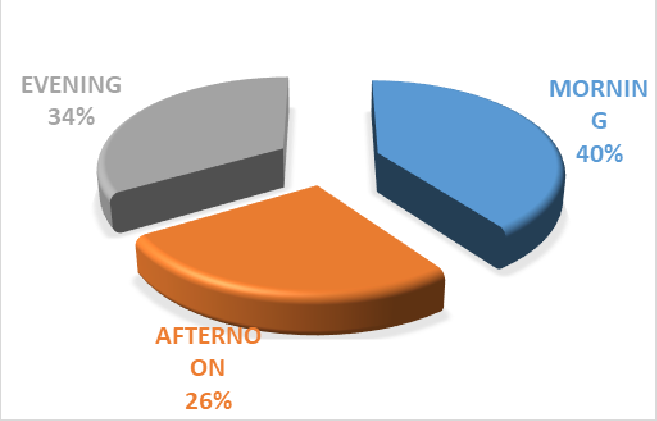

Fig. 15: Day-period

A significance was equally expressed on dump proximity and dump-weight $X^2 = 272.878$ df=6, P=0.000 (fig.16). The dump-weight of 1 tonne (45%) were closest to the building compared 2 tonnes (31%), and 3 tonnes (24%) respectively (fig.17). Solid waste disposal in many communities in the country has a traditional trend of been done closer to buildings, especially during the rainy season when most people would not like to cover a distance to dispose their waste because of rain. This behavior facilitates dump accumulation closer to human residence. Hence, the reckless waste disposal method has often made waste to get into surface drainage systems causing flooded roads and cities.

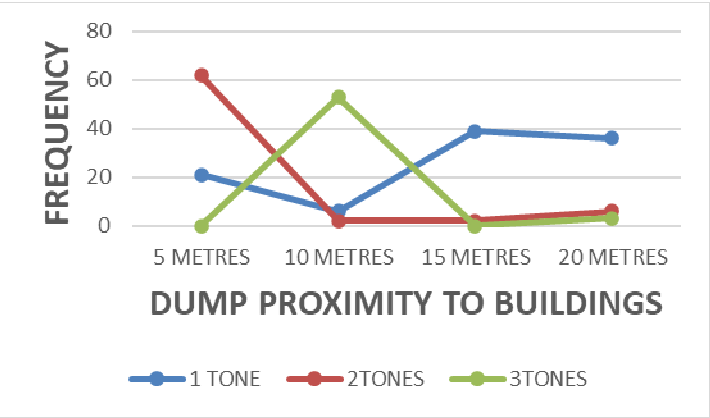

Fig.16: Dump proximity and dump-weight

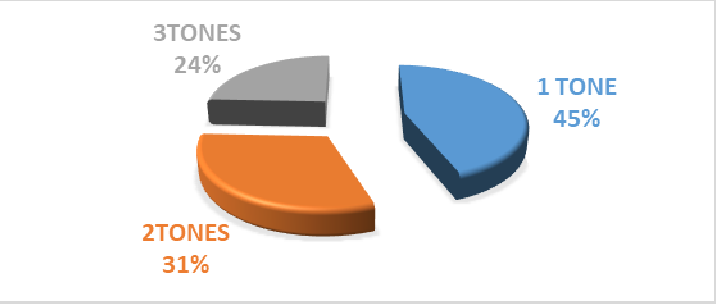

Fig.17: Dump-weight

DISCUSSION

Rubbish dumps can sustain populations of suboptimal individuals using this food resource to survive (Genovart et al., 2010). These suboptimal individuals can introduce undesirable characters to the entire population (Parvinen, 2005), as malformations or low pathogen resistance, which may affect the population fitness, and disease transmission in the entire ecosystem. Moreover, the alterations in the movement patterns produced by these food subsidies can generate expansion of different species to new territories, modifying species interactions, diseases spread and consequently ecosystem functioning (Chapin Iii et al., 2000). For instance, the increment of gulls populations due to organic waste use may produce the contamination of surface waters through faecal pollution in places far from dumps (Converse et al., 2012) affecting ecosystem health (Rapport et al., 1998).

Despite the fact that the different kind of waste disposal sites do not produce the same availability of organic waste, and that some agencies in Europe are trying to reduce availability of this kind of food subsidies, waste production is an acute problem which will worsen in the coming years (Hoornweg et al., 2013). Therefore, large impacts can be expected for the near future associated with the important increase in waste production (Hoornweg et al., 2013). It is necessary to focus on studying these impacts to adequately establish conservation and waste management practices.

Therefore, it is important to highlight some consequences produced by this kind of food subsidies. First, the enhancement of body condition, the improvement of reproductive performance, the increment of population abundances and survival rates can be responsible for populations' growth of the species that exploit rubbish dumps. As a result of this, severe consequences in species and populations that do not use these sites may occur due to inter specific competition and depredation. Secondly, the high risk of poisoning, foreign bodies ingestion and pathogen infection may make these places ecological traps (Battin, 2004), with negative consequences for several species using them. Thirdly, rubbish dumps could be a source of emerging pathogens transmitted from the species that use these sites to other species that do not, and even to humans (Dobson and Foufopoulos, 2001). Moreover, they can be transferred to other geographical sites by ecological processes as migrations. Fourthly, rubbish dumps might behave as invasion centers favoring the invasion process of exotic species, a subject that merits special attention. Finally, changes in space use produced by these sites can be responsible for conflicts with humans like disease transmission, attacks or aircraft collision risk, which produce important damages and economic costs.

Some studies have demonstrated the presence of biologically active antibiotic residues in animal and human waste, such as sewage and manure (Cycoń et al., 2019; Menz et al., 2019). In the case of wild birds, most of the studies have associated the influence of human activities such as farming, presence of dumpsites, or even tourism with the detection of antibiotic resistant bacteria (Ahlstrom et al., 2019). In addition, several reports have suggested the importance of wildlife in the dissemination of CR *E. coli* (Báez et al., 2015). Since wild birds in their natural environment are not treated with antibiotics (Santos et al., 2013), they are potential sentinels of multidrug resistant bacteria discharged into the environment.

In rubbish dumps threatened species, particularly scavenger birds, can find an alternative and predictable food resource to sustain their populations. For instance, an endangered species as the Egyptian vulture takes advantage of food discards (waste and carcasses) provided by humans in Socotra, Yemen (Gangoso et al., 2013). In fact, there is a novel mutualism where people provide food resources, which facilitate the maintenance of the population of this species, whereas vultures provide a regulating service by cleaning up carrion. Interestingly, the densest population known for this endangered vulture is reached in this geographic location (Gangoso et al., 2013). Other critically endangered species, the hooded vulture and the endangered crowed crane use these food subsidies in Africa (Annorbah and Holbech, 2012, Pomeroy, 1975). The critically endangered California condor, the threatened Andean condor, the vulnerable Malayan sun bear and the vulnerable polar bear regularly use rubbish dumps as a food resource (Finkelstein et al., 2015, Pavez, 2014). It is clear that some species of conservation concerns use and may depend on this kind of food subsidies. However, it is crucial to know both the positive and negative effect of rubbish dumps on the population health of those species.

CONCLUSION

The poor waste management strategy laid down by the campus hygiene authorities of University of Yaoundé I might have favored bird population increase at the expense of human health problems. However, paper, plastic, and cloth fragments were waste materials most incinerated at the dumpsites while food fragments were the most abundant at the sites because of their resistant incineration ability. Waste dumps are rich in rodents, birds, reptiles, insects, domestic animals like cats, dogs, and pigs, that very much dependent on the dump-subsidized food for their suivival. This is one of the major causes of human-wildlife conflict since some of these animals and insects would vector diseases like malaria, typhoid, and cholera, amongst many others into the human society. Though, waste management is given a little attention in the country, inability for waste segregation at dumpsites, together with cycling gaps might fuelled health problems in campuses and cities. Moreover, waste-management-budget increase and training of personnel may needed if human-health improvement is expected in the country.

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