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Research Article

Demographic Dynamics of Owned and Free-Roaming Dogs in Juba City, Central Equatoria State, South Sudan

Lily Poulino[1], Jaja Lewis Khamis[2], Ammar A.H. Ahmed[6], Jubara Ambrose Samuel[4], Ochi Erneo Bernardo[5] and Adill MA. Salman[3]

[1]Lecturer in the Department of Infectious Diseases, School of Veterinary Medicine, University of Juba, South Sudan

[2]Professor of Pathology, School of Veterinary Medicine-University of Juba, South Sudan

[3]Professor of Epidemiology, University of Bhri, One Health Centre, Sudan

[4]Professor of Gynecology, College of Veterinary Medicine, University of Upper Nile, South Sudan

[5]Professor of Parasitology, College of Veterinary Science, University of Bhar El-Ghazal, South Sudan

[6]Lecturer, Faculty of Veterinary Medicine, University of Bahri, Sudan

***Corresponding Author:** Adill MA Salman, Professor of Epidemiology ,University of Bhri, One Health Centre, Sudan.

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Abstract

Free-roaming dogs pose a significant public health hazard in developing countries, including Juba, South Sudan, where rabies is endemic. Understanding the core demographic characteristics and population size of domestic dogs is crucial for designing and implementing effective zoonotic disease control and dog population management programs. The presence of roaming dogs in public spaces presents serious threats to public health and safety, contributes to environmental pollution, and raises animal welfare concerns.

The aim of this study was to estimate the population size and demographic structure of domestic dogs in Juba City, South Sudan.

A cross-sectional demographic survey was conducted using direct dog count methods for both owned and free-roaming dogs across six selected study areas known for high dog populations. A total of 3,473 dogs were identified, of which 3,051 were owned and 422 were classified as free-roaming.

The demographic structure revealed that 88.5% of the dogs were male, with the majority being of local breed. Age distribution showed that most dogs were adults aged 1–3 years for both owned and free-roaming groups (59.8% and 57.5%, respectively). A small proportion of owned dogs were sterilized, with 3.1% castrated and 5.3% spayed. Most free-roaming dogs (77.2%) were in good body condition, and all were intact. Demographic distribution indicated that the highest population of owned dogs was found in Gurei (27.2%) and Gudele (25.1%), while the highest number of free-roaming dogs was recorded in Kator (20.0%) and Gudele (19.4%).

The data presented in this paper are essential for informing authorities in planning effective intervention programs for dog population control and zoonotic disease prevention.

Keywords: Demographic Characteristics; Owned and Free-Roaming Dogs; Juba; South Sudan

Introduction

The domestication of dogs marks one of the most significant transitions in human history. It reflects a longstanding relationship between early wolves and hunter-gatherers, dating back over 14,000 to 15,000 years in Eurasia [1]. The domestic dog (Canis lupus familiaris) is now widely distributed across the globe and is considered one of humanity's closest companion animals-the only canine species globally associated with human settlements [2-5].

The global domestic dog population has been estimated at approximately 703 million , with regional figures suggesting around 87.6 million in specific areas [6]. Although it is commonly believed that pet dogs are usually confined to households, studies reveal that a significant proportion of the global dog population is free-roaming. Research estimates that 75–85% of the global dog population is free-roaming [8-10].

Managing free-roaming dogs poses a serious challenge globally due to their high reproductive rates and rapid population turnover. These dogs are often cited as a major obstacle to rabies control through mass vaccination campaigns and represent a broader issue for dog population management [11-13]. In developed countries, dogs are typically considered family members and are confined accordingly [14]. In contrast, in many developing countries, dogs are primarily valued for their functional roles such as guarding property and livestock, hunting, and providing security [15,16].

In these regions, free-roaming dogs have emerged as both animal welfare and public health concerns. Dogs are responsible for 99% of human rabies transmissions globally [10,17-19] and are known vectors for more than sixty other zoonotic diseases [20]. These dogs also pose serious community challenges, including dog bites, transmission of diseases, threats to other animal populations, road traffic accidents due to unpredictable movement, and environmental pollution caused by feces and vectors [8,21,22].

In particular, rabies remains the most concerning public health issue associated with free-roaming dogs, accounting for 99% of global human rabies deaths [10,17,18]. To develop effective disease control and population management strategies, a clear understanding of both owned and free-roaming dog population dynamics is essential.

In Juba, South Sudan, there is a significant population of domestic dogs, many of which are owned but allowed to roam freely. These dogs present major public health concerns due to disease transmission, particularly rabies, as well as economic burdens related to post-exposure prophylaxis and general poor animal welfare. While some rabies control and sterilization efforts have been implemented in Juba, these programs largely depend on owners' willingness to vaccinate and sterilize their dogs. Moreover, public awareness of the role of dog population dynamics in zoonotic disease transmission remains limited.

Compounding these issues is the absence of a comprehensive dog ownership policy that addresses dog registration, vaccination, treatment, feeding, and movement control. These gaps have contributed to the increasing number of free-roaming dogs in Juba City.

This study represents the first attempt to assess the population size and demographic characteristics of both owned and free-roaming dogs in Juba, South Sudan. The findings provide critical baseline data to support planning for national rabies vaccination campaigns, improved dog welfare initiatives, and the design of effective dog population management programs.

The objective of this study was to estimate the population size and demographic structure of domestic dogs in Juba City, South Sudan.

Materials and Methods

Study area

The demographic survey was conducted in Juba city, South Sudan. The city, situated on the White Nile, serves as the capital of the Republic of South Sudan. Juba located at latitude 4°51'5.94" N and longitude 31°34'56.89" E, at an elevation of 518 meters, with a total area of 1,699 km^2. As of 2024, Juba City has a total population of 479,000 according to the current metro area population data. The areas for the survey were selected based on the presence of a significant dog population, particularly free-roaming dogs. The study covered six residential areas namely: Gudele, Gurei, Gumbo, Juba, Kator, and Munuki. These locations represent six payams of Juba County.

Figure 1: Map showing study areas.

Study design and sampling method

This study employed a cross-sectional design, conducted over a three-month period from September 2022 to December 2022, across six locations in Juba City known for high populations of both owned and free-roaming dogs. The primary method used to estimate and assess dog population demographics was the direct dog count method.

Survey timing and methodology

The field survey was structured around two daily observation periods:

- **Morning:** 6:00 AM to 9:00 AM (3 hours)
- **Evening:** 5:00 PM to 7:00 PM (2 hours)

These sessions allowed for observing dog activity at times of peak movement and visibility. The enumeration of owned dogs was conducted primarily at government veterinary outpatient clinics and rabies vaccination centers, particularly during World Rabies Day events. Key variables recorded included: Age group: Puppy, Adult, Senior, Sex: Male or Female, Neuter status: Castrated/Spayed or Entire (intact).

Survey execution

Data collection was scheduled over weekends-Saturdays and Sundays-to maximize accessibility and ensure consistent observation. Survey areas included: Main roads, public markets, Areas near slaughter slabs Garbage collection points, and Food service areas. The field team comprised two members: an observer (assessor) and a motorbike rider. The team traveled at an average speed of 10 km/h, enabling thorough scanning of the environment while covering larger geographic areas. All free-roaming dogs (FRDs) observed during the survey were recorded manually on pre-designed data sheets. Locations where FRDs were frequently encountered included: Street markets, Restaurant vicinities, Garages and areas beneath parked vehicles, Temporary waste disposal sites and Roadsides with accumulated garbage. Observed Variables for FRDs include: Sex: Male or Female, Age group: Puppy, Adult, or Senior and Body condition score (BCS): Rated from 1 to 5, where:

- 1-2 indicated emaciation
- 3-4 indicated normal body condition
- 5 indicated obesity

Data Collection

Data were collected using a structured direct observation form, in which each sighted dog's demographic and physical characteris-

tics were logged. The survey focused on real-time visual identification, without handling animals, to record:Sex, Estimated age group. Body condition and Visible health indicators.

Data management and analysis

The data were entered into Microsoft Excel 2013 for proper storage, validation, and cleaning. Descriptive statistical analysis was conducted to explore and summarize: Age and sex distribution, Neuter and vaccination status. Body condition scores. In addition, observed social behaviours and activities of free-roaming dogs were descriptively analysed to support the interpretation of demographic trends and environmental interactions.

Results

Demographic characteristics of owned dog population

A total of 3,051 dogs were counted over a period of three months. The demographic distribution according to the study areas was summarized in Table (1). The study revealed most dogs were male, about 2,769 (90.7%), compared to female dogs, 282 (9.3%). The age distribution showed a high number of adult dogs aged 1-3 years old, about 1,821 (59.8%). The breed was predominantly local, with 2,881 (94.7%) local breed dogs. The sterilization status shows low number of dogs were neutered: about 93 (3.0%) castrated, and 15 (2.0%), were spayed.

Study Location	Number of dogs reported	Dog breed		sex		Age group			Neuter status	
		Local	Foreign	Male	Female	Puppies 1m< year	Adult 1-3 years	>3 years old	Castrated	Spaying
Gudele	766	734	32	698	68	228	452	86	26	5
Gurei	831	810	21	767	64	209	576	46	9	2
Gumbo	224	222	2	198	26	82	109	33	5	0
Juba	276	235	41	252	24	47	192	37	13	1
Kator	566	527	39	519	47	210	302	54	19	4
Munuki	388	363	25	335	53	123	190	75	21	3
Total	3051	2891 (94.7%)	160 (5.3%)	2769 (90.7%)	282 (9.3%)	899 (29.5%)	1821 (59.8%)	331 (19.8%)	93 (3.3%)	15 (5.3%)

Table 1: Demographic Structure of owned dog populations.

Demographic Characteristics of Free Roaming Dogs (FRD).

The demographic characteristics of free-roaming dogs (FRDs) are summarized in table 2. A total of 422 FRDs were sighted in six study areas during morning and evening. The highest population of FRDs was seen in the Kator area, about 93 (22.0%), while the fewest number, 42 (9.9%), was sighted in the Gurei area. The sex distribution shows a high proportion of male FRDs, about 308 (72.9%), with a lower number of female free-roaming dogs, about 114 (27.1%). The body condition indicated that, the majority of FRDs sighted were characterized by good body condition, about 77.2%. The age group analysis shows that most dogs 243 (57.5%), were adults aged 1-3 years old. The young dogs aged between 1 month and less 1 year accounted for 152 (36.0%). In contrast, the proportion of old dogs in the study areas was lower, about 25 (6.5%). The neutered status shows that, all dogs sighted were intact.

Social behavior and Activity

Adult dogs were frequently observed in groups of twenty, ten, eight, and significantly in groups of five, while older dogs were typically seen alone. The majority of free-roaming dogs observed were active, particularly during the reproductive season-engaging in running, walking, feeding, and resting-especially during the morning survey. A few dogs were inactive, particularly those showing signs of severe health conditions; these were often found lying down or sleeping under parked cars and in abandoned buildings.

Location of free-roaming dogs and number of dogs sighted during the time of survey

The location of free-roaming dogs varied significantly. The majority were observed near roadsides where irregular garbage

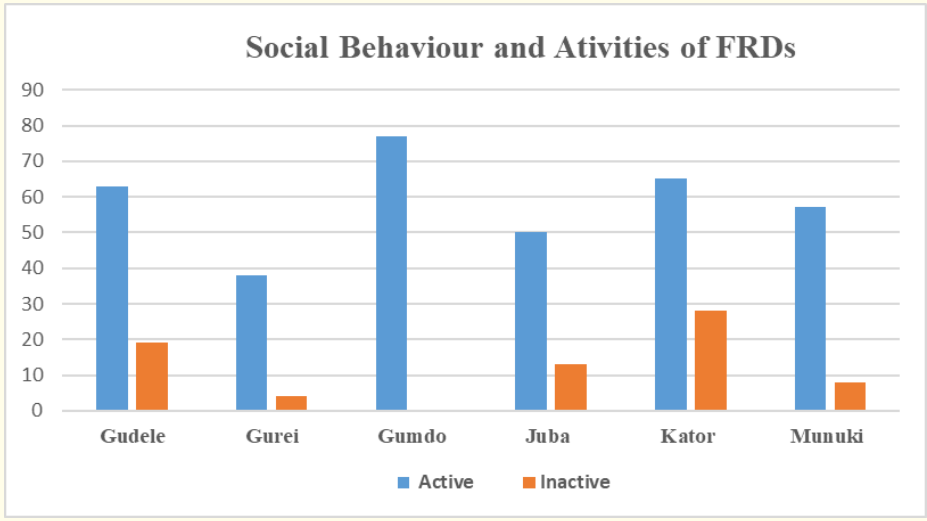

Figure 2: Showing behaviour and activities of FRDs During Survey.

dumping occurred (21.0%), followed by areas near slaughter slabs (75 dogs, 17.7%) and marketplaces (73 dogs, 17.2%). Additionally, 58 dogs (13.7%) were seen in uncompleted buildings, 49 (11.6%) were found walking within residential areas and around food service places or restaurants, while 43 dogs (10.1%) were observed near garages and 35 (8.2%) were seen resting under parked cars.

Location	Number of dogs sighted	Percentage
Near food services places	43	10.10%
Near roads where there is garbage accumulation	89	21.00%
Near slaughter slabs	75	17.70%
Markets	73	17.20%
Garages and packed cars	35	8.20%
Uncompleted building	58	13.70%
Within residential areas on walk	49	11.60%

Table 3: Locations of Free Roaming Dogs during Survey Time.

Discussion

Understanding dog population dynamics is essential for designing effective intervention programs, particularly in regions with high populations of free-roaming dogs and endemic rabies. This study represents the first attempt to estimate the population size and demographic characteristics of owned and free-roaming dogs in Juba City, South Sudan, using the direct dog count method. This approach allowed assessors to observe dogs from a close distance (less than two meters), enabling detailed assessment of their body and health condition.

A total of 3,473 dogs were counted, of which 3,051 were owned and brought to veterinary clinics or rabies vaccination centers, while 422 were free-roaming dogs observed in public places. The population was significantly skewed towards male dogs (88.5%), consistent with findings from similar studies conducted in Herat [23], India [24], Uganda [25], Bhutan [26], Mexico [27], Bali and South Africa [28], Chile [4], and Kenya [15]. This male dominance is often attributed to a preference for male dogs due to their perceived suitability for security roles, as well as the abandonment of

female pups and higher female mortality during early life stages [13,29-31]. Educational programs promoting sterilization and female dog acceptance are therefore crucial.

The majority of dogs were adults aged 1–3 years (59.8%), with only 19.8% aged over three years. This trend is in line with studies from India [24], Tanzania [32], Nepal [33], Mali [34], and Bali [28], where high puppy mortality due to disease, poor veterinary care, and accidents results in lower proportions of older dogs. The highest concentration of owned dogs was found in Gurei and Gudele, likely due to higher human population density and increased insecurity, encouraging dog ownership for protection. Free-roaming dogs were most prevalent in Kator and Gudele, attributed to the availability of food near temporary garbage dumps, poor confinement practices, and proximity to food service establishments.

Most free-roaming dogs (77.2%) had a normal body condition score (3-4), which is associated with the accessibility of food in garbage sites and near slaughter slabs. A smaller portion (23.7%) appeared emaciated, reflecting findings from studies by [24] and [23]. Poor health among a significant proportion of free-roaming dogs aligns with previous observations from Bhutan, India, and other developing regions [10,26,35]. Regarding location, 17.7% of FRDs were seen near slaughter slabs (especially in Gumbo), feeding on offal that could serve as a source of parasitic zoonoses such as *Echinococcosis*. The majority (21.0%) were observed near garbage accumulation points, reinforcing the association between poor waste management and high free-roaming dog presence [35,36]. Social behaviour observations showed that 82.9% of FRDs were active, in agreement with [24]. Dogs were frequently seen in groups of five, ten, or twenty, with male-dominated social groupings reflecting the population's gender imbalance. However, these groupings can pose serious threats to public safety due to the risk of dog attacks and bites.

Conclusion

This study confirms that the dog population in Juba, South Sudan, is significantly skewed toward males, reflecting both regional and global trends. The highest concentration of owned dogs was recorded in Gurei and Gudele, while free-roaming dogs were primarily found in Kator and Gudele-areas associated with poor waste management and access to food sources. Most free-roaming dogs were in good body condition and intact (not sterilized), and their common presence near slaughter slabs and garbage dumps raises public health concerns due to potential zoonotic risks such as *Echinococcosis*. These findings highlight the urgent need for a comprehensive dog ownership policy that enforces proper confinement, regular vaccination, sterilization, and feeding practices to minimize roaming behavior and improve dog welfare.

The study recommends the implementation of a Capture-Neuter-Vaccinate-Return (CNVR) program, targeting free-roaming dog populations for both rabies control and prevention of unwanted reproduction. Furthermore, a larger-scale demographic survey encompassing the entire state is essential to gather baseline data for effective rabies control, improved dog welfare, and sustainable population management.

Limitations of the Study

- Limited literature on dog population dynamics in South Sudan for comparison.
- Time constraints restricted the survey to six residential areas in Juba; future studies should expand coverage.
- The direct count method may have introduced bias depending on dog visibility during the survey period.
- Difficulty in differentiating between owned free-roaming and unowned dogs due to the absence of identification marks.

Ethical Approval

This study was approved by the Research Ethics Committee of the School of Veterinary Medicine, University of Juba. Permission to conduct the data collection was granted by the Ministry of Animal Resources, Fisheries, and Tourism, Central Equatoria State, South Sudan.

Author Contributions

The authors collaboratively designed and conducted the study, collected and analyzed the data, and contributed equally to the writing and review of the manuscript.

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