Indian Free-ranging dogs (*Canis lupus familiaris*) : A Longitudinal Census and The long term effects of Sterilization on their time activity budget.

A Thesis

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by

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Certificate

This is to certify that this dissertation entitled Indian Free-ranging dogs (Canis lupus familiaris) : A Longitudinal Census and The long term effects of Sterilization on their time activity budget, towards the partial fulfillment of the BS-MS dual degree programme at the Indian Institute of Science Education and Research, Pune represents study/work carried out by Siddhartha Naik Mudavath at Indian Institute of Science Education and Research under the supervision of Dr. Anindita Bhadra, Associate Professor, Department of Biological Sciences, Indian Institute of Science Education and Research, Kolkata during the academic year 2022-2023.

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This thesis is dedicated to Nibba, Cookie and Choco.

Declaration

I hereby declare that the matter embodied in the report entitled Indian Free-ranging dogs (Canis lupus familiaris) : A Longitudinal Census and The long term effects of Sterilization on their time activity budget, are the results of the work carried out by me at the Department of Biological Sciences, Indian Institute of Science Education and Research, Kolkata, under the supervision of Dr. Anindita Bhadra and the same has not been submitted elsewhere for any other degree.

Siddhartha Naik Mudavath

Date: 20.10.2023

Table of Contents

List of Tables

List of Figures

Abstract

This thesis presents a comprehensive study on Indian free-ranging dogs (Canis lupus familiaris) through a longitudinal census and an investigation into the long-term effects of sterilization on their time-activity budget. Free-ranging dogs in India play a significant role in public health, ecology, and animal welfare. Understanding their population dynamics and behavioral patterns is crucial for effective management and policy development.

The study was conducted in two phases. In the first phase, a census of free-ranging dogs was conducted in 13 locations in and around Kalyani, West Bengal, India.

The longitudinal census aimed to assess the population size, distribution, and demographic characteristics of free-ranging dogs in selected urban and rural areas of India over a specific time period. Data collection involved a combination of field surveys, direct observations, and remote sensing techniques. The results provide valuable insights into the spatiotemporal dynamics of the free-ranging dog population and serve as a baseline for future population management strategies.

The study investigated the long-term effects of sterilization on the time-activity budget of free-ranging dogs. Sterilization programs are commonly employed as a population control measure, but their impact on the behavior and daily activities of dogs remains understudied. Through behavioral observations, data logging devices, and statistical analyses, the study examined changes in activity levels, social interactions, foraging behavior, and territoriality post-sterilization.

The findings of this research shed light on the potential effects of sterilization on the time-activity budget of free-ranging dogs. It provides insights into how sterilization may impact their behavior, social dynamics, and interactions with the environment. Understanding these effects is vital for designing effective sterilization programs and ensuring the overall well-being of the free-ranging dog population.

This thesis contributes to the existing body of knowledge on Indian free-ranging dogs by providing a detailed longitudinal census and a comprehensive assessment of the long-term effects of sterilization on their time-activity budget. The results offer valuable insights for

policymakers, animal welfare organizations, and researchers involved in the management and conservation of free-ranging dog populations. Further research in this area can build upon these findings to develop more targeted and effective strategies for the welfare and population control of free-ranging dogs in India. Free-ranging dogs (Canis lupus familiaris) are a common sight in India. They are often seen as a nuisance, but they can also be a valuable asset to communities. This study provides a longitudinal census of free-ranging dogs in India and examines the long-term effects of sterilization on their time activity budget.

The results of the study showed that sterilization had a significant effect on the time activity budget of free-ranging dogs. Sterilized dogs spent more time resting and less time scavenging for food. They were also less likely to be involved in aggressive interactions with other dogs.

The study provides valuable information on the population dynamics and behavior of free-ranging dogs in India. The results of the study can be used to develop more effective management strategies for free-ranging dogs.

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Chapter 1
Introduction

Approximately 75% of the estimated 700 million to 1 billion dogs worldwide are free-ranging dogs (FRDs), making them the most abundant set of carnivores, who coexist in a complex ecosystem with domestic animals, wildlife, and people (Daniels & Bekoff, 1989; Kartal & Rowan, 2018; Hughes.J and Macdonald.D.W , 2013; Belsare.A and Vanak.A.T . 2020; Range, F., & Marshall-Pescini, S. 2022). India has the largest free-roaming dog population among nations with large street dog populations, with an estimated 30-40 million free-ranging dogs (Kartal & Rowan, 2018; Rakesh Kumar, 2018). FRDs are both effective human commensals and independent roamers due to their evolved adaptability to attain sexual maturity earlier, have larger litters, and produce waste created by humans(Range, F., & Marshall-Pescini, S.,2022). The population of free-roaming dogs varies per country. Canine overpopulation and stray dogs are seen as a global concern posing major socioeconomic, and hence, political, issues as they are perceived to be a threat to public health, conservation, and animal welfare in rural and urban ecosystems. Free-ranging dogs have adopted a scavenging lifestyle, feeding on typically garbage bins and leftovers (Bhadra et al., 2016), which is a common sight on city streets in urban and semi-urban areas (Bhadra et al., 2016; Bhattacharjee et al., 2021; Majumder, Bhadra, et al., 2014;). In addition to free-ranging dogs offering the companionship and security that come with being territorial, human commensals, they are perceived to be complicating rural and urban environments as disease transmitters and hence, experiencing a high level welfare problems, such as, debilitating conditions diseases, infections, malnutrition, starvation and injury and even human-induced mortality(Sparkes, J., Körtner, G., 2014). A lack of enforcement of regulations, an abundance of human-derived materials (HDM) for survival (Mallick, Urmila. 2020.), and ineffective population management interventions leads to an over population in their numbers. Many nations have experimented with various policies, including sterilization, adoption shelters, and euthanasia, in response to the rapidly growing numbers of feral domestic dogs (Rowan, A., & Kartal, T., 2018). However, developing a workable and effective intervention necessitates a combination of social, ecological, economic, and cultural understanding supported by systematic thinking.

1.1 Model System

The evolution of dogs began over 15,000- 34000 years ago when wolves and humans first started to form a bond (Bhattacharjee,. Bhadra, A. 2021). Wolves would scavenge around human campsites for food, and humans would sometimes share their leftovers with them. Over time, these wolves became less fearful of humans and formed a unique relationship with them. As the relationship between wolves and humans developed, some wolves became more specialized in living near humans and developed traits that made them better suited to life alongside humans (Coppinger, R., & Coppinger, L. 2001), including a more docile temperament, physical changes such as a smaller size and floppy ears, and a reduced fear response to humans.

The early domestication of dogs might have occurred in two ways, both of which have numerous advocates. According to a particular narrative, early humans adopted newborn wolves and deliberately tamed and bred them, eventually leading to the speciation of the earliest ancestors of dogs as we see them today, in the school of theory called active domestication(Ha, J. C., & Campion, T. L. 2018). Another popular narrative holds that wolves at the bottom of the pack's hierarchy having to scavenge for human generated materials near human settlements grew less and less aggressive, more sensitive to their surroundings and more entitled to human generated materials and gradually tamed themselves over time, in a process known as self-domestication (Hare and Tomasello, 2005). Over time, humans accept them as pets because of their affiliative nature. Both theories offer different explanations for the close bond between humans and dogs. The self-domestication theory suggests that dogs have evolved to be more social and tolerant of humans due to their long history of living alongside humans(Range, F., & VirÃ¡nyi, Z. 2015). In contrast, the active domestication aka the pet hypothesis suggests that humans are attracted to dogs because of their friendly and appealing nature. However, regardless of how it began, domestication resulted in the creation of a species that was very sensitive to human presence and behavior.

Around 15,000 years ago, at the beginning of civilization, Asian and European gatherers began to selectively breed dogs for specific purposes such as hunting and

herding (Fiala, I. 2013; Frantz et al., 2016; Galibert et al., 2011). Dogs were developed for various human requirements after their development from wolves and later or concurrent domestication. As a result, various dog breeds evolved over the world for hunting, herding, guiding, protecting, and even companionship. Over time, humans continued to selectively breed dogs, resulting in various dog breeds we know today. The evolution of dogs from wolves to domesticated animals was a long and complex process that took thousands of years(Konno, A., Romero, T., 2016). The bond between humans and dogs is a unique and complex one which has been shaped by thousands of years of selective breeding, history and evolution (Miklósi, Á. 2014). As a result, dogs became popular pets, and a species that originated in the wild developed to be pets.Today, dogs play various roles in human society, and their importance to humans will likely continue to grow(Coppinger et al., 2001). Understanding the evolution of dogs and the factors contributing to their close relationship with humans is crucial for understanding the dynamics of human-dog interactions and promoting positive interactions between the two species. As time passed, studies for effective dog breeding expanded into study into dog behavior and cognition, as well as their relationships with humans.

1.1.1. Free Ranging Dogs

The dog population is made up of a variety of subspecies, including companion animals that live in homes as members of the family in most parts of the world and are completely dependent on humans. But, over time dogs grew abundant due to their high breeding rates and large litter sizes, and soon, it became normal for dogs to be viewed as strays—that is, as animals who are not pets but instead live close to human settlements and forage for food. Approximately 80% of dogs worldwide are stray animals who interact with humans positively and negatively (Hughes, J., & Macdonald, D. W. 2013). Free-roaming dogs that are ownerless, not under immediate human supervision, and whose breeding and foraging activities and movements are not limited by humans (Cafazzo et al., 2010) are referred to as "free-ranging dogs" (Adda, M. 2020). They have unrestricted access to public property and are partially dependent on

humans for sustenance. Free-ranging dogs exist worldwide and are particularly noticeable in developing and third-world nations. The majority of reports on them originate from the Global South, which includes South American, Asian, and African nations. (Belsare and Gompper, 2013; Cortez-Aguirre et al., 2018; Kartal and Rowan, 2018; Otolorin et al., 2014; Beck, 1973; Rinzin et al., 2016). They predominantly inhabit urban and rural habitats, primarily living on streets, surviving on garbage, human-provided food and human feces (Banerjee, A., and Bhadra, A. 2021). They not only depend on humans for food but also prefer to be close to humans while giving birth(Sen Majumder, S., Paul, M., Sau, S., & Bhadra, A. 2016). They are primarily scavengers, showing a high degree of flexibility in their food habits, eating anything from vegetable peels to meat (Bhadra et al., 2016). They are efficient scavengers, using a simple 'Rule of Thumb' to sequester protein-rich food using their olfactory prowess (Bhadra and Bhadra, 2014) and also have a high degree of flexibility in their interactions with humans (Bhattacharjee et al., 2017; Atickem et al., 2010; Sen Majumder, Chatterjee and Bhadra, 2014; Gompper, 2013). Humans, on the one hand, are the major source of food and shelter for the free-ranging dogs and on the other, a cause of morbidity and mortality (Sen Majumder, Chatterjee and Bhadra, 2014; Paul et al., 2016).

Recently, free-ranging dogs have become more popular as a model system for answering evolutionary concerns, and several research on their behavior, ecology, and cognitive capacities have been conducted (Miklósi, Á. 2014; Bensky, M. K., Gosling, S. D., & Sinn, D. L. 2013). Research has indicated that dogs that are allowed to roam freely have distinct behavioral traits from shelter and companion dogs (Miternique, H. C., & Gaunet, F. 2020). Complex interactions between and among groups occur in free-ranging dogs; these include reported instances of communal pup raising, intra- and inter-group conflicts, territory expansion, pack formation, and later aggressive territory defense (Miternique, H. C., & Gaunet, F. 2020). As a result, it is critical to investigate how dogs are permitted to coexist with humans on a day to day basis.

1.1.2 Human-free-ranging dog interactions and the free-ranging dog problem

Free-roaming dogs behave differently from shelter and companion dogs (Brubaker et al., 2019). Pack formation, care of young, mate choice, territorial expansion, inter and intra group disagreements, and eventual violent territory defense have all been seen in free-roaming dogs (Ditchkoff et al., 2006; Paul and Bhadra, 2017; Paul et al., 2014; Paul et al., 2015). The relationship between a pet dog and its owner differs greatly from that of free-ranging dogs' interaction with humans on a daily basis, and this leads to many acquired features and behavioral plasticity in free-roaming dogs that domestic dogs fail to replicate (LS Hall, MJ Prescott, 2021; Lazzaroni et al., 2019; Saavedra-Aracena et al., 2021). We can find distributions of dog packs that disperse or move in sites adjacent to human-generated resource rich areas (Sen Majumder et al., 2013). As a result, every free-roaming dog's existence is heavily reliant on human relationships, rather than the other way around. Free-roaming dogs frequently develop social networks where they may get food and are treated decently (Bhalla et al., 2022; P. W. Bateman, P. A. Fleming).

In India there were approximately 59 million unowned/free-ranging dogs in 2014 (Gompper, 2014), with the number having likely increased significantly since 2014 as stray dog numbers are related to urbanization and human population. Free-roaming dogs are constantly in touch with humans and are subjected to both positive (feeding, social affection through caressing) and negative stimuli (threats, beatings, and even poisoning (Paul et al., 2016). This significant characteristic distinguishes free-roaming dogs from pets, as do other ecological aspects relevant to survival (inter-group dynamics, food rivalry, and so on). Free-roaming dogs and people interact in complex and dynamic ways, resulting in these canines becoming involved in confrontations with humans on several levels (Vanak and Gompper, 2009; Gompper, 2015). On the one hand, dogs may exhibit greater positive behavior in response to pleasant contacts with humans. According to studies, dogs who get human affection and attention are more likely to behave amiably toward people in the future (Nagasawa et al., 2015). It is crucial that people take into account how their actions affect dogs that are allowed to roam

freely. Humans can lessen the possibility of unfavorable interactions and encourage positive behavior by showing compassion and respect to these canines.

A percentage of the human population regards free-ranging dogs as pests and treats them in an aggressive manner which conditions the dog to either flee or react aggressively in turn. And in areas where they are treated mildly and can acquire food, free-ranging dogs establish social communities. Unfortunately, no research has been done to date on the interactions between people and dogs in slums as opposed to clean, well-maintained cities to document the behavioral variations between the two. Due to their varied behavioral characteristics, free-ranging canines and people will inevitably interact on a regular basis wherever they are present, leading to conflicts. Where populations of free-ranging dogs have developed communities, it is common to witness dog fights on the road between two dogs, either over territory or dominance. People view these kinds of behaviors as bothersome, and they search for solutions to reduce or even get rid of them. Thus, minimizing some conflict is aided by documenting and research into the understanding of interactions between humans and free-ranging dogs.

Recent studies have suggested that human behavior toward free-ranging dogs can significantly impact dog behavior toward humans (Coppola et al., 2018). In many parts of the world, dogs can roam freely and interact with humans regularly. However, human behavior towards these dogs can vary widely, ranging from friendly interactions to aggression and violence (For example, "Residents kill stray dog after it mauls four-year-old in Mumbai's Khar" (India Today, 2021) and "7-year-old boy dies after being mauled by stray dogs in Tamil Nadu" (The New Indian Express, 2021). Research has shown that dogs subjected to negative interactions with humans, such as being hit or kicked, are more likely to display aggressive behavior toward humans in the future (Arhant et al., 2010). This can be especially problematic in areas where dogs can roam freely, as aggressive dogs can threaten human safety. Population management of free-ranging dogs is gaining attention due to the significant threat these animals pose to human health and wildlife through their roles as potential zoonotic disease transmission, particularly rabies, can cause conflicts with humans through dog bites, particularly those

involving children, nuisance through pollution and noise, road accidents, aggressive behavior toward people, and livestock predation (Carter, 2008; Dalla Villa et al.) As a result, for health and animal welfare considerations, establishing efficient population control techniques is of the utmost importance.

1.1.3 ABC Guidelines

Free-roaming dogs are constantly in touch with humans and are subjected to both positive (feeding, social affection through caressing) and negative stimuli (threats, beatings, and even poisoning (Paul et al., 2016). This significant characteristic distinguishes free-roaming dogs from pets, as do other ecological aspects relevant to survival (inter-group dynamics, food rivalry, and so on). Free-roaming dogs and people interact in complex and dynamic ways, resulting in these canines becoming involved in confrontations with humans on several levels (Vanak and Gompper, 2009; Gompper, 2015). As a result, for health and animal welfare considerations, establishing efficient population control techniques is of the utmost importance. Sterilization has been a widespread strategy in underdeveloped nations to fight overpopulation of undesired canines or to change undesirable habits (Dalla Villa et al., 2010; E. Garde et al., 2016).

The Animal Welfare Board of India announced an animal birth control program in 2001 to capture, sterilize, vaccinate stray dogs against rabies and perform the capture-neuter-release procedure and release or euthanize FRD through the formation of local monitoring committees (John F. Reece et al., 2008; Thamaria, 2003). Other nations have also adopted similar catch-neuter-vaccinate-release (CNVR) programs (Jackman & Rowan, 2007; Tenzin, Ahmed, et al., 2015; Tenzin, McKenzie, et al., 2015; Totton et al., 2010). However, Indian FRD have never experienced a comprehensive, nationwide population assessment, impact analysis, or management intervention. A few noteworthy studies have been conducted on the FRD sterilization/vaccination programs in Jaipur, Jodhpur, and Sawai Madhopur, three cities in the Indian state of Rajasthan. Numerous unsuccessful attempts have been undertaken to control the Indian FRD population since the late 20th century, when stray animals were granted welfare rights (U Mallick - 2020).

Reducing the number of dogs that are allowed to roam freely is the primary objective of ABC programs (OIE, 2015). But according to a study based on observation surveys carried out in Jaipur City, the eight years that the ABC program was implemented had a significant impact on rabies reduction in addition to reducing the dog population by 28% (J. F. Reece & Chawla, 2006). Furthermore, a study indicated that the incidence of human-dog bites peaks during dog reproduction, indicating that ABC programs can lower dog bite injuries by decreasing street dogs' protective behavior toward their mothers and by lowering the overall number of roaming dogs (J. F. Reece et al., 2013). The success of ABC programs has occasionally been questioned due to the fact that they are primarily concentrated on urban areas and are not adequately monitored or evaluated to understand the impact on population size and reproduction in the area's remaining unsterilized dog population (Hiby et al., 2011; John F. Reece et al., 2008). It takes a lot of resources for communities to pursue ABC programs that entail surgical sterilization; these programs need significant funding, infrastructure, and staff support (Belsare & Vanak, 2020; Leoci et al., 2014). According to research from India, population control strategies (ABC Programs) can be successful if they are carried out for a number of years and are followed up on by frequent population surveys that compare the demographics and size of the stray dog population before and after the program is put into place (Carter, 2008; Hiby et al., 2011; J. F. Reece & Chawla, 2006; Totton et al., 2010). By creating realistic scenarios and evaluating strategies for reaching the goal through careful planning for successful execution, population demographic models can be a useful tool in determining the expected effort needed to lower the number of dogs in the world (Belsare & Vanak, 2020). According to population demographic model simulations used in an ABC program that was observed in Jodhpur for ten years, the effects of sterilization are gradual. The current rate of rabies vaccination and sterilization in the city is expected to cause the dog population to decline by 69% and stabilize in roughly thirteen to eighteen years (Totton et al., 2010). Further research is necessary to understand the effects of such ABC programs in other Indian cities, even though studies conducted in Jodhpur and Jaipur suggest that sterilization is effective in reducing the dog population and may be recommended to reduce major public health concerns (J. F. Reece et al., 2013; Totton et al., 2011).

According to a mathematical model created for stray dogs, sterilization is ineffective at controlling dog populations in nations with high rates of animal abandonment, even after long periods of use (Amaku et al., 2010). Therefore, in these nations, in addition to sterilization, educational initiatives promoting responsible animal ownership and practical measures against abandonment practices ought to be implemented (Belo et al., 2017; Dias et al., 2015). In order to eradicate canine-mediated human rabies, sterilization programs are frequently coupled with vaccination campaigns. However, the most practical and economical approach currently advocated is mass dog vaccination, and sterilization should be considered a distinct endeavor from rabies control (Collinsonid et al., 2020; Gibson et al., 2015).

Dog population control can help to establish a safer and more peaceful community for both humans and dogs, which is especially relevant in locations where dogs are commonly seen (Shivaraju et al., 2016). Therefore, it is important to understand the strength of the numbers of FRDs around humans by recurring censuses and uptake population control programs like mass vaccination and sterilization.

1.1.3.1 Census

An understanding of the core demographic characteristics of the populations and area demarcated sub-populations of FRD is essential to effectively implement both rabies control interventions through mass vaccination of FRD, and dog population control programmes. This includes taking a regular census to enumerate the free-ranging dog population. In India, free-ranging dogs live in social groups where social interactions have a significant impact on group dynamics. Examples of these interactions include defending their territories, foraging in pairs during mating seasons, and providing extensive parental care when caring for pups is primarily the responsibility of the mother (Pal, 2005; Paul & Bhadra, 2018). It is crucial to comprehend the intragroup dynamics and ecology of wild populations of free-ranging dogs due to the intricate social connections and degree of behavioral flexibility shown in these populations over various seasons. A census is the procedure of systematically acquiring, recording and

calculating population information about the members of a given population. The methods used in this study is a spot sampling approach.

1.1.3.2. Sterilization

Surgical sterilization is used to treat and prevent behavioral problems such as dogs' aggressive behaviors and make better-behaved companion animals (Farhoody et al., 2018; Root Kustritz, 2012). There are series of literature that has reviewed the benefits and effects of sterilization on behaviors and health, claiming that the undesirable behaviors of males like inter-male aggression, mounting, marking, and motivation to roam has decreased in the pet dog populations (Hart, 1968, 1974; Neilson et al., 1997; Palestrini et al., 2021), which is also supported by a study that regardless of age the motivation to roam is more prevalent in male dogs than females (Baquero et al., 2020). Literature also supports contrary findings where surgical sterilization does not result in a predictable change in aggressive behaviors or improvement in certain behavioral patterns-mounting, overmarking, urinating in male pet dogs (Carina A, 2017; Farhoody et al., 2018). The authors suggested that the results showing no change in the aggressive behavior could be that there could be multiple environmental and genetic factors and not just gonadal hormones linked with aggressive behavior. Some studies also reported that neutered dogs differ in certain personality traits like being less calm, less confident, less sociable, and more trainable than the intact ones, suggesting that neutering may change the behaviors of the dogs (Carina A, 2017; Kubinyi et al., 2009; P Lorenz, 2018; Petra Lorenz et al., 2019). However, these studies were based on surveys/questionnaires, observations from the dog owner's perspective, or recordings of video analysis in the presence of the owner on a small sample size, which might have affected the dogs' behaviors; thus, further research is required for better understanding the behavioral alterations in neutered dogs. Garde, in 2016, reported the first detailed behavioral observations on surgical and chemical sterilization in male free-roaming dogs in Puerto Natales, Chile. The study showed that surgical sterilization showed no association between aggression and testosterone levels and no reduction in sexual activity, aggression, and home range between the pre and post-intervention periods.

This is also supported by a study that shows sterilization did not produce significant alterations in the home range areas of free-roaming dogs. Food availability strongly influences the spatial distribution of these dogs in those urban areas (Melo et al., 2020). Veterinarians also suggest surgical sterilization in preventing reproductive tract disease (e.g., mammary gland cancer and prostate hyperplasia/infection) (Gigantesco & Giuliani, 2011; Palestrini et al., 2021; Totton et al., 2010) and prolonging lifespan in pet dogs (Hoffman et al., 2013) but some studies reported adverse effects on dogs' health, including an increased risk of prostate cancer and diabetes mellitus in males and the risk of some form of cancer in both males and females (Cooley et al., 2002; Hart et al., 2016; Mattin et al., 2014). However, Kutzler in 2020 reported that the risk of fatal disease associated with retaining the gonads (mammary cancer or prostatic enlargement) is relatively low; thus, a surgical sterilization method that allows the gonads to remain intact (e.g., ovary-sparing hysterectomy, vasectomy) should be performed which may also prolong their health. Because other than the reproductive function of gonads, the presence of gonads appears necessary in maintaining homeostasis. (However, Kutzler 2020)

1.2. Background of this study

India holds the highest free-ranging dog populations among countries with prevalent street dog populations, around 30–40 million dogs globally(Kartal & Rowan, 2018; Rakesh Kumar,2018). Population management of free-roaming/ free-ranging dogs is gaining interest due to the significant threat these animals pose to people health and wildlife through their roles of potential zoonotic disease transmission, particularly rabies, can cause conflicts with humans by dog bites, in particular, those involving children, nuisance through pollution and noise, road accidents, aggressive behavior towards people and predation of livestock (Carter, 2008; Dalla Villa et al., 2010; Feldmann, 1974; Garde et al., 2013; Jackman & Rowan, 2007; Lunney et al., 2011; Reece 2008; Reese, 2005). Therefore, the first priority for issues pertaining to animal welfare and health is to establish efficient population control measures. Sterilization has become a popular strategy for reducing the overpopulation of unwanted dogs or changing

undesirable habits in developing nations where the problems are more severe (Dalla Villa et al., 2010; E. Garde et al., 2016). The only approved technique for managing the dog population in India is the Animal Birth Control (ABC) program, which was launched in 2001 and is used in numerous Indian cities to vaccinate rabies and capture stray dogs. (John F. Reece et al., 2008; Thamaria, 2003). Other nations have also adopted similar catch-neuter-vaccinate-release (CNVR) programs (Jackman & Rowan, 2007; Tenzin, Ahmed, et al., 2015; Tenzin, McKenzie, et al., 2015; Totton et al., 2010). Programs like this focus on spaying bitches instead of castrating males because it is thought to be a more effective way to control the population. The idea is that fewer bitches will breed, which will reduce male aggression. Additionally, males who are not neutered can better defend the territory of their group, preventing inward migration of dogs that may carry infectious diseases like rabies (Thamaria, 2003).

Controlling the number of dogs that are allowed to roam freely is the primary objective of ABC programs (OIE, 2015). But according to a study based on observation surveys carried out in Jaipur City, the eight years that the ABC program was implemented had a significant impact on rabies reduction in addition to reducing the dog population by 28% (J. F. Reece & Chawla, 2006). Furthermore, a study indicated that the incidence of human-dog bites peaks during dog reproduction, indicating that ABC programs can lower dog bite injuries by decreasing street dogs' protective behavior toward their mothers and by lowering the overall number of roaming dogs (J. F. Reece et al., 2013). The effectiveness of ABC programs is criticized at times because these programs are not well monitored or evaluated for understanding the impact on population size and reproduction in the remaining unsterilized dog population of an area and are mainly focused on urban areas (Hiby et al., 2011; John F. Reece et al., 2008).

Communities that aspire to ABC programs that mandate surgical sterilization find it resource-intensive, and such programs require considerable financial, infrastructural, and personnel support (Belsare & Vanak, 2020; Leoci et al., 2014). As studies reported in India shows that population control strategies (ABC Programs) can be successful if such programs are implemented for years and monitored by repeated population surveys by measuring the population size and demographics of stray dogs before and

after implementing an ABC program (Carter, 2008; Hiby et al., 2011; J. F. Reece & Chawla, 2006; Totton et al., 2010). The population demographic models can be an effective tool by generating real-world scenarios in understanding the expected effort required to reduce the population size of dogs and assessing methods for achieving the target by thorough planning for successful implementation (Belsare & Vanak, 2020). An ABC program monitored in Jodhpur over a decade; the population demographic model simulations predicted that the impact of sterilization is a slow process and suggested that at the current rate of sterilization/rabies vaccination in the city, the dog population should reduce at 69% and reach stability in about 13-18 years (Totton et al., 2010). Though studies reported in Jodhpur and Jaipur suggests that sterilization is effective in reducing the dog population and may be recommended to reduce major public health concerns; however further research is required to understand the impacts of such ABC programs in other cities of India (J. F. Reece et al., 2013; Totton et al., 2011). A mathematical model developed for stray dogs concluded that sterilization is inefficient for controlling dog population even after prolonged periods of use in countries where abandonment rates are high (Amaku et al., 2010), thus in such countries, along with sterilization implementing educational programs to promote responsible animal ownership and effective strategies against abandonment practices should be imposed (Belo et al., 2017; Dias et al., 2015). Sterilization programmes are often combined with vaccination campaigns to eliminate canine-mediated human rabies, but current recommendations focus on mass dog vaccination as the most feasible and cost-effective strategy and suggest that sterilization should be viewed as a separate undertaking to rabies control (Collinsonid et al., 2020; Gibson et al., 2015).

1.4. This Thesis

The primary objective of our study was to investigate the long-term effects of sterilization in the social behaviors of sterilized dogs and compare them with non-sterilized dogs in the same natural habitat. We also examined these dogs' time activity budget (i.e., the proportions of time spent by different individuals in performing different behaviors) and any variation in sterilized male and female dogs' behaviors. The study results will extend our understanding of whether sterilization can alter social interactions, specifically the mating, affiliative, and aggressive behaviors in the population of free-ranging dogs. However, our study does not report any variation in the physiological parameters that might have been affected in the sterilized dogs during this procedure.

Chapter 3 Sterilization

This was a case study designed to Investigate the long term effects of sterilization on Indian free-ranging dogs in regards to activity levels throughout the day.

Subjects and Locations

15 sterilized free-ranging dogs in the IISER Kolkata campus (22.9638° N, 88.5245° E.).

Methods

A total of 15 sterilized dogs (11 males, 4 females) were selected in the IISER Kolkata Campus. The dogs were studied across the twenty-four hours of the day. The day's twenty-four hours were classified into diurnal and nocturnal hours, each of which was further sub-classified into two slots. The four-time blocks were -Diurnal (0600 hours -1200 hours and 1200 hours to 1800 hours) and Nocturnal (1800 hours-0000 hours and 0000 hours -0600 hours). Videos of five continuous minutes or ten continuous minutes at a time were recorded in each of these time slots for each dog. A total of eight hundred minutes of recordings were collected in each season of only sterilized dogs spread over twenty-four hours. These dogs were studied across the twenty-four hours of the day, for Pre-Mating season (June-July) and Mating season (August-September).

Data

The video recordings were decoded as instantaneous scans, taken every 30 seconds and the behaviors classified as active or inactive. Active behaviors were further classified into the following categories as mentioned in the dog lab ethogram for free-ranging dogs.

Behavioral Category	Behaviors Included
Inactive	Sleep, laid down, sitting, lazing
Active- Postures	Stand up, curl up, roll, stand, sit or stand alert, arching its back, walk, run, trot, jump
Maintenance	Hang out tongue, groom, lick self, removing insects, urinate, eat grass, scratching, urinate, yawning, rubbing, marking with urine, digging

Feeding and Foraging	Eat, drink water, foraging, chew, food search, carry food
Vocalizations	Bark, howl, growl, angry barking, whine
Affiliative	Show affiliation, tail wag, allogrooming
Affiliative associated with mating	Investigating another dog, genital sniffing, investigating urine spot, showing submissive behavior, genital licking, male noses female ear, lick the urine spot, showing play bow
Mating	Mount, Penetrate, Locking, Dismount, Try to mount, Running together, stand facing the opposite direction, over marking, nape bite, soliciting behavior
Aggressive	Fight, show aggression, bite, threaten, aggression towards approaching, does not allow, crouch down, throw the male off balance
Play	Play, Object Play, Play with others, showing play bow, mock bite, nibble dog, lick
Others	Inspect Object, Chase Dog, chase other, follow dog, follow human, follow other, approach dog, approach human, approach other, beg, dog are called by humans

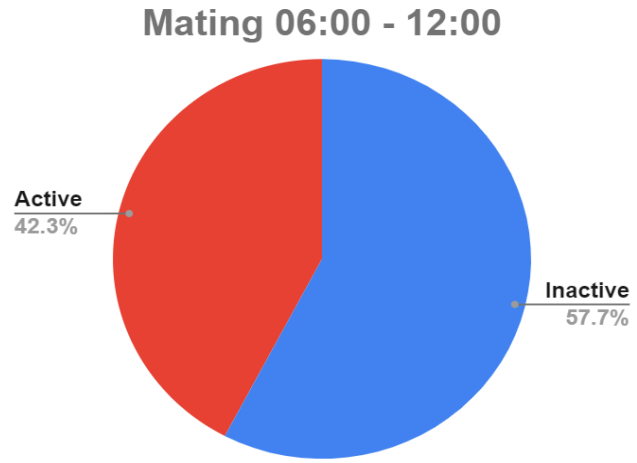
Table : Behavioral categories used for analysis based on a detailed dog lab ethogram

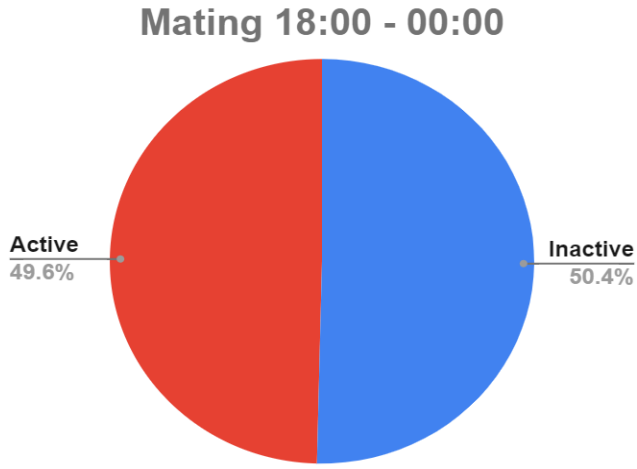
Results

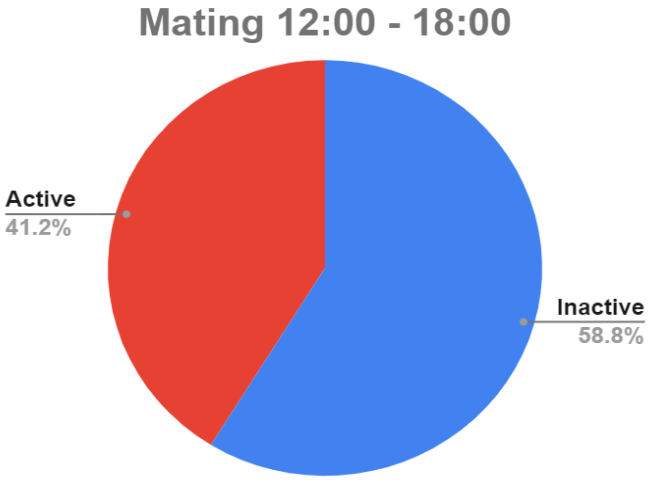
DogID	Mating					Pre-mating			
Slot	0:00	06:00 - 12:00	12:00 - 18:00	18:00 - 00:00		0:00	06:00 - 12:00	12:00 - 18:00	18:00 - 00:00
Chicku	0	18.18	18.18	63.64		13.04	0	8.69	28.57
Monkey boi	16.67	100	29.41	45.45		40	26.67	60	100
Sad face	72.73	100	100			60	40	80	88.89
Scar face	20	18.18	0	27.27		10	4.34	80	20
Coco									
Black Skull	72.73	36.36	27.27	81.82		72.73	0	36.36	100
Boltu	9.09	90.91	0	100		0	4.76	26.08	38.09
Madur	36.36	9.09	54.55	36.36		0	42.85	0	30
Pikachu	58.33	54.545	94.44	0		13.04	80	27.27	30.43
Total black	72.72	54.54	63.64	72.73		30			
Jon Snow							34.78		
Mete	45.45	9.09	66.67	63.64		0	36.86	31.57	0
Problem						0	77.27	100	
Leo	100	27.27	33.33	0		36.36	0	4.54	63.64
Round	54.55	0	10	36.36		7.142	0	20	4.54
Total	46.61	42.31	41.21	49.61		23.76	17.41	32.35	50.45

The dogs included in this study with their activity levels as percentages.

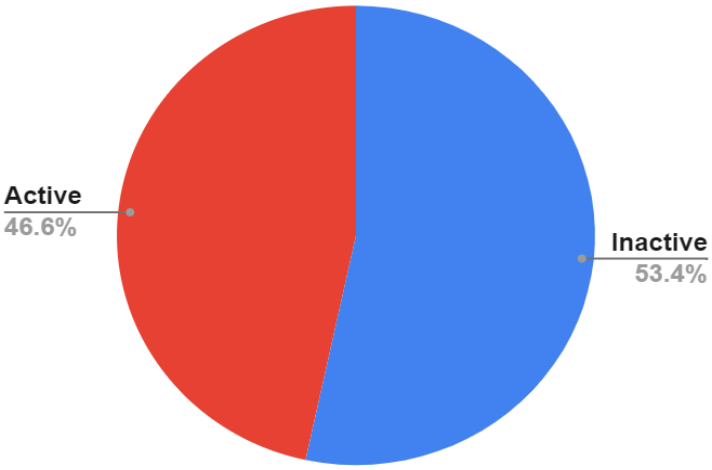
The activity levels in the four time slots in the two seasons can be visualized as follows:



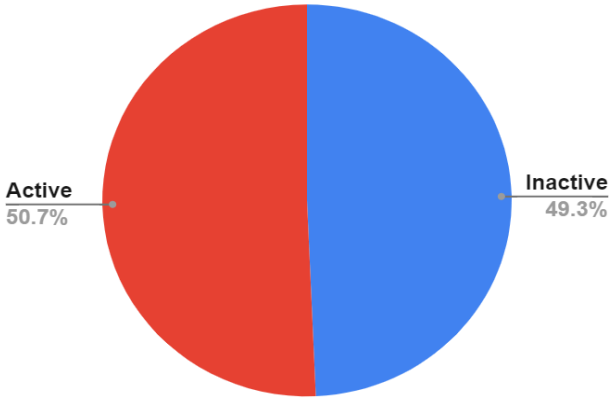




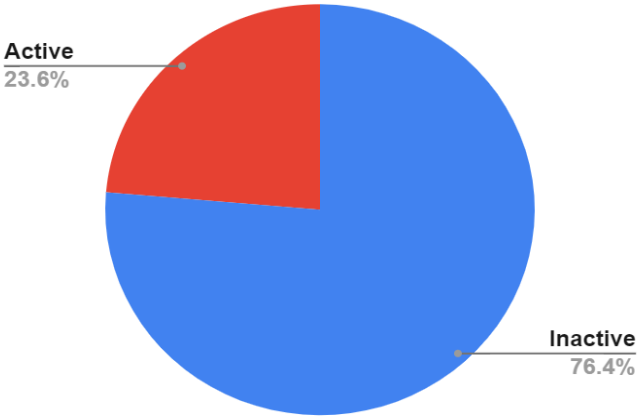
Mating 00:00 - 06:00

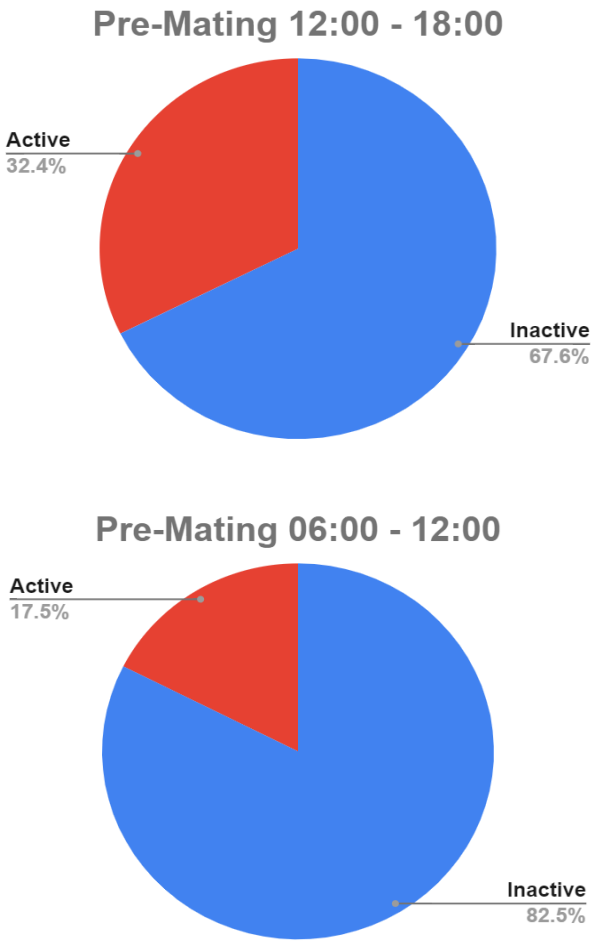


Pre-Mating 18:00 - 00:00



Pre-Mating 00:00 - 06:00





Graph: Activity levels in different time slots across 2 seasons

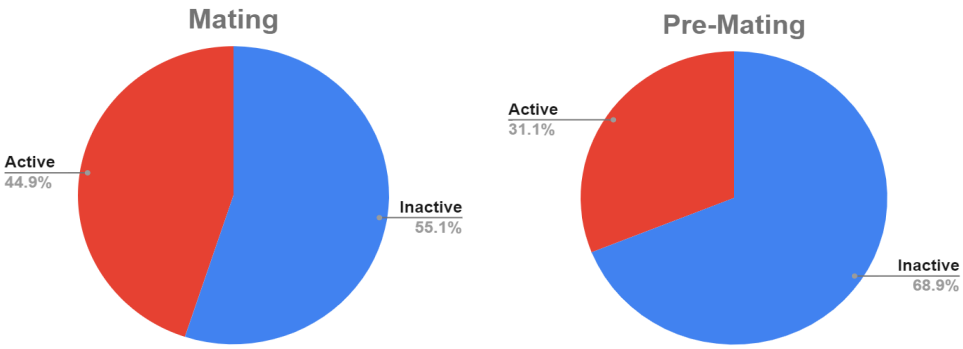
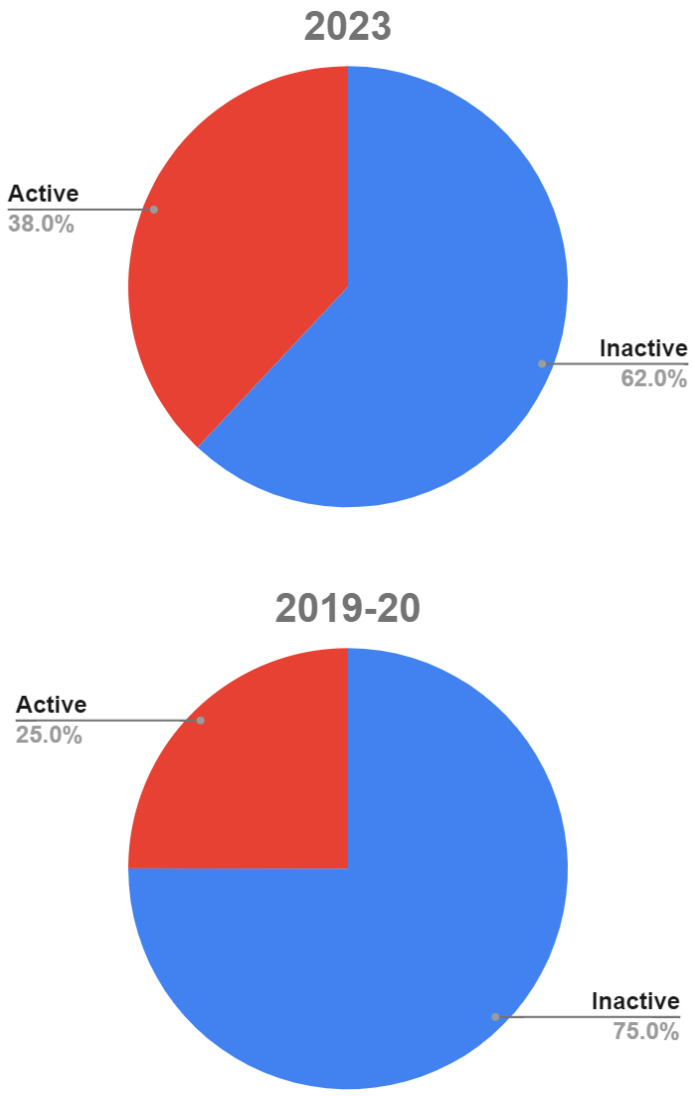


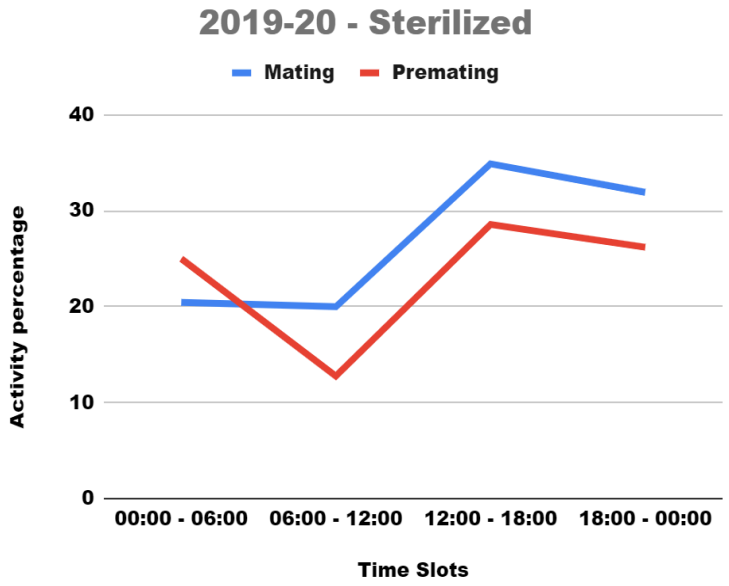
Figure:24 hour activity levels in the mating and pre-mating seasons

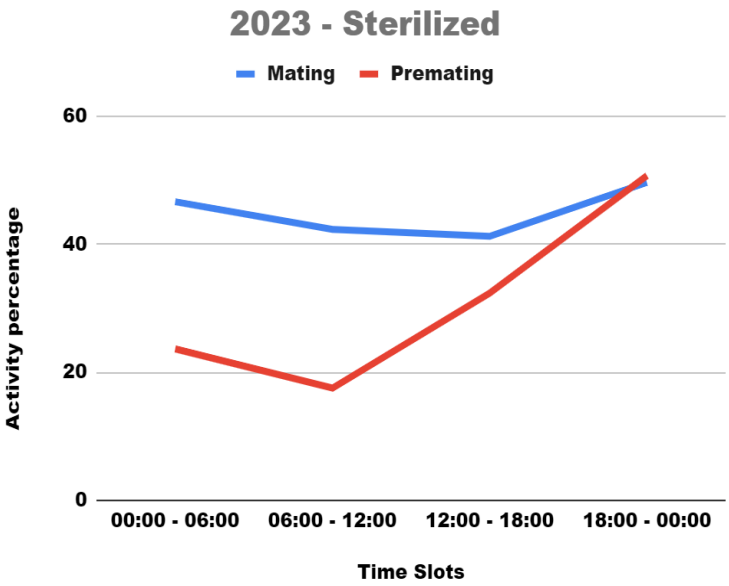
Discussion

These results were compared to those of a study done previously by Rituparna Sonowal* - “A Case Study- Effects of surgical sterilization on social behaviors of free-ranging dogs in India” (unpublished). The original study was designed to compare between activity levels of sterilized and unsterilized dogs to investigate the effects of sterilization.

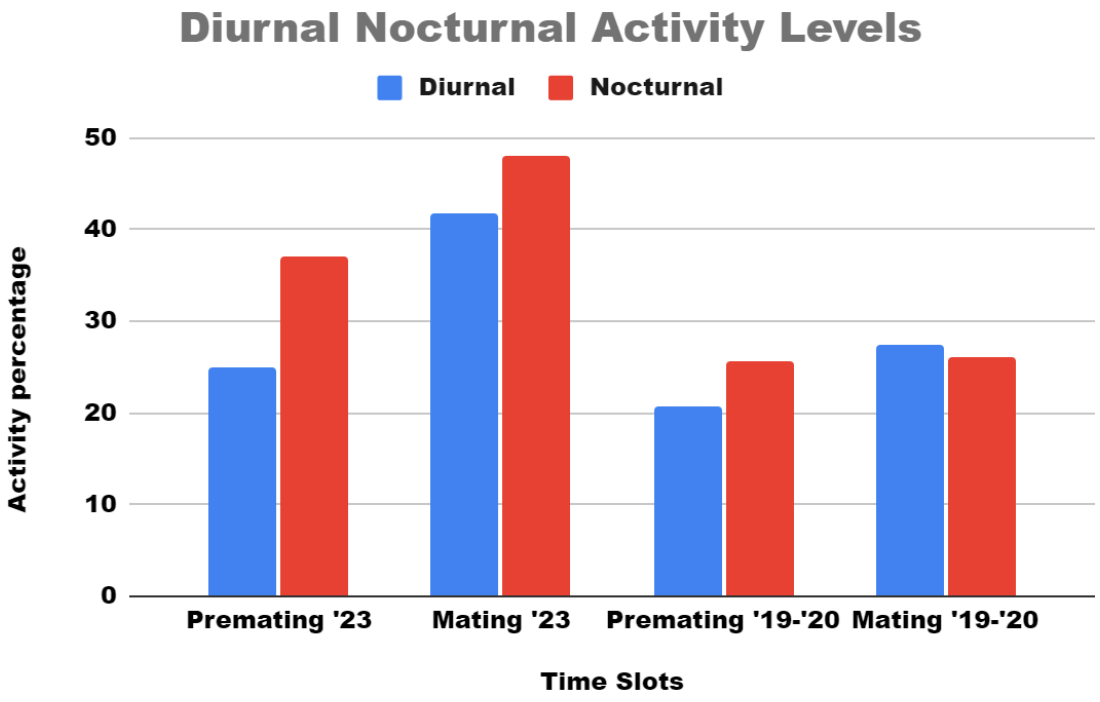


Graph: 24 hour activity levels in the mating and pre-mating seasons across y

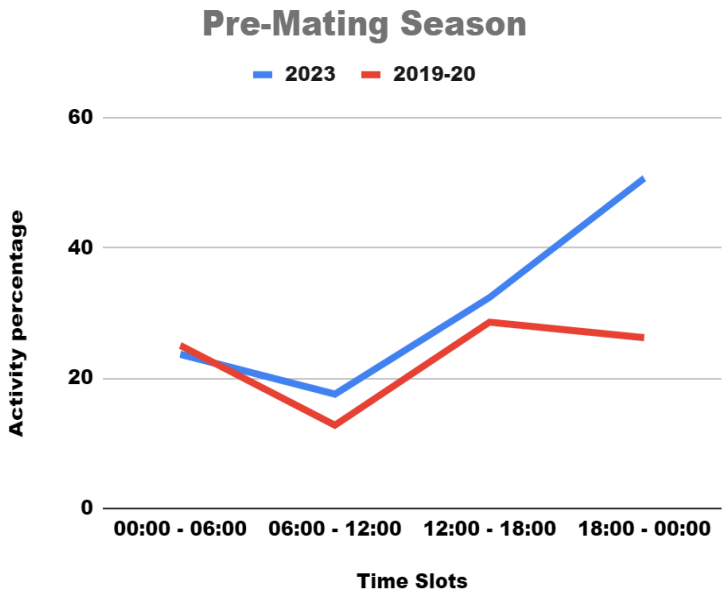


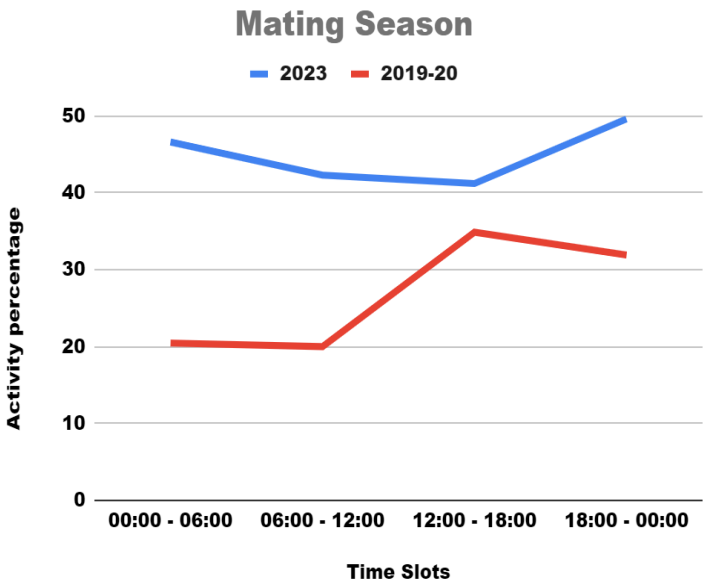


Graph: Activity levels in the mating and pre-mating seasons in the two years



Graph: Activity levels during day and night in the two years in the mating and pre-mating seasons


Pre-Mating Season
2023
2019-20
60
40
20
0
Activity percentage
00:00 - 06:00
06:00 - 12:00
12:00 - 18:00
18:00 - 00:00
Time Slots


Mating Season
2023
2019-20
50
40
30
20
10
0
Activity percentage
00:00 - 06:00
06:00 - 12:00
12:00 - 18:00
18:00 - 00:00
Time Slots

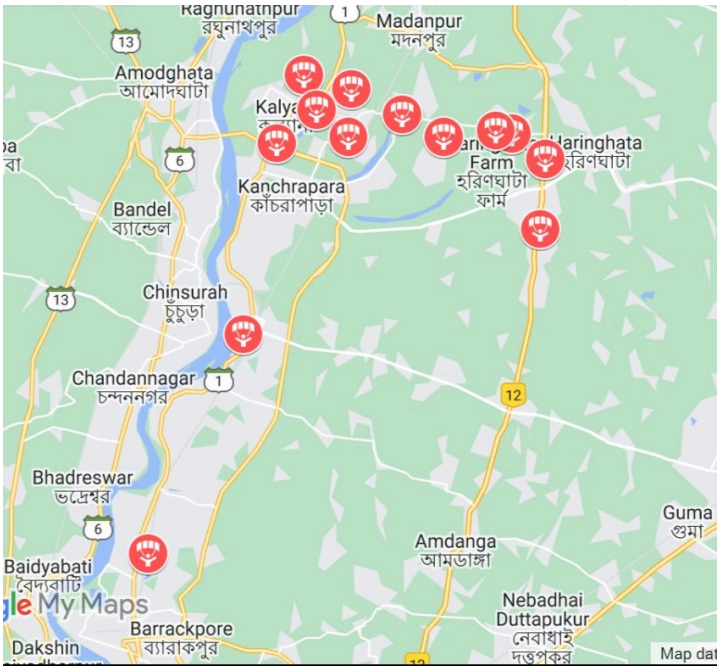
Chapter 2 Census

This study was designed to study the changes in population parameters of Indian free-ranging dogs in urban and semi-rural settings in and around Kalyani in an extensive longitudinal study conducted through one-time spot censuses.

Subjects and Locations

Free-ranging dogs in and around Kalyani (30.3024" N, 88° 26' 4.2324" E.), (the nearest city to the IISER Kolkata campus) West Bengal, India, were included in this study. Thirteen different locations were included:

D block, Kalyani
C Block, Kalyani
A block, Kalyani
Buddhapark area, Kalyani
Jaguli
Haringhata
Anandanagar
Basantapur
Naihati
Gyeshpur, Kalyani
7no, IISERK
Near Station, Icchhapur
Pourasabha More, Kalyani



These locations are spaced out as shown in the map.

Methods

Data collection involved one-time spot censuses of free-ranging dogs at various urban and semi-urban localities in and around Kalyani. The enumeration was done at 13 different locations as mentioned above. Upon a dog spotting, the sex and age of the dog were noted (Pups and juveniles were both categorized as juveniles whereas adults and sub-adults were both categorized as adults). Data collection was done on foot and dogs spotted within range of vision on walking on the streets were included in the data. Data collection was mostly done during daylight hours to ensure clear visibility to help discern the age and sex of the dog correctly.

The same localities were sampled from in two seasons:

- pre – mating (June to mid August)
- mating (mid August to mid October).

A total of 754 dogs were enumerated across the two seasons (451 in the mating season and 303 in the pre-mating season).

Results

The census collected data for the pre-mating season in the different locations is as follows:

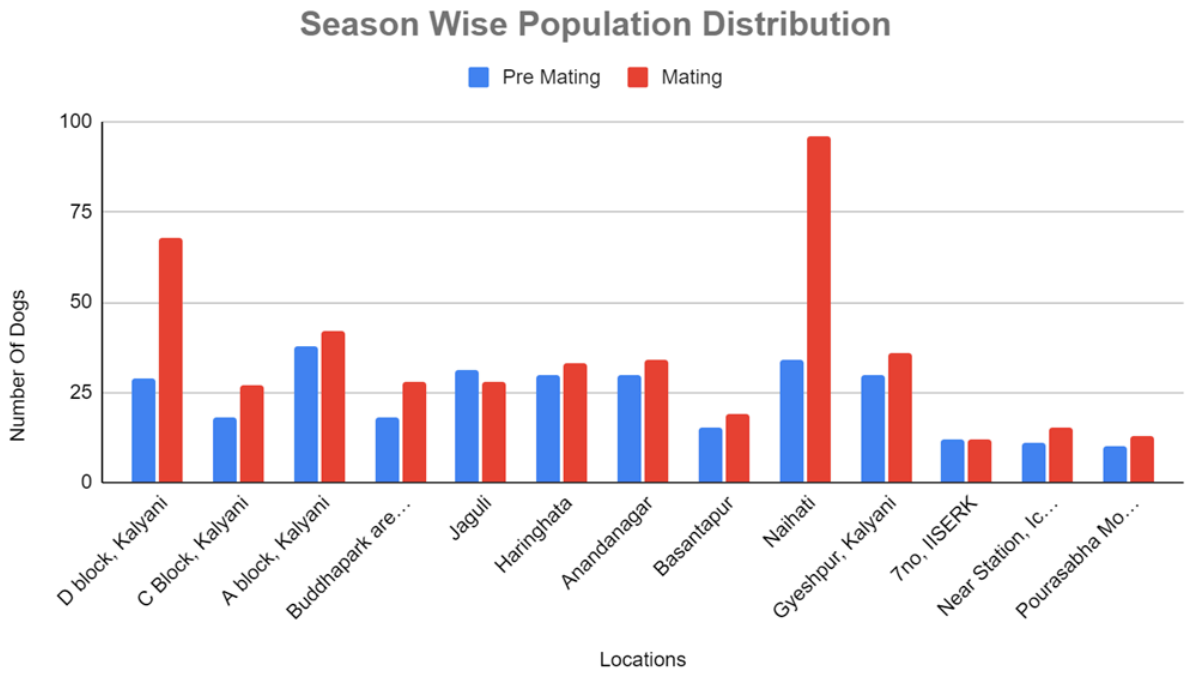
Location	Male Juvenile	Male Adult	Female Juvenile	Female Adult	Male	Female	Adult	Juvenile	Total
D block, Kalyani	7	10	3	9	17	12	19	10	29
C Block, Kalyani	4	7	1	6	11	7	13	5	18
A block, Kalyani	6	18	4	10	24	14	28	10	38
Buddhapark.	0	12	2	4	12	6	16	2	18
Jaguli	6	12	2	11	18	13	23	8	31
Haringhata	4	16	3	7	20	10	23	7	30

Anandanagar	6	13	1	10	19	11	23	7	30
Basantapur	2	7	2	4	9	6	11	4	15
Naihati	1	13	2	15	14	17	31	3	34
Gyeshpur, Kalyani	2	15	1	12	17	13	27	3	30
7no, IISERK	1	6	0	5	7	5	11	1	12
Near Station, Icchhapur	1	5	1	4	6	5	9	2	11
Pourasabha More,	0	6	0	4	6	4	10	0	10
Total	40	140	22	101	180	123	241	62	303

The census collected data for the mating season in the different locations is as follows:

Location	Male Juvenile	Male Adult	Female Juvenile	Female Adult	Male	Female	Adult	Juvenile	Total
D block, Kalyani	3	33	2	30	36	32	63	5	68
C Block, Kalyani	1	13	0	13	14	13	26	1	27
A block, Kalyani	2	18	0	22	20	22	40	2	42
Buddhapark.	0	18	0	10	18	10	28	0	28
Jaguli	1	11	1	15	12	16	26	2	28
Haringhata	4	12	3	14	16	17	26	7	33
Anandanagar	2	15	1	16	17	17	31	3	34
Basantapur	0	10	0	9	10	9	19	0	19
Naihati	6	44	9	37	50	46	81	15	96
Gyeshpur, Kalyani	0	21	0	15	21	15	36	0	36
7no, IISERK	0	7	0	5	7	5	12	0	12
Near Station, Icchhapur	1	9	1	4	10	5	13	2	15

Pourasabha More,	0	8	0	5	8	5	13	0	13
Total	40	140	22	101	180	123	241	62	451



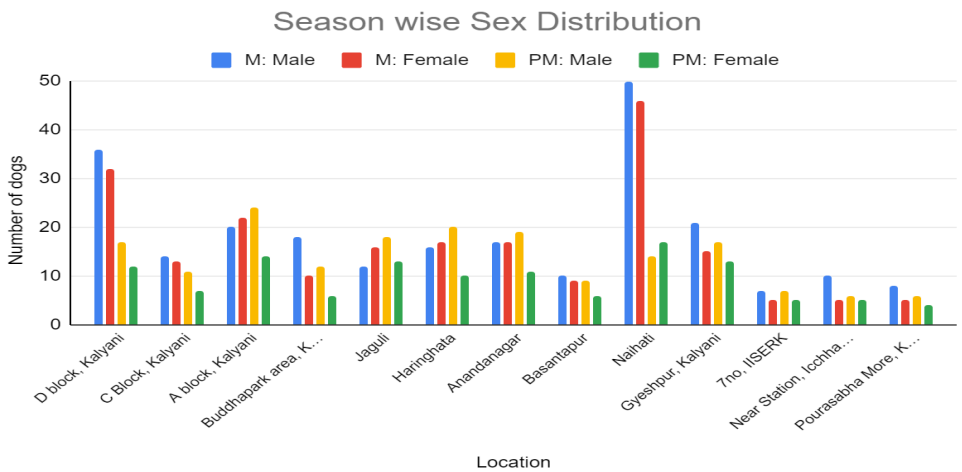
Graph : Location wise distribution of dogs across the two seasons

In the pre- mating season, the average female to male ratio was found to be 86.48 per 100 whereas, in the mating season, the average female to male ratio was found to be 68.33 per 100.

	Pre-mating				Mating			
Location	Male	Female	Sex Ratio	Total	Male	Female	Sex Ratio	Total
D block, Kalyani	17	12	70.58823529	29	36	32	88.88888889	68
C Block, Kalyani	11	7	63.63636364	18	14	13	92.85714286	27
A block, Kalyani	24	14	58.33333333	38	20	22	110	42
Buddhapark.	12	6	50	18	18	10	55.55555556	28
Jaguli	18	13	72.22222222	31	12	16	133.3333333	28
Haringhata	20	10	50	30	16	17	106.25	33
Anandanagar	19	11	57.89473684	30	17	17	100	34
Basantapur	9	6	66.66666667	15	10	9	90	19

Naihati	14	17	121.4285714	34	50	46	92	96
Gyeshpur, Kalyani	17	13	76.47058824	30	21	15	71.42857143	36
7no, IISERK	7	5	71.42857143	12	7	5	71.42857143	12
Near Station, Icchhapur	6	5	83.33333333	11	10	5	50	15
Pourasabha More, Kalyani	6	4	66.66666667	10	8	5	62.5	13
Total	180	123	68.33	303	239	212	86.48015873	451

Table: Population level sex distribution of dogs in the locations targeted

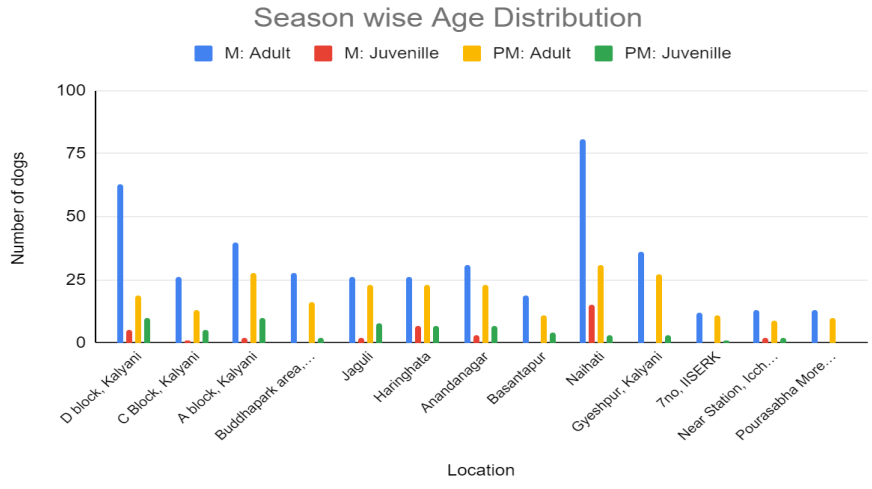


Graph : Population level sex distribution of dogs in the locations targeted across seasons

In the pre- mating season, the average juvenile to adult ratio was found to be 7.66 per 100 whereas in the mating season, the average juvenile to adult ratio was found to be 25.73 per 100.

	Pre-mating				Mating			
Location	Adult	Juvenile	Juv:adult Ratio	Total	M: Adult	M: Juvenille	Juv : Adult Ratio	Total
D block, Kalyani	19	10	52.63157895	29	63	5	12.6	68
C Block, Kalyani	13	5	38.46153846	18	26	1	3.846153846	27
A block, Kalyani	28	10	35.71428571	38	40	2	5	42
Buddhapark.	16	2	12.5	18	28	0	0	28
Jaguli	23	8	34.7826087	31	26	2	7.692307692	28
Haringhata	23	7	30.43478261	30	26	7	26.92307692	33
Anandanagar	23	7	30.43478261	30	31	3	9.677419355	34
Basantapur	11	4	36.36363636	15	19	0	0	19
Naihati	31	3	9.677419355	34	81	15	18.51851852	96
Gyeshpur, Kalyani	27	3	11.11111111	30	36	0	0	36
7no, IISERK	11	1	9.090909091	12	12	0	0	12
Near Station, Icchhapur	9	2	22.22222222	11	13	2	15.38461538	15
Pourasabha More, Kalyani	10	0	0	10	13	0	0	13
Total	241	62	25.726141	303	414	37	7.664776286	451

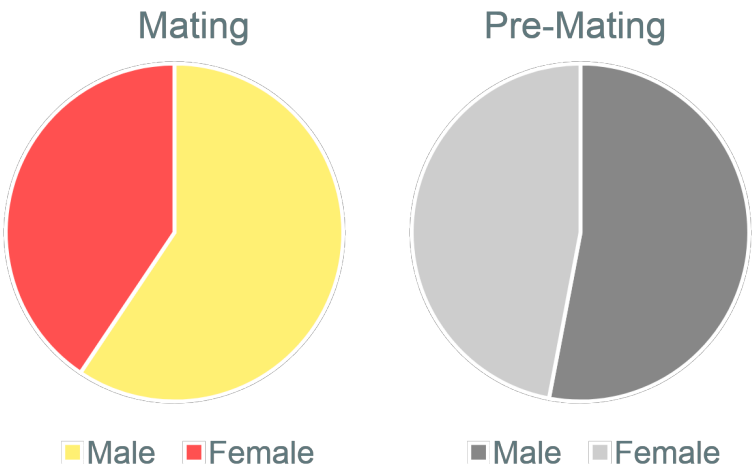
Table: Population level age distribution of dogs in the locations targeted



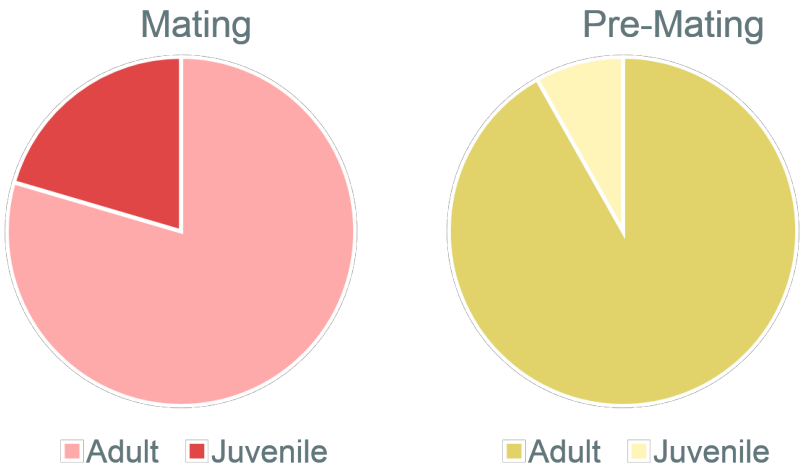
Graph : Population level age distribution of dogs in the locations targeted across seasons

In the pre- mating season, there were 123 females encountered and 180 males which is a statistically significant disparity in numbers (Chi square test: X2 = 10.72, p = 0.001, significant at p<0.05), whereas, in the mating season, there were 212 females encountered and 239 males which is similar at a statistically significant level (Chi square test: X2 = 0.029, p = 0.58, not significant at p<0.05).

In the pre- mating season, there were 241 adults encountered and 62 juveniles whereas, in the mating season, there were 414 adults encountered and 37 juveniles.



Graph : Representative fraction of sex distribution of dogs in the locations targeted

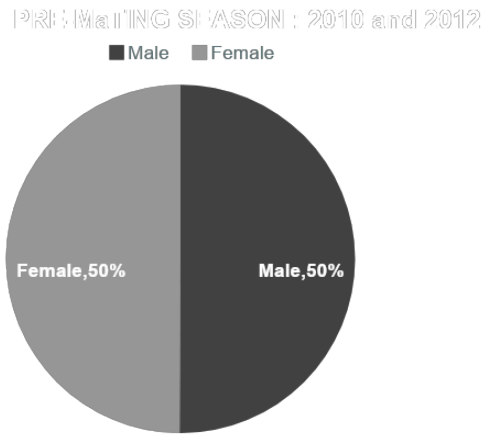


Graph : Representative fraction of sex distribution of dogs in the locations targeted

Discussion

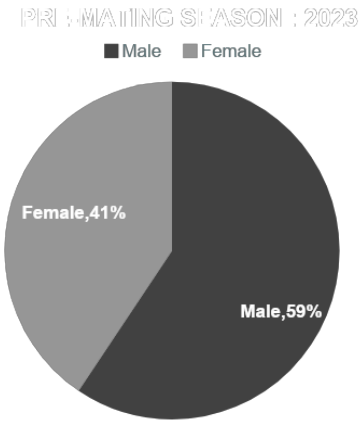
These results were compared to those of a study done previously by Sen Majumder et.al., 2013.

Pre-mating season:



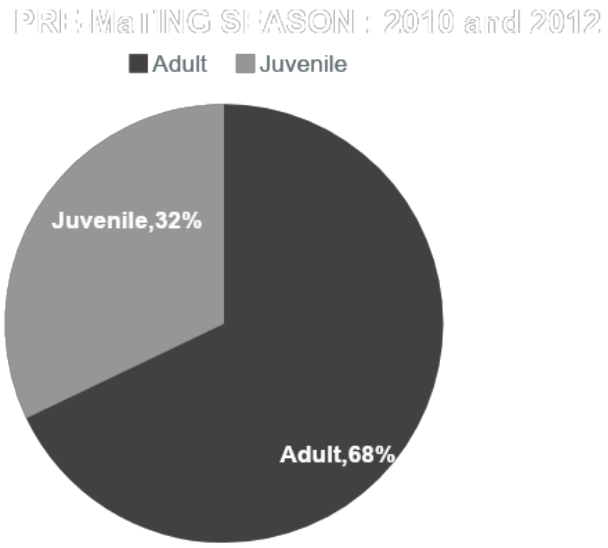
Chi square test:

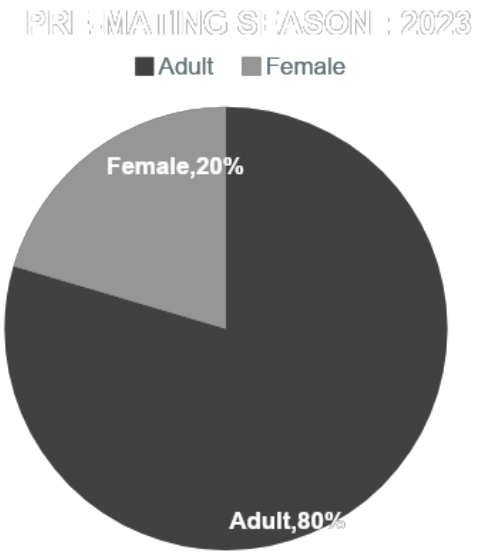
X2 = 0.002. p = 0.97.*not significant at p<0.05’



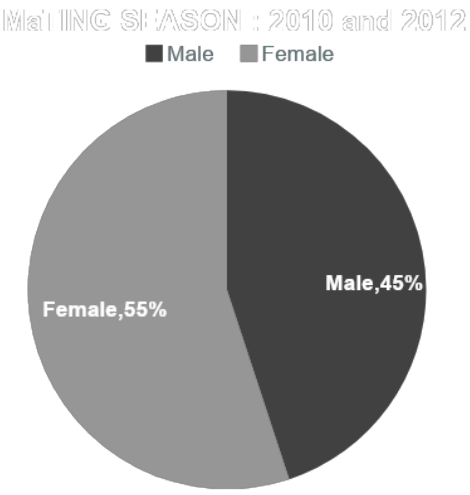
Chi square test:

X2 = 10.72. p = .00106.*significant at p<0.05.



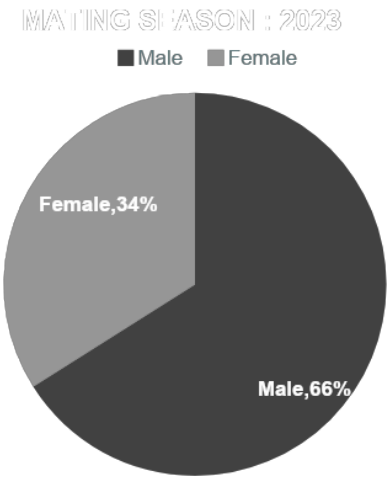


Mating season:



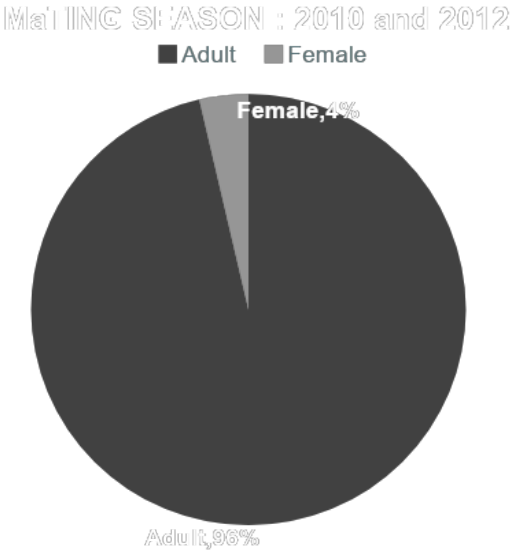
Chi square test:

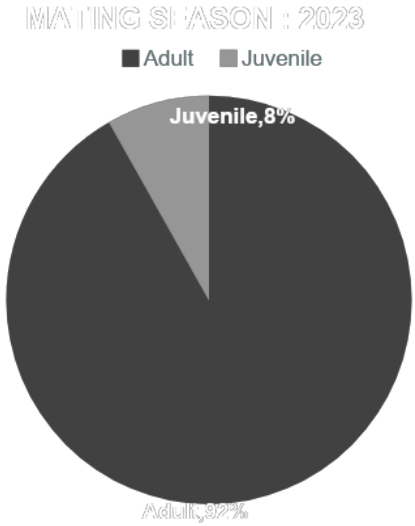
X2 = 0.4199. p = .517006.*not significant at p<0.05.



Chi square test:

X2 = 0.6926. p = .405279.*not significant at p<0.05.


Mating season : 2010 and 2012
Adult
Female
Female,4%
Adult,96%


MATING SEASON : 2023
Adult
Juvenile
Juvenile,8%
Adult,92%

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