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Street dogs opt for proteins over carbs: An experimental inference from streets of Kathmandu

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Abstract: Proper management of street dogs demands knowledge on their multiple aspects including population, behavior and food preferences. This study was conducted in Kirtipur Municipality, Kathmandu aiming to estimate the population of street dogs and explore their foraging behavior and food preferences. Street dogs were surveyed along unidirectional route and population estimation was done by photographic mark-capture-recapture method using the Program MARK. Food preference by street dogs were tested by one-time-multi-option choice test. The total population of street dogs in the study area was estimated to be 342 (95% CI 316–376), males 227 (95% CI 206–256), females 93 (95% CI 87–106) and spayed female to be 29 (95% CI 27–34). The population density was 855 dogs per km2 with the female to male sex ratio of 1:2.45. Mostly (73%) of dogs got food from humans by begging, they were scavenging and searching less (27%). Dogs showed a clear preference of protein at their first choice during carbohydrate vs protein test and real food experiment ($p < 0.05$). There was a significant rejection of carbohydrates over proteins ($p < 0.0001$). These findings could be useful in management of street dogs in areas of their high density.

Key Words: Mark-capture-recapture; Monochromatic dogs, Population density; One-time-multi-option choice test; Spaying

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Introduction

Since the dawn of human civilization, dogs have been the human's best friend and kept as pets and they are being studied closely on their history, social behavior, and their ecology (Majumder et al., 2014). Though the most percentage of the dogs are domesticated there is still a larger percentage of the dogs that roam on the streets (Massei & Miller, 2013), that form a specific group of the population that is known as stray, free-roaming or street dogs (Belo et al., 2015). Street dogs may be usually mixed breed of abandoned feral dogs, but some might be pure breeds (Miklósi, 2014).

Dogs can survive and habituate a broad range of habitats, from rural villages to highly dense metropolitan cities throughout the globe (Li, 2019). Street dogs live by scavenging, begging for food and with occasional hunting (Vanak & Gompper, 2009; Dominguez-Rodrigo & Pickering, 2017). Most of the street dogs are disowned pets which have become old, diseased, with aggressive behavior or the future offspring of these animals. Street dogs are reservoirs and vectors of various infectious pathogens and they pose a major threat on the health and wellbeing of the humans and livestock (Bögel et al., 1990). Around 100 zoonotic diseases can be transmitted from dogs to humans (Acharya & Dhakal, 2015) but, the major health problem that arises from stray dogs are rabies-related, especially in the south and south-eastern Asia (Gupta & Gupta 2019; Pantha et al., 2020). Ninety-five percent of total cases of rabies occur in Asia and Africa; among them 99% are dog mediated (WHO, 2021). Since 2003 South Asian Association for Regional Cooperation (SAARC) has also identified rabies as a major health problem of south Asian countries. More than 90% reported cases of rabies in Nepal are due to dogs and due to under reporting the actual cases could be even higher (Pantha et al., 2020).

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For the proper management of street dogs, it is must to know their current population, health condition, roaming habitats, foraging behavior and food preferences. Street dogs usually scavenge for food (Majumder et al., 2014; Acharya & Dhakal, 2015; Bhadra et al., 2016; Li, 2019) while pet and domesticated dogs are fed by humans. Stray dogs live in a highly competitive environment (Das, 2012). Hence, to adapt to any human-dominated habitats, it is crucial for scavenging street dogs to utilize a broad range of food resources (Bhadra et al., 2016). Animal protein is most liked by dogs, but due to high competition and a lesser amount of available food, scavenging street dogs utilize any kind of food (Bhadra & Bhadra 2014; Bhadra et al., 2016). Since the preference for meat on the dog is not innate (Bhadra et al., 2016), street dogs need to be generalists to survive. So, there might be no difference in preference over food by street dogs in resource limited areas with higher density population.

Estimation of population size has been used for dogs monitoring, conservation, controlling, finding abundance and design programs for vaccination campaign (Manning et al., 2010). Various methods have been implemented to estimate the population of the street dogs involving total count method, distance sampling, household survey and mark-recapture method (Punjabi et al., 2012; Belo et al., 2015). Photographs of dogs in larger number and various position have higher sensitivity and specificity where there is no need for physical contact with the animal (Skrzypczak, 2010), thus reducing the risk of dog bites or disease exposure.

Kathmandu, the capital city of Nepal is densely populated and holds a large population of unmanaged street dogs. Limited data is available regarding the street dogs population in major cities of Nepal including Kathmandu (Kakati, 2012). Street dogs of Kirtipur Municipality, Kathmandu were spayed on 2018 AD, however, relative proportion of such spayed dogs in the current population is not known. Dogs have been reported to prefer animal protein over other foods, however, street dogs in resource limited areas and under high population density are rarely studied. Such untrained street dogs could have different behavior than the trained ones (Giannone & Zilocchi, 2019). Hence, this study surveyed the street dogs of Kirtipur Municipality, Kathmandu (inside ring road) to know their population and foraging behavior. Additionally, the street dogs were experimented on their food preference behavior by using a one-time multi-option test (Bhadra & Bhadra, 2014; Bhadra et al., 2016). This study will build a base for managing the street dogs with long term vision to make their harmony with humans.

Materials and methods

Study area

Kirtipur municipality lies on the southern part of the Kathmandu valley at 1343 meters above sea level (Fig. 1). According to the census of 2011, Kirtipur municipality has a population of 67,171 and population density is 4550.88 persons/km^2. Household density is 1318.69 per km^2. The average annual temperature and rainfall of Kirtipur are 17.7°C and 1479 mm, respectively (Climate-Data.org, 2020). The study area comprised the Kirtipur ring road area situated in Kirtipur municipality. It covers the area of 0.4 km^2 that include various historical sites, some vegetation and urban housing. The northern part has human-influenced vegetation with no building structure, the eastern side is less dense compared to the southern region with religious sites. The central region consists of traditional Newari culture housings and buildings with a narrow pathway which provides a good roaming and gathering site for street dogs. The southern region is mostly populated and consists of modern buildings.

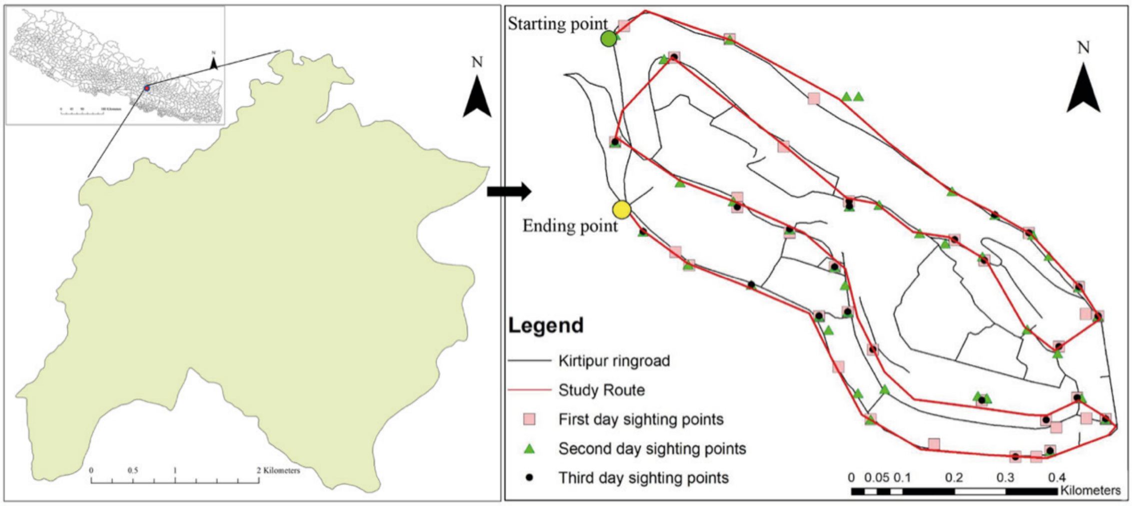

Figure 1. Map of Kirtipur Municipality, Kathmandu showing the survey route for population estimation of street dogs.

Population estimation and foraging behavior of dogs

The entire fieldwork was done from during the August 2020 for two weeks. An initial pilot survey was performed to find the possible routes for a survey. By looking at the satellite image and the field data the single line survey route of length about 5 km was prepared (Fig. 1). Starting and ending point for the route was pointed and the survey was performed in the morning from 7.00 AM to 12.00 noon. The photographic mark-capture-recapture method was applied for population estimation. Three observers moved on foot through the route collecting details of sighted dogs. The observers made indirect approach by moving towards the dog with a semicircular trajectory, avoiding eye contact (Ricci & Carlone, 2016), until reaching observable distance. One took the photographs, second noted the GPS location and the third noted down the sex, identification characters and sterilization status. If a dog was encountered feeding, the type of food, and behavior of feeding (whether it is scavenging, soliciting, begging, hunting) was noted. If dogs were encountered feeding in pair, triad, or group, numbers of males and females were noted.

The three-sample method was used to estimate the size of the dog's population. It involves one session of marking (photograph) and double re-sighting session. High quality photos of the dogs were taken and their image number and identifying characters were noted. For marking the dogs their body size, body coloration, spot, ears, tail, facial uniqueness were taken into consideration and for the monochromatic dogs, multiple photos were taken to identify other special characters that help them in distinguishing from other similar looking dogs (Fig. 2). To minimize the misidentification of the dogs they were given a separate identification number and multiple angle photos were taken. Since the street dogs had a smaller home range and had high territoriality behavior, most of the dogs were identified by the area of points where they were previously marked. As the study was for a shorter duration of time the population was assumed to be closed. The survey route was covered in an only unidirectional way to avoid recounting. To reduce the dogs re-encounter along the route, the gap of 60 m or more was designed for survey path between two lines of survey route.

Figure 2. Identification of street dogs for mark-capture-recapture analysis. A- Dog with a distinctive natural marker; B- Dog characterized by body condition; C- Monochromatic dog identification with a unique scar on the nose; and D- Monochromatic female spayed dog with identified ear notch.

After the collection of the photos, the similar dog's image was named with the same number and for the second and third re-sighting the images were compared thoroughly and the data was prepared for each dog for three sightings. The total length of the study route transect was 5 km and the meantime for conducting the study was 5 hours 7 AM to 12.00 noon as suggested by (Belsare & Gompper, 2013) where the detectability was higher and due to good lighting it favored good quality of the photos. Dogs that were inside the house and with recent collar were not taken into the data and the ownership of the dogs was also confirmed with the interview of people near the dogs sighting.

Food preference test

Two sets of experiments were carried out to test the food preference of street dogs from 8th August to 11th August 2020. The general model of one time multi-option choice test was done (Bhadra et al., 2016). A single dog encountered while walking along the street was offered three different foods (A= Meat, B = Lentils + Rice, and C = Biscuits) for real food experiment and four different foods (F1-Dry bread, F2- Bread + Water, F3- Bread soaked in meat soup, and F4- a piece of meat) for carbohydrate versus protein test. The food options were placed randomly on white cardboard at an equal distance. A dog was chosen only for an experiment to avoid learning by dogs to choose a preferred one. If dogs were found in groups, a single dog was lured in and experimented with. If any other dog invaded and disturbed during an experiment, the experiment was aborted. During the test, the order of eating food and sniffing was noted. If a dog sniffed food at first and ate, that was referred to as sniffing and if a dog did not sniff over food and ate as soon as possible it was referred to as non-sniffing.

Data processing and analysis

The three-day raw data of mark-capture-recapture and foraging behavior was recorded and sorted in the excel sheet. The population analysis was performed in Program MARK, using closed captured data type estimator where (Belsare & Gompper, 2013) it assumes the population is closed and no births, death or migration occurred during the survey period, all individuals had an equal probability of being photographed, marked individuals did not lose their marks during the survey. Chi-square one-way goodness of fit test was done to know if there was a significant difference between the choices made at first. A two-way Fischer exact test was done to know if there is a difference between the choices over food options.

Results

Population of the street dogs

A total of 233 dogs were identified in the study period that included 151 males and 82 females. Out of 233 dogs that were photographed and marked 35 (21 males and 13 females) were sighted on three occasions, 75 (45 males and 20 females) were sighted on two occasions and 123 (85 males and 38 females) on a single occasion.

Table 1. Observed and estimated street dog population inside Kirtipur ring-road

Population	Observation	Male	Female	Spayed female
Observed	Mark	79	50	15
	Capture	79 (38 new)	47 (23 new)	19 (10 new)
	Recapture	80 (34 new)	43 (9 new)	16 (2 new)
	Observed subtotal	151 males	82 females	27 spayed females
	Total observed = 233			
Estimated	Population size	227 (206 – 256)	93 (87 – 106)	29 (27 – 34)
(CI 95%)	Total estimated = 342 (316 – 376)			

Program CAPTURE indicated M_h model as the most appropriate model, jackknife as the suggested estimator for total population estimation of street dogs as well as for male dogs. For female population estimation, the program suggested M_o model and the suggested estimator was null. The estimated population of street dogs in Kirtipur was 342 (95% CI 316–376), with the standard error of 15.3487 and an estimated probability of capture, p-hat = 0.3684. The male population was estimated to be 227 (95% CI 206–256), with standard error 12.7965 and a probability of capture 0.3495. Female estimated population was 93 (95% CI 87–106) with standard error 4.7999, probability of capture, p-hat = 0.5012 and estimated number of spayed females was 29 (95% CI 27–34), standard error 1.8244, p-hat 0.5829.

The population density of street dogs was found to be 855 dogs per km^2. The sex ratio of male is to female was 1:2.45. About 32% of observed females were spayed showing an identified ear notch and 2.6% of the total population were young pups. Among the observed dogs, 12.5% were very thin compared to normal body weight and 6.8% had damaged skin condition.

Foraging behavior

A total of 378 encounters of street dogs were recorded during the field survey. Among which, 39.6% (150 out of 378) were involved in the act of foraging. Out of 150 dogs involved in the act of foraging, 48.95% were begging with humans, and only 7.36% were scavenging food (Fig. 3). However, there was not a single encounter of a dog found to be hunting.

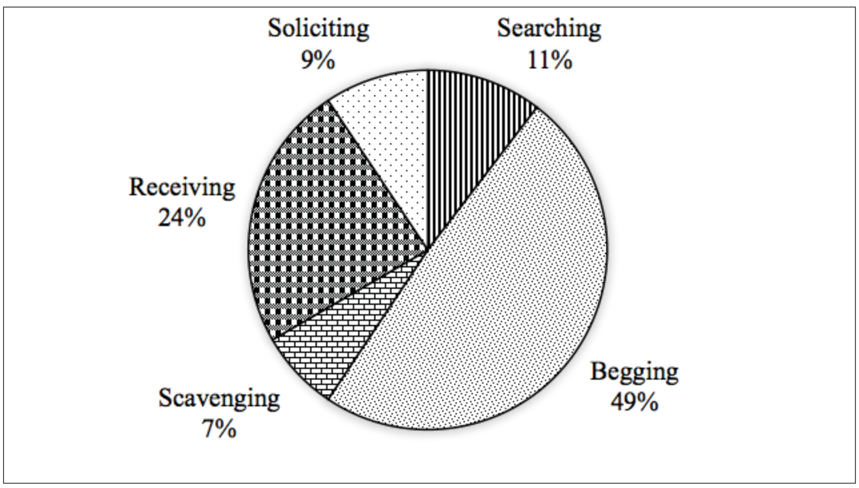

Figure 3. Percentage of dogs encountered in a different act of feeding.

The maximum number of dogs were found to be fed by humans directly (42.85%). Other 23.07% of dogs were found feeding on bones and foul meat outside meat shop, 19.78% were feeding on grocery leftover foods and only 14.28% were found feeding on garbage. Eighty six percent of dogs were observed foraging in groups. Only 14% of dogs were found to be solitary; 23% found in pairs, 8% found in groups of three, and 55% were found in a group of 4–9 individuals. There were only 6 dogs who show aggression among groups during foraging.

Food preference

The eating order of food during carbohydrate versus protein test and real food experiment was noted. Fifty-eight percentage of dogs did not sniff over food during the experiment. There was no significant difference between the sniffing by dogs in carbohydrate versus protein experiment and real food experiment ($\chi^2 = 1.514$, $p = 0.218$).

Carbohydrate versus protein test

During the carbohydrate versus protein experiment, dogs showed significant preference towards the protein (Fig. 4) as the first choice of food ($\chi2 = 26.273$, $p < 0.0001$). However there was no significant difference between the choice of F1 over F2 (Two-tailed Fisher's exact test F1-F2: $p = 0.2$), F1 over F3 (Two-tailed Fisher's exact test F1-F3: $p = 0.067$), F1 over F4 (Two-tailed Fisher's exact test F1-F4: $p = 0.475$) and F2 over F3 (Two-tailed Fisher's exact test F2-F3: $p = 1$), But dogs preferred F4 over F2 (Two-tailed Fisher's exact test F2-F4: $p = 0.003$) and F4 over F3 (Two-tailed Fisher's exact test F3-F4: $p = 0.001$).

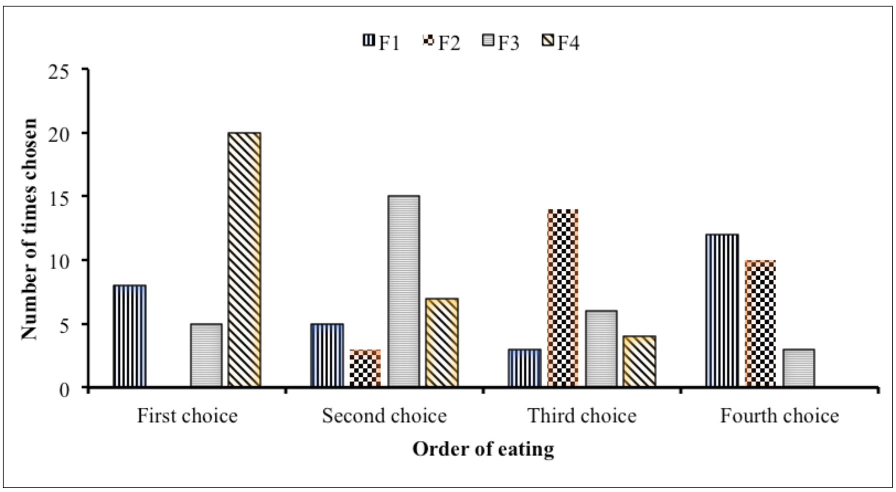

Figure 4. Graph showing the order of food eaten during carbohydrate versus protein experiment; F1=Dry bread, F2= Bread + Water, F3= Bread soaked in meat soup, F4= Piece of meat

Real food experiment

During real food experiments also, dogs showed a preference to meat as the first choice ($\chi^2 = 7.0$, $p = 0.030$) (Fig. 5). However, there was no significant difference between the choices of A over B (Two-tailed Fisher's exact test A-B: $p = 0.410$), A over C (Two-tailed Fisher's exact test A-C: $p = 0.237$) and B over C (Two-tailed Fisher's exact test B-C: $p = 0.752$).

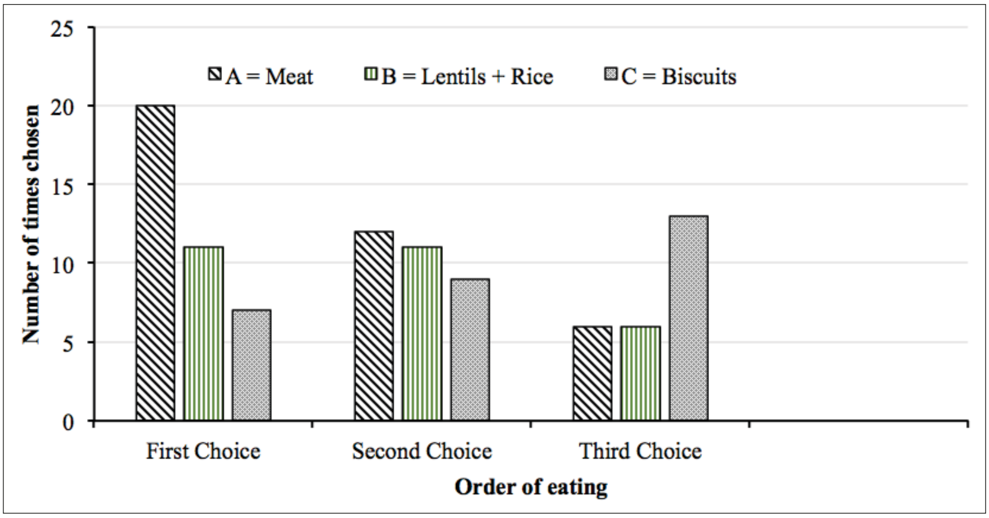

Figure 5. Graph showing the order of food choice during real food experiment.

The most preferred order of eating was F4>F3>F2>F1 in carbohydrate vs protein experiment and A>B>C in real food experiment (Table 2). 23 dogs rejected at least one food option. Most rejected food option was lentils + rice (18 times) followed by biscuits (17 times) followed by bread soaked in water (6 times) followed by dry bread (5 times) followed by bread soaked in chicken soup (4 times) and meat piece was rejected only 6 times during food preference tests. There was a significant difference between the rejections of carbohydrates than proteins (χ^2 = 37.5429, p < 0.0001).

Table 2. Eating order in food preference experiment

Experiment	Eaten first	Eaten second	Eaten third	Eaten fourth
Carbohydrate Vs. protein (n=33)	F1=8, F2=0, F3=5, F4=20	F1=5, F2=3, F3=15, F4=7	F1=3, F2=14, F3=6, F4=4	F1=12, F2=10, F3=3, F4=0
	The most preferred option was F4			
Real food experiment (n=40)	A=20, B=11, C=7	A=12, B=11, C=9	A=6, B=6, C=13	
	The most preferred option was A			

Discussion

This study employed the photographic mark-capture-recapture method to estimate the population of street dogs in Kirtipur Municipality of Kathmandu. The proportion of dogs that were first marked and were resighted in the next survey was stable across both events as 0.50 and 0.47 indicating that about half of the marked dogs were resighted during the next survey. The resighting probability of this study (0.35–0.59) was comparable with the finding of the overall mean re-sighting probability of 0.53 (Punjabi et al., 2012; Tenzin et al., 2015) but was lower than the finding of Amaral et al., (2014).

The age distinction between the adult dogs and puppies were not possible so we considered the individuals that were visually small having the length of the body below 1.5 feet and height below one foot as young and other as adult street dogs. The number of male dogs outnumbered the females, which is consistent with the results of (Daniels & Bekoff, 1989; Pal, 2008; Totton et al., 2010; Majumder et al., 2014; Acharya & Dhakal 2015; Tenzin et al., 2015). It may be explained as males are preferred as a pet and abandoned dogs also become street dogs (Beck, 2002), and higher death among female dogs due to pregnancy and child-birth (Belo et al., 2013). In the previous study, Kathmandu city had 2930 dogs per km^2 (Kato et al., 2003), 57 dogs per km^2 in Indian sub-urban area (Punjabi et al., 2012), 14 dogs per km^2 in Bangladesh (Hossain et al., 2013) and 6 dogs per km^2 in Timor Leste (Amaral et al., 2014). A higher density of street dogs was seen in our study area 855 per km^2, this may be attributed with higher human population density and availability of food that provide an ideal environment for the dogs, including garbage scattered on the streets and some dog-lovers that feed street dogs (Bogel et al., 1990; Kato et al., 2003).

For surgical sterilization, spaying females instead of castrating males is done in most countries of South Asia including Nepal, our result was lower compared to about 57% spayed females in Pokhara valley (Acharya & Dhakal, 2015) and higher compared to 29% in Lalitpur Dog survey, 2015. This study showed that the street dog population is higher in Kirtipur and a large number of non-spayed females are present in the study area suggesting upregulation on the reproduction.

During the foraging survey, most of the dogs were found to be begging and receiving food from humans, where only 7% of dogs were encountered scavenging. This result contrary to the results of (Bhadra et al., 2016) where they found most dogs (70%) scavenging. The foraging behavior of dogs may be different in the different areas due to their culture of feeding dogs. Only 14% of dogs were found to be browsing garbage for food which was very less than expected. Dogs around Kirtipur might have been habituated to receive food from humans. During the COVID-19 pandemic and lockdown, peoples started feeding street dogs so that dogs might be expecting food from any human and usually they get it. Majumder et al., (2014) found 41–58% solitary dogs in their study but we found that dogs preferred to forage on the groups rather than solitary (14%). This can conclude that the dogs are usually seen foraging alone if they are scavenging.

A significant difference between the choices of food that is rich in protein was observed by (Bhadra & Bhadra, 2014) in adult dogs. Similarly, in this study dogs significantly chose meat or meat smelling food over carbohydrate-based food. Dogs being scavengers and living in very competitive environments try to eat food which is rich in proteins (Bhadra & Bhadra, 2014), and they follow the Rule of Thumb if it smells like meat eat it (Bhadra & Bhadra, 2014; Bhadra et al., 2016). Dogs indeed preferred meat over other food but they did not always reject the foods provided. The choice of food one over another is usually insignificant during our food preference experiment. But dogs chose meat over bread soaked in water and bread soaked in meat soup. This result is supported by the result of (Bhadra & Bhadra, 2014; Bhadra et al., 2016) where adult dogs chose food that had a higher amount of protein in the reverse gradient experiment.

Since dogs try to follow optimal foraging, they usually eat food encountered at first. The percentage of dogs that rejected other option than meat piece was only 15%. Optimal utilization of available food makes an animal living in a competitive environment to survive and compete better. If food becomes less in the garbage, if people stopped feeding street dogs, they try to maximize the available food and eat everything (Li, 2019). If dogs are continuously fed by humans, they try to obtain food from humans and their choice over food increases.

Conclusion

The population of street dogs in Kirtipur Municipality was estimated to be 342 (95% CI 316–376) with the density of 855 per km^2. Begging food from the humans and foraging in groups are the most common foraging strategies for street dogs. Street dogs show clear preference to animal proteins over other foods even in resource limited conditions and under high population density.

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I cani di strada preferiscono le proteine ai carboidrati: un'inferenza sperimentale dalle strade di Kathmandu

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Sintesi

Una corretta gestione dei cani di strada richiede la conoscenza dei loro molteplici aspetti, tra cui popolazione, comportamento e preferenze alimentari. Questo studio è stato condotto nel comune di Kirtipur, Kathmandu, con l'obiettivo di stimare la popolazione di cani di strada ed esplorare il loro comportamento e le preferenze alimentari. I cani di strada sono stati rilevati lungo il percorso unidirezionale e la stima della popolazione è stata effettuata mediante il metodo fotografico mark-capture-recapture utilizzando il programma MARK.

La preferenza alimentare dei cani di strada è stata testata con un test di scelta una tantum multi-opzione. La popolazione totale di cani di strada nell'area di studio è stata stimata in 342 (95% CI 316-376), maschi 227 (95% CI 206-256), femmine 93 (95% CI 87-106) e femmine sterilizzate 29 (IC 95% 27-34). La densità di popolazione era di 855 cani per km^2 con un rapporto tra femmine e maschi di 1:2,45. La maggior parte (73%) dei cani riceveva cibo dall'uomo o lo trovava nei rifiuti (27%). I cani hanno mostrato una chiara preferenza per le proteine alla loro prima scelta durante il test carboidrati vs proteine nell'esperimento alimentare reale ($p < 0,05$). C'è stato un rifiuto significativo dei carboidrati rispetto alle proteine ($p < 0,0001$). Questi risultati potrebbero essere utili nella gestione dei cani di strada nelle aree ad alta densità.