GIS ANALYSIS OF STRAY DOGS ATTACKS IN THE MUNICIPALITY OF CENTAR IN THE CITY OF SKOPJE

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Svemir GORIN, Arse KUZMANOSKI, Ivan RADEVSKI, Olgica DIMITROVSKA, Emilija MANEVSKA
Institute of Geography, Faculty of Natural Sciences and Mathematics,
Ss. Cyril and Methodius University in Skopje, 1000 Skopje, North Macedonia
e-mail: svemir@pmf.ukim.mk

ABSTRACT

In the last few years, in addition to other municipalities, the Municipality of Centar, as a central urban part of the City of Skopje, has been faced with the presence of a number of stray dogs, which threatens the safety of the citizens. The expansion of street stray dogs creates an ongoing current problem that covers all age groups of citizens because dog bites in humans are a complex problem that covers public health and the welfare of the population and animals. This paper covers the recorded attacks by stray dogs, the demographic predisposition, and the spatial and temporal characteristics of bites by stray dogs in the territory of the Municipality of Centar in the period from 2018 to 2023. A total of 639 attacks and bites by stray dogs, which were registered in the regional units of the Ministry of the Interior, were analyzed. From the total number of recorded bites, 596 (93.27%) attacks were committed by a single stray dog, while 43 (6.73%) attacks were by a pack of dogs. Also, in 231 (36.15%) cases, the attacked persons are female, while in 407 (63.85) cases, the attacked persons are male. Regarding the age of the attackers, 58 cases (9.06%) are minors (0–17 years), while 581 cases (90.94%) of the attackers are adults. The aim of the paper is to locate the hotspots of attacks by stray dogs throughout the municipality by applying geographical information methods. Also, by using GIS, it is possible to create the so-called "geography of homeless animals" of the studied territory, which will allow a better understanding and may even lead to better management of the situation of stray animals.

Keywords: Stray dogs attack, GIS, Medicine geography, Skopje, Municipality of Centar

INTRODUCTION

According to the Law on the Protection and Welfare of Animals, published in the "Official Gazette of the Republic of Macedonia", no. 149/2014, Article 28, the municipalities in the city of Skopje, are competent to collect homeless dogs, i.e., unregistered dogs and registered dogs, if they are found on public lands without the presence of the owner, and to temporarily place them in appropriate facilities - shelters. In these facilities, elementary protection of the animals from unfavorable weather conditions should be ensured, and their effective closure should be estabish (Official Gazette of the Republic of Macedonia, 2014). Stray dogs in the last few years have represented a significant security problem for the residents of the municipality of Centar, because with each attack, the safety and health of the population are directly threatened, but at the same time, humans are one of the main factors for the appearance of the large

number of street dogs that appear through the streets of Centar. However for solving the problem with stray dogs, one important link is missing, and that is the registration of dog kennels (Trajkov, 2023). But with the adopted proposal-amendments and additions to the Animal Welfare Law, the establishment of a system for controlling the reproduction of dogs is foreseen through the registration of kennels and the registration of registered dog breeders. With this measure, owners of pet dogs who do not want to keep their pet for reproduction (do not want to register as a kennel or registered dog owner) are required to sterilize the pet (FVA, 2022). It is also estimated that irresponsible pet ownership and abandonment are two of the biggest sources of homeless dogs in urban and rural areas.

There is no official number, record or national registry of street dogs within the Municipality of Centar, City of Skopje, in the Republic of North Macedonia, but in the registry of the FVA (Food and Veterinary Agency), 72.156 pets are registered, of which 69.234 are dogs (FVA, 2024). But the number of attacks and bites by stray dogs is not only a problem in our country, but also in European countries (Alberghina et. al., 2023; Cianciara et al., 2022; Sarenbo & Svensson, 2021; Mara et al., 2018; Fragoso et al., 2022; Rosado, 2008), in the territory of Australia (Rajshekar et al., 2017) and the United States of America (Langley, 2009; Bregman & Slavinski, 2012; Vertalka et al., 2018), Mexico (Quezada-Nolasco et. al., 2023; Brock, 2018), Uruguay (Roman et al., 2023), Kenya (Kung′ u, & Brodbelt, 2023), India (Masthi & Vairavasolai, 2016) where numbers are increasing every year.

Usually, the attacks are incited and carried out by the street dog, but there are also rare cases when the main initiator of the attack and bite is the person himself (Trajkov, 2023). Also, several studies indicate that the male population is most affected by dog bites (Alberghina et. al., 2023; Alam et al., 2020; Benfield et al., 2010; Bregman & Slavinski, 2012; Roman et al., 2023; Rosado, 2008; Morgan & Palmer, 2007; Georges, & Adesiyun, 2008), where also in this paper, based on the processed data, it is confirmed. However, no relationships were found between income and the level of education, marital status, or ethnic and racial composition of persons attacked by stray dogs. However, there is limited, incomplete information on dog bites in Skopje, due to the lack of a comprehensive reporting system, which would include several institutions such as outpatient centers, hospitals, and the food and veterinary agency, since the data is reported exclusively in the regional centers of the Ministry of Internal Affairs on the territory of the City of Skopje. According to the practice guideline for medical care for bite wounds, published by the Ministry of Health (Ministry of Health, 2015), dog bites are the most common, followed by cat and human bites, dog wounds become infected in 5-20% from cases and bites on the limbs and face can be accompanied by invoices.

AIM OF STUDY

The main purpose of the study is to represent the spatio-temporal analysis and hot spots of stray dog attacks in the territory of the municipality of Centar in the period from 2018 to 2023, through the application of Geographic Information Systems.

DATA AND METHODS

Study Area

The Municipality of Centar covers the central part of the City of Skopje. This includes Macedonia Square, both banks of the Vardar River, and part of the extreme northern slopes of the Vodno Mountain. Within its territory, there are several administrative buildings, including the Government, Parliament, ministries, state offices, agencies and administrations. The rectory of the Skopje University "St. Cyril and Methodius" together with several faculties and the assembly of the city of Skopje. On the northern side, the municipality of Centar borders with the municipality of Chair, on the northeast it borders with the municipality of Gazi Baba, while on the eastern side, Centar borders with the municipality of Aerodrom, and it extends from the International Railway and Bus Station, to the Tobacco Factory and the Ministry of Interior (Ministry of the Interior). On the southeast side, Centar borders the municipality of Kisela Voda, while on the south side, the municipality of Centar borders the municipality of Karposh, and it stretches from the Vodno intersection to the old part of the City Park in Skopje (Agency for Real Estate Cadastre, 2024).

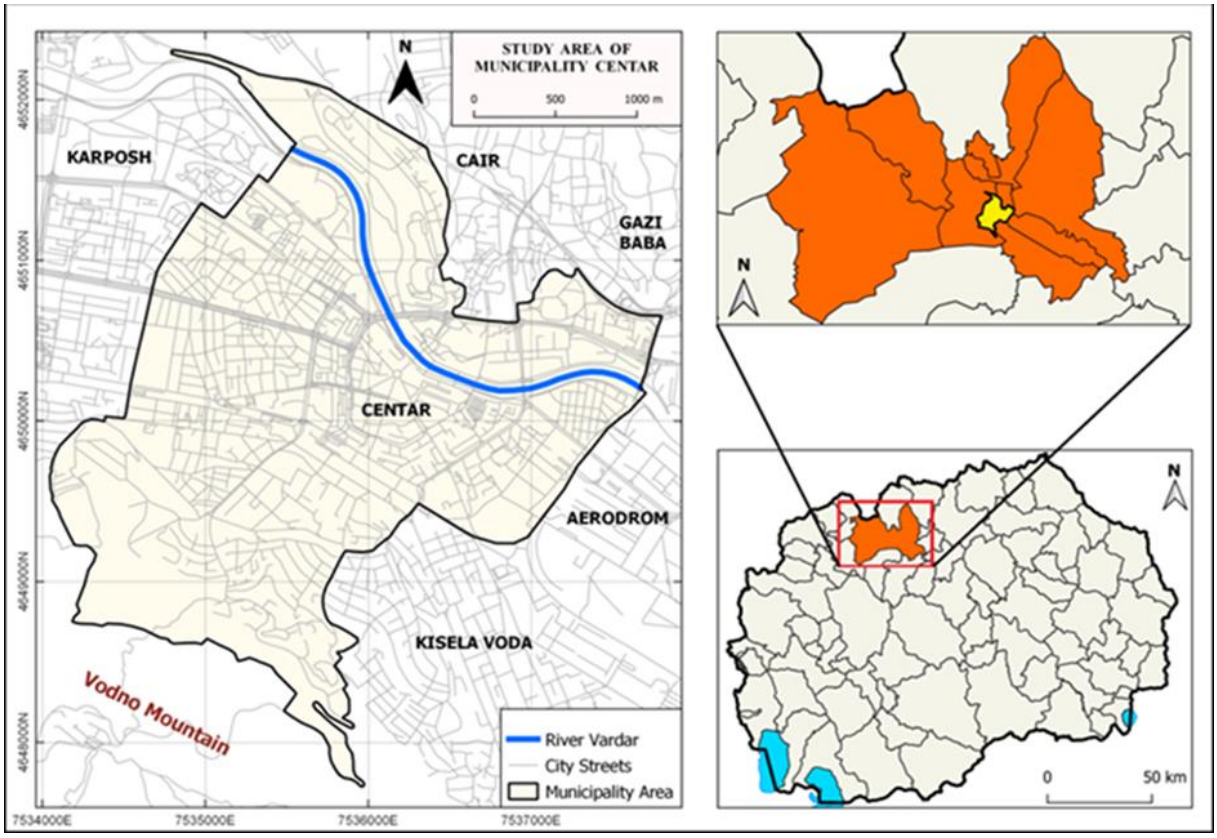

Figure 1. Municipality of Centar, City of Skopje.

Within these borders, the municipality of Centar covers an area of 7.52 km^2 and borders five neighboring municipalities. According to the absolute altitude of 320 meters, it is counted among the lowest municipalities in the country (Municipality of Centar, 2023). It has a northeast-southwest direction. Based on the last consolidated census of 2021, 43,893 inhabitants live

within the municipality (State Statistics Office, 2022) and it is one of the most densely populated municipalities in the Republic of North Macedonia, with 5,837 people per km^2.

Data collection

Since dog attacks are a complex problem, characterized by a spatial-temporal character, they are reported to the regional units of the Ministry of Interior. Reported cases of attacks by stray dogs are mostly reported by the attacked persons themselves, during the same day, while for minors, the cases are reported by their parents (Daily Bulletin, Ministry of Interior). The data on stray dog bites, which is publicly available on the website of the Ministry of Internal Affairs. For this paper, data spanning from 11.01.2018, to 29.12.2023, was analyzed. It is necessary to state that at the beginning of the first three years of reporting stray dog attacks until 19.05.2020, in addition to the basic data on the time and location of the event and the age and gender of the attacked person, it was also recorded in which area of the body, the affected person was attacked by the stray dog, while from 20.05.2020, are no longer entered in the daily bulletins, which significantly affects the overall analysis of stray dog attacks.

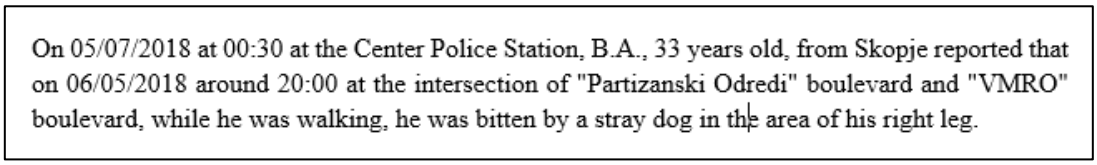
On 05/07/2018 at 00:30 at the Center Police Station, B.A., 33 years old, from Skopje reported that on 06/05/2018 around 20:00 at the intersection of "Partizanski Odredi" boulevard and "VMRO" boulevard, while he was walking, he was bitten by a stray dog in the area of his right leg.

Figure 2. Excerpt from the daily bulletin of the Ministry of the Interior for 07 May 2018. (Source: https://mvr.gov.mk/izvadok-od-dnevni-nastani/1118). Translated by the authors

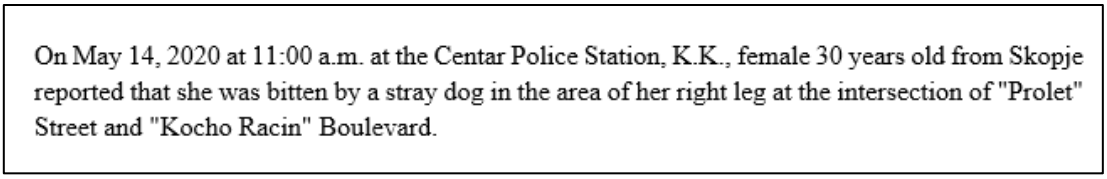
On May 14, 2020 at 11:00 a.m. at the Centar Police Station, K.K., female 30 years old from Skopje reported that she was bitten by a stray dog in the area of her right leg at the intersection of "Prolet" Street and "Kocho Racin" Boulevard.

Figure 3. Excerpt from the daily bulletin of the Ministry of the Interior for 14 May 2020. (Source: https://mvr.gov.mk/izvadok-od-dnevni-nastani/1862). Translated by the authors

In terms of spatial data, the administrative boundaries of the municipality of Centar and the settlements that are an integral part of the studied area are taken from the publicly available websites of the Agency for Real Estate Cadastre of the Republic of North Macedonia (Agency for Real Estate Cadastre, 2024) and the urban plan of Municipality of Centar. In addition, for the spatial layout of road infrastructure, green areas and parks, educational institutions, and other infrastructure facilities, data from Open Street Map (OSM, 2024) and desktop Google Earth Pro (Google Earth, 2024) were taken from Open Source.

Methods and Analysis

Because the research period span from 2018 to 2023, with a total of 639 reported cases of attacks by stray dogs, a descriptive method of analyzing and presenting the data will be approached, calculation of the total incidence of bites as well as the incidence by sex, stray dog

attacks by days, months and spatial locations are included. Statistical data were calculated using Microsoft Excel. Spatial analyses were also conducted simultaneously using QGIS (version 3.32.2) software, which was used in the development of map displays of hotspots using dog bite data identified from Ministry of Internal Affair daily bulletin data as well as census data of the population in 2021 as official data for the population in the municipality of Centar.

RESULTS

Based on the analyzed data on the reported bites of stray dogs, it was recorded that most of the attacks take place in an open space, mostly on the trim paths and the quay of the Vardar river and through the city boulevards, i.e., where there is an increased frequency of people. As stated in the data and methods section, until May 19, 2020, in the daily bulletins of the Ministry of the Interior, in addition to the time, location, age and gender of the attacked person, it was recorded in which part of the body the injury occurred from the attack of a stray dog. So out of a total of 639 reported attacks, 255 registered cases have a record of the type of injury, while in 384 registered cases, that information is missing

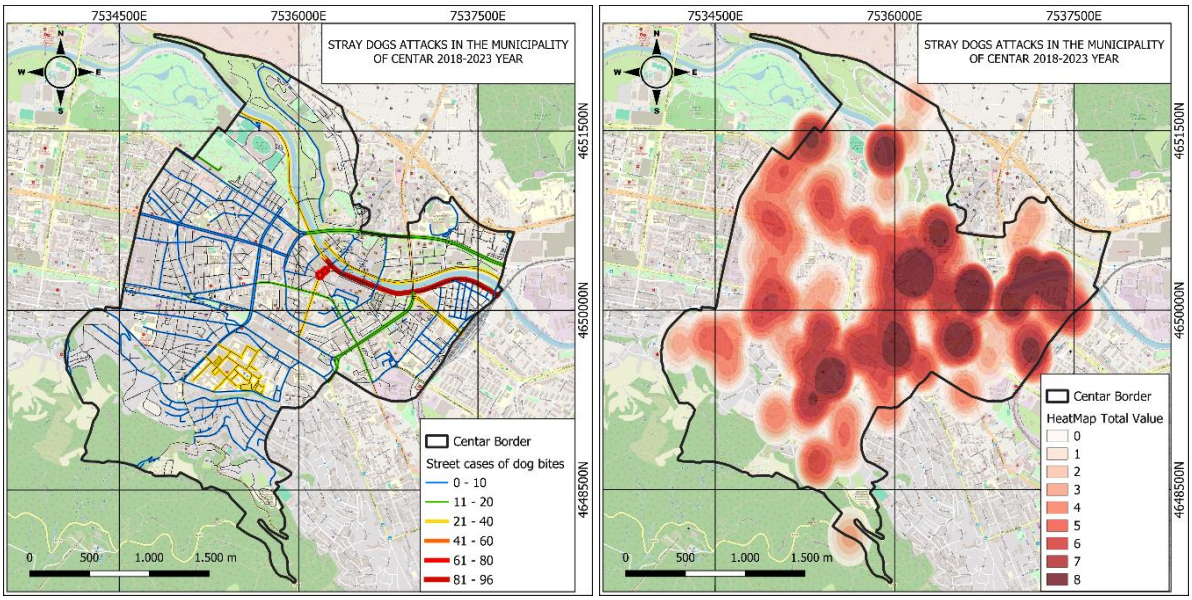

Figure 4. Stray dogs attack in the Municipality of Centar, period 2018-2023.
Left map: Stray dog attack per streets. Right map: Heatmap of all stray dogs attacks.

According to the age of the attacked people, out of a total of 639 reported cases, minors under the age of 18 are 58 registered cases, i.e., 9.07% of the total number of cases reported to the Ministry of the Interior, while 588 registered cases are people aged 18 and over. Of them, 57% are male minors (33 reported cases), while 43% of those attacked, are female (25 cases). According to the distribution of bites by day, most minor children are attacked on Mondays and Saturdays, while the lowest number of registered attacks are on Fridays. Regarding the time of occurrence of an attack by stray dogs, the most were registered between 20:00 and 21:00 pm, while the lowest number of attacks were registered between midnight and 07:00 in the morning.

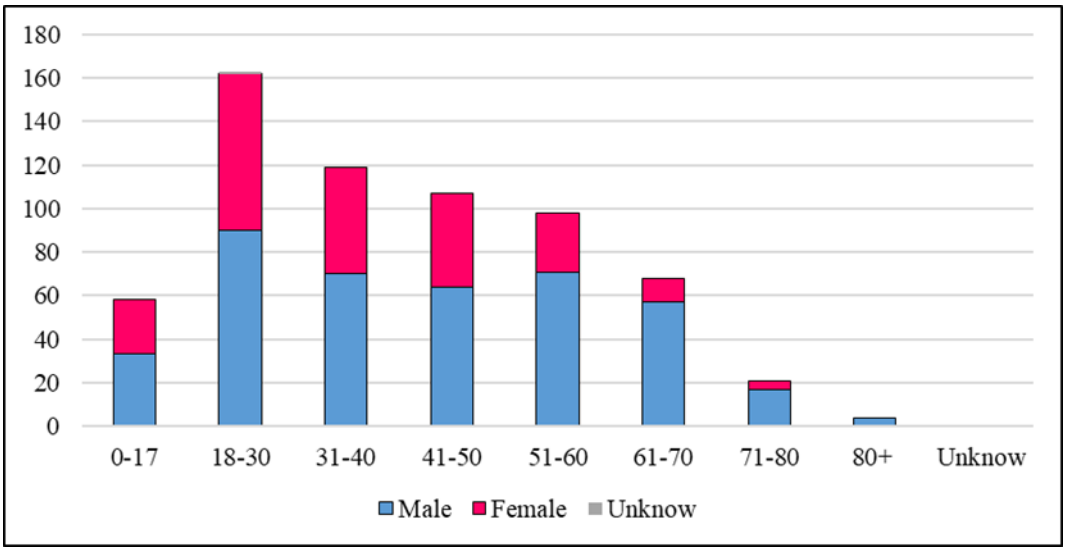

Figure 5. Age and gender of persons attacked by canines in Canter, year 2018-2023.

According to age, there are 61 registered cases of stray dog bites (9.54% of all reported cases) among the individuals over 65 years of age. The representation of young people up to 18 years old and people over 65 years age has an almost equal percentage share in relation to the total number of reported cases of attacks by stray dogs. According to the gender structure, 10 cases of injured persons are female (16.4%), while 51 cases of injured people are male (83.6%). In terms of the time of occurrence of bites from stray dogs on individuals aged 65 and over, the most common time of bite is between 1-2 pm (11 reported cases), then from 11-12 am (10 reported cases), while in the late night hours from 21:00 to 06:00 in the morning only one case was reported. We can notice that stray dogs most often attack the individuals over 65 years of age in the morning and afternoon during the day, while at night, the number is drastically lower. If the overall data is taken, out of 639 reported cases of dog attacks, 407 reported cases are male (63.7% of cases), while 231 reported cases are female (36.15% of cases). Only in one case the gender of the person who was injured by the bite of a stray dog was not specified.

In 2018, the incidence rate was 19.14 per 10,000 inhabitants, and the highest value was in 2019, when it was 36.38. This is due to the increased number of reported cases (161 bites), which is twice as high as the previous year in 2018 (84 bites). From 2018 until 2022, there has been a continuous decrease in the incidence rates, which in 2020 is 26,65, in 2021 is 21,87 and in 2022 is 18.23, because in that year, the number of reported cases was 80, and it represents the lowest number of cases in the entire six-year examined period. In the next year, 2023, a slight increase in the incidence is recorded, which is 23.01, because in that year 101 cases were reported in the Municipality of Centar.

According to the representation of the gender structure, the incidence of bites among the female population is 98.28 in a period of 6 researched years, while the incidence of bites from stray dogs among the male population in the municipality of Centar is 199.62, i.e., the incidence in the male population is twice as high as the female population, although the female population is 53.5% of the entire population in the Centar, and 46.5% of the population is male.

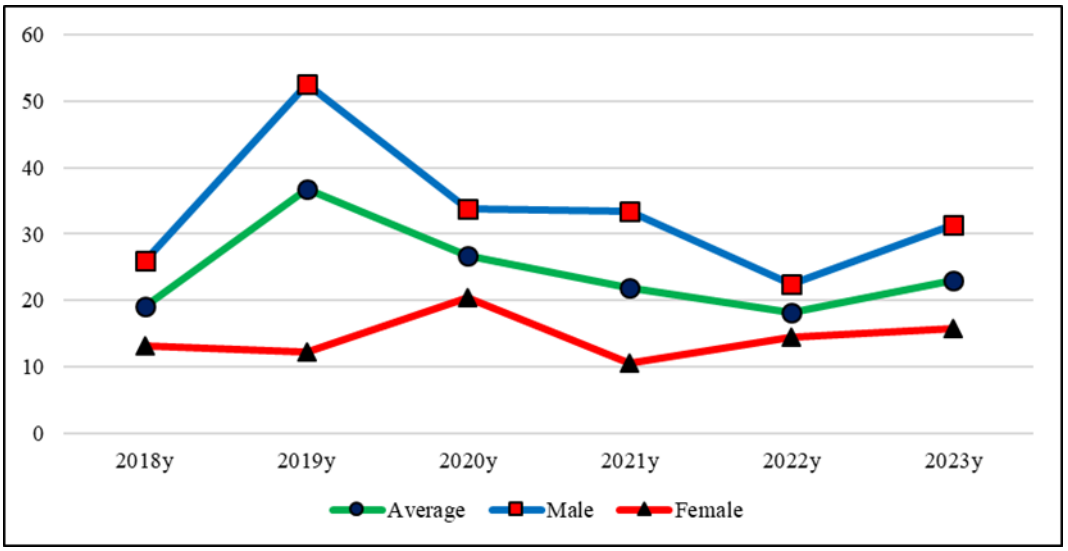

Figure 6. Incidence rate of dog bites in Centar per year.

According to the time interval of attacks by stray dogs, in the entire six-year study period, the most bites occurred in the period from 11:00 to 12:00, with a total of 86 attacks (13.45% of the reported cases), while in the period from 05:00 to 06:00, not a single case was reported.

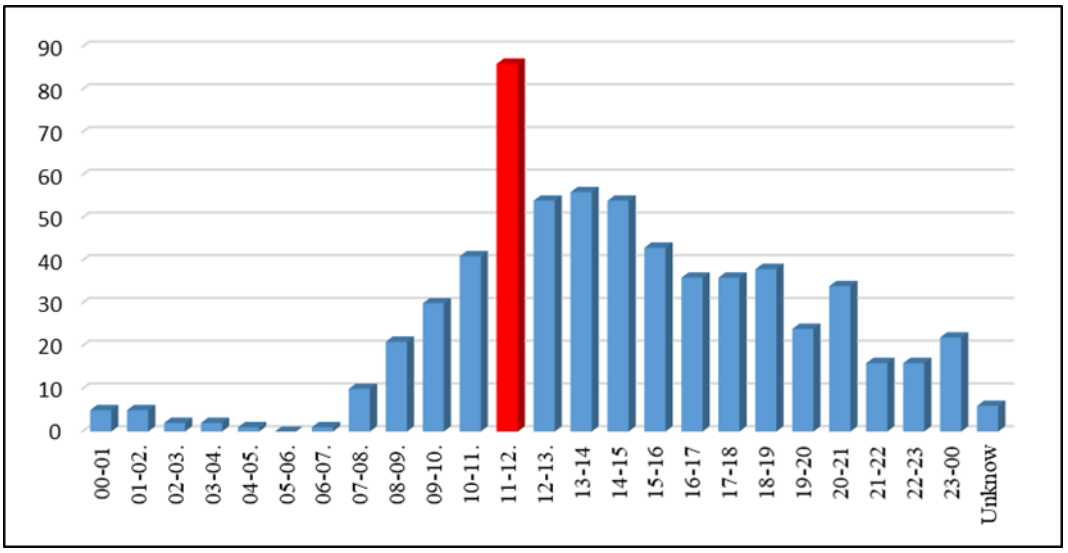

Figure 7. Number of registered bites from dogs per hour in Centar, period 2018-2023

Based on the data on the time of the bite, we can record that there is a gradual increase in the number of attacks by stray dogs in the morning hours, the highest representation is in the afternoon hours and then follows a decrease towards the night hours. According to the time of attack, there is a trend of increasing cases of attacks by stray dogs, especially in the morning and early morning hours, with a maximum peak in the period from 11-12 am with a gradual decline towards night hours, with the exception of small increased deviations in the period from 8-9 pm and 11–12 pm. These numbers are due to the increased movement of students towards educational institutions and employees in the public and private sectors. The lowest number of reported cases are in the early hours of the morning from 04 to 08 am, because during that period of the night, almost the entire population within the municipality is in their

homes. As a specific feature, it can be pointed out that during the working days, most attacks took place between 11:00 and 12:00, but during the weekend, this is not the case. Thus, on Saturday, most bites occurred between 11:00 and 13:00, while on Sunday, most attacks by stray dogs were recorded between 17:00 and 18:00. These values are due to the fact that, unlike weekdays, where there is an increased movement of the population in the morning, during the weekend, this is not the case, so the time with the most bites is in the afternoon. Also, according to the reported cases, during the weekend, most of the cases with dog attacks are in the late afternoon and night hours of the day.

In addition to the temporal character, dog attacks during the working week were also analyzed. According to the cases reported to the Ministry of the Interior, the most attacks were registered on Monday (118 bites), Tuesday (100 bites), Wednesday (114 bites), Thursday (93 bites), Friday (78 bites), Saturday (76 bites) and Sunday (60 bites).

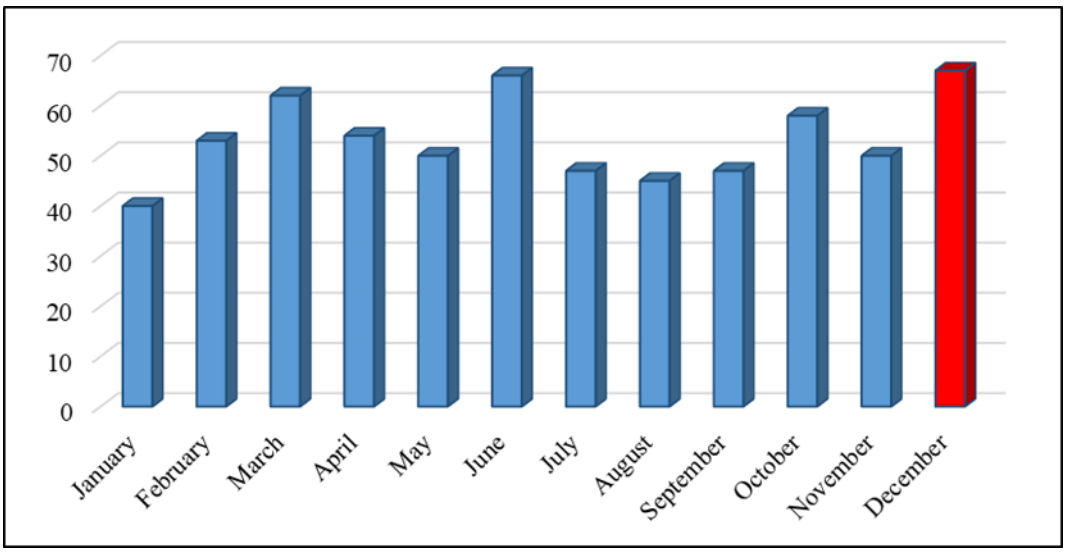

Figure 8. Total bites per month, period 2018-2023.

According to monthly and annual statistics of reported cases of bites from stray dogs, the number varies by month and year. Regarding the months, in the period from 2018 to 2023, December had the most bites is with 67 reported cases, followed by the months of June (66 reported cases) and March (62 reported cases), while the months with the fewest bites from stray dogs are the months January (40 reported cases) and August (45 reported cases). Based on the data shown in Figure 7, we can state that the bites vary by month; that is, the months with the highest number of bites are the months when the annual seasons begin.

In 2018, a total of 84 cases of attack and bite by a stray dog were reported within the Municipality of Centar. The most bites were recorded in the month of February (17 cases), and the lowest number in the month of November, only one case. In the following year 2019, a double growth of almost 91.67% was recorded in the number of reported attacks by street dogs, i.e., 161 reported cases. Months with the highest number of dog bites are April (22 cases) and March (21 cases), while the lowest number was recorded in January with four reported cases. The increased number of attacks can also be observed in Figure 5, where the incidence rate is 36.38 and represents the highest measured rate in the entire examined period.

Table 1. Registered dog attacks in Municipality of Centar

Months	2018	2019	2020	2021	2022	2023	Total
January	2	4	5	7	10	12	40
February	17	5	10	9	7	5	53
March	5	21	7	14	6	9	62
April	6	22	7	6	6	7	54
May	8	14	13	9	4	2	50
June	10	20	4	14	7	11	66
July	5	10	10	9	8	5	47
August	6	7	10	7	4	11	45
September	5	12	8	5	6	11	47
October	7	18	18	2	6	7	58
November	1	16	10	7	8	8	50
December	12	12	15	7	8	13	67
Total	84	161	117	96	80	101	639

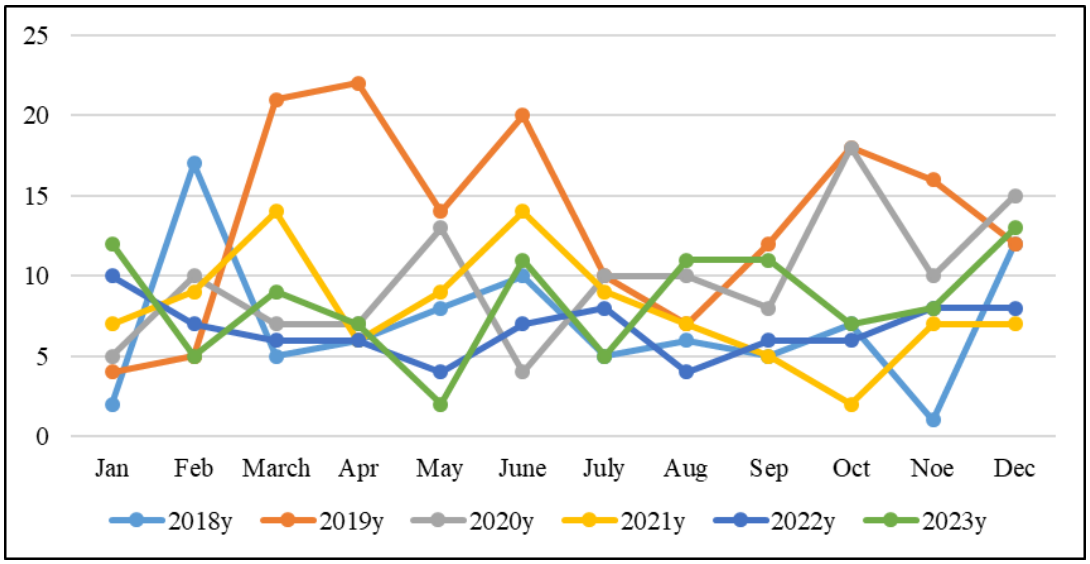

Figure 9. Rate of dog bites by months and years in the municipality of Centar.

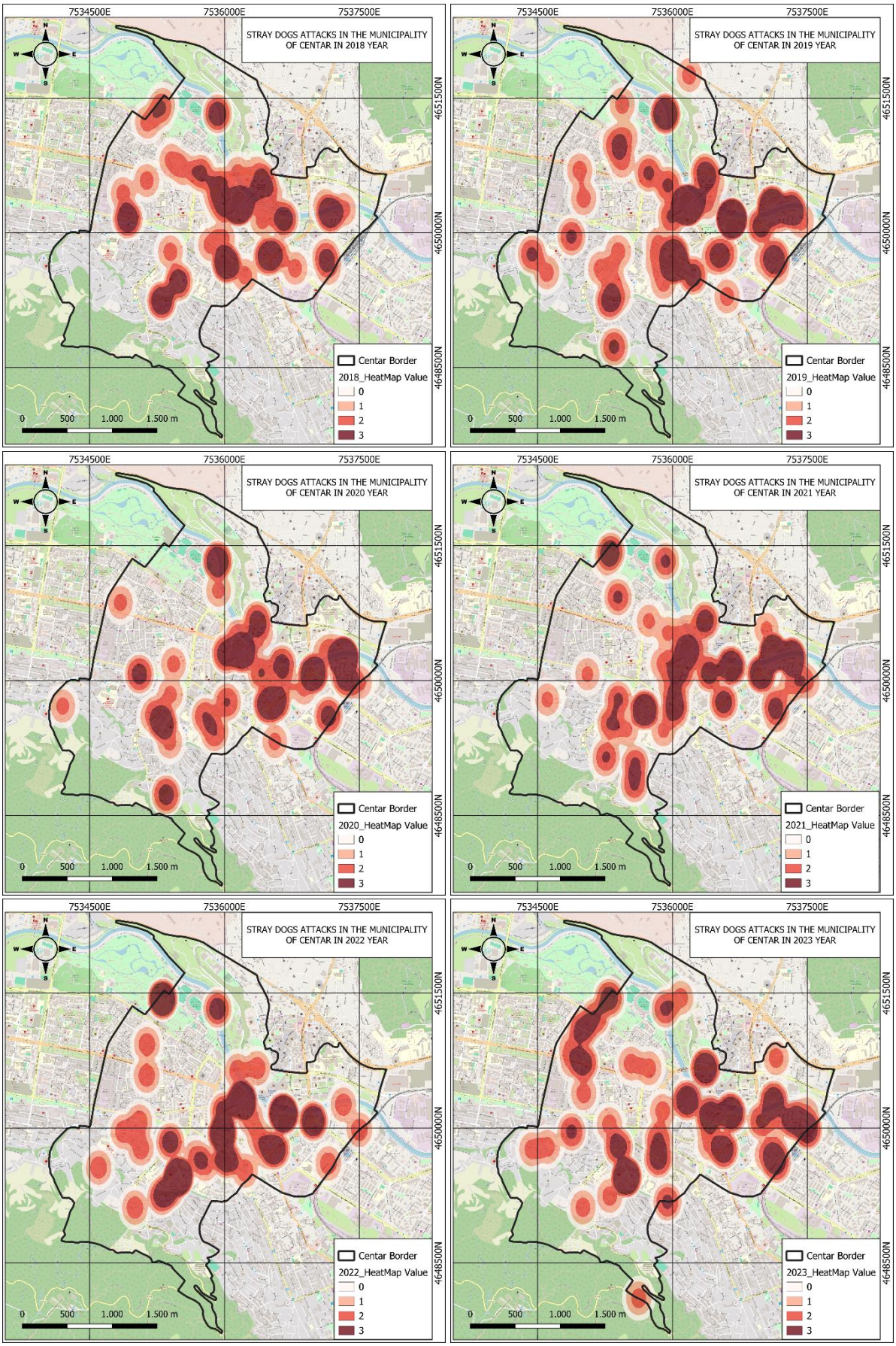

Figure 10. Spatial patterns of Heatmaps for dogs attack per year.

In 2020, there was a decrease in the number of reported cases of attacks by stray dogs, so a total of 117 cases were registered. During the month of October, 18 cases were reported, while the lowest number, a total of four bites, were reported in June. In 2021, the trend of reducing the number of bites by stray dogs continues, with a total of 96 cases reported, of which the most were reported in the months of March and June, 14 each, while only 2 bites were reported in October. The trend of decreasing attacks by stray dogs in the municipality of Centar continues in 2022, with 80 cases of bites reported. So, the most reported cases are in January (10 cases), while the lowest number of reported attacks are in May, with only two cases of bites by a stray dog. Also, 2022 is the year with the lowest number of reported cases in the period from 2018 to 2023, where the incidence rate is 18.23. In the following year, 2023, a slight increase in the number of attacks and bites was recorded, with a total of 101 bites from stray dogs reported to the Ministry of the Interior. The most reported cases were recorded in December (13 cases), while only two cases were reported in the month of May.

In terms of the spatial distribution of attacks by stray dogs, all attacks are in the urban part of the municipality, where the population is constantly moving. So, the most cases of attacks and bites by stray dogs is "Macedonia" Square with 71 reported cases, followed by the Vardar river quay path with 51 reported cases, then the "Mother Teresa" Clinic complex with 35 reported cases, Goce Delchev Boulevard with 17 reported cases, etc. According to the distribution of districts in the Municipality of Centar, the most cases are Centar-1 with 306 attacks, the second is the district of Madzir Maalo with 71 cases, the third is Novo Maalo with 47 cases, Krnjevo with 30 cases, Debar Maalo with 26 cases, the Kapishtec with 25 cases of bites, Prolet with 21 cases of bites from stray dogs, Kale with 20 cases, Tasino Chesmiche with 20 cases, Vodno with 12 cases, Bunjakovec with 9 cases of bites, Centar-2 with 6 cases and Panorama with 6 cases. The southeastern part of City Park which administratively belongs to the Municipality of Centar has total of 40 cases of stray dog attacks registered.

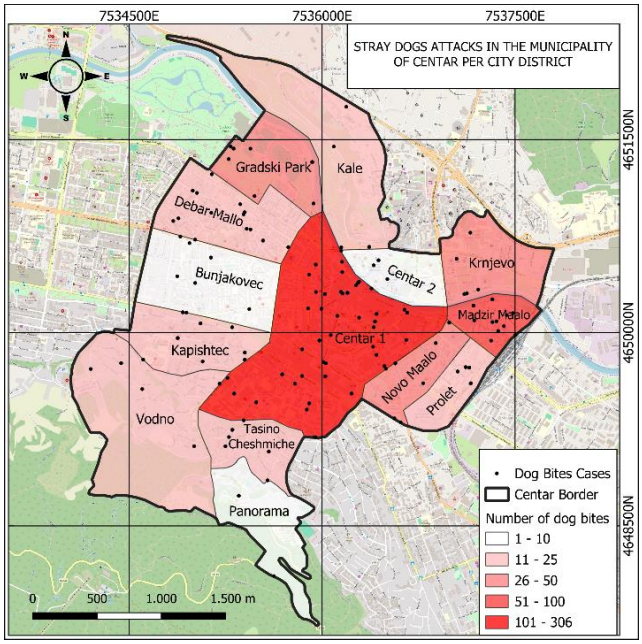

Figure 11. Stray dogs bites per city district in Municipality of Centar

DISCUSSION

Dogs are a part of human's life, and he interacts a lot with them. Dog bite injuries, especially from stray dogs, represent a significant public health problem that needs to be better studied in order to develop better strategies to improve the condition, mitigate the consequences for humans and dogs, and as follow-up of the situation and the population of vagrants in the Centar and in the neighboring municipalities of the territory of the City of Skopje. Out of 639 reported cases of dog bites, only 255, apart from having a record of the type of injury to the affected person, while in 384 registered cases, there is no such information. Also, no single fatalities has been reported as a result of stray dog attack. For comparison, in 2016 alone, in Europe 45 people died as a result of being bitten by a stray dog, while in the United States, between 2003 and 2017, a total of 433 people died from an attack by stray dogs (an average of 33 people per year) (Sarenbo & Seunson, 2021). There are approximately 250,000 reported cases of dog bites in the UK each year that require medical attention (Morgan & Palmer, 2007).

In the territory of the municipality of Centar, the total incidence rate is 145.58 per 10,000 inhabitants, while the average annual incidence rate is 24.26 per 10,000 inhabitants. The incidence of bites by stray dogs in Sicily had doubled in a decade, where the trend of significant increases in incidence is in men and women (Alberghina et al., 2023), while in Uruguay the incidence of bites is 87.51 per 100,000 persons (Roman et. al., 2023). In the period between 2004 and 2014, the incidence of dog bites in New Zealand was 11.3 per 100,000 inhabitants, i.e. 496 reported cases per year (Mair et al., 2019). In Kenya, however, there is a large variation, where the highest value is in 2018 with 433.6 cases per 100,000 inhabitants (Kung'u & Brodbelt, 2023).

According to the representation of children and minors, in the municipality of Centar, they represent only 9.07% of the reported attacks. However, in other countries, minors represent a significant number of dog bites, i.e. 32.3% (Alberghina et al., 2023). In Poland, in the period from 2006 to 2020, 23.8% of hospitalized persons from stray dog bites were children up to 9 years of age (Cianciara et al., 2022), while in Portugal, 34.2% of bitten cases from dogs are young people under 18 years old (Fragoso et al., 2022). In Bangladesh, people under the age of 20 represent 40% of all registered cases of bites (Alam et al., 2020), while in Kenya, the share of children under the age of 15 is 51% of the people bitten (Kung'u & Brodbelt, 2023).

Even though children and minors have a significant share in the total number of reported cases of bites from stray dogs in the Municipality of Centar, the largest represented group is people aged 18 to 64 with 520 bites (81.39% of cases). In the territory of Poland alone, 60% of reported cases are adults (Cianciara et al., 2022), while in Kenya, 49% of reported cases of bites are aged 16 and over (Kung'u & Brodbelt, 2023).

In terms of the representation of attacks in the seasons, in the territory of the municipality of Centar, they are evenly represented, i.e. no single time of year dominates the number of bites and attacks by stray dogs. But this is not the case in Uruguay (Roman et al., 2023), where the percentage of people bitten by stray dogs is higher in spring and summer. Similar results were published in the research in Spain (Rosado et. al., 2023), where most of the bitten people are registered in the summer period. In Kenya, the lowest number of stray dog bites are reported during the dry season, while the highest number of stray dog bites are recorded during the short rainy season in October-December (Kung'u & Brodbelt, 2023).

CONCLUSION

According to the analyzed data, we can determine that despite the number of aggression of stray dogs that varies over the years, they still represent a significant problem for the population in the Municipality of Centar. The municipality covers an area of 7.52 km^2 with a total population of 43,893 inhabitants. In the period from 2018 to 2023, a total of 639 attacks and bites from stray dogs were reported. Of these, 255 registered cases have a record of the type of injury, while in 384 registered cases, that information is missing. According to the representation of age groups, 9.07% are minors under the age of 18. Of them, 57% are male minors (33 reported cases), while 43% of those attacked are female (25 cases). People over 65 years of age are represented in 9.54% of all reported cases. According to the gender structure, 10 cases of injured persons are female (16.4%), while 51 cases of injured persons are male (83.6%). The population aged 18 to 30 is most represented with 162 bites (25.32% of cases), followed by the next group from 31 to 40 years old with 119 bites (18.62% of cases), and then the rest of age groups. From the total number of reported bitten persons, according to the gender structure, the male population significantly dominates with 407 reported cases (63.7%), while only 231 cases are from the female population (36.15%). In only one case, the gender of the person who was bitten by a stray dog was not specified. The male population is 1.76 times more represented in this statistics of bites, although the male population is 46.5% of the population in the Municipality of Centar. According to the representation of the gender structure, the incidence of bites in the female population is 98.28 per 10,000 inhabitants for the entire period of six researched years, while the male population incidence is 199.62 per 10,000 inhabitants. The average incidence rate in the studied six-year period is 145.58 per 10,000 inhabitants. Based on the time interval of attacks by stray dogs, overall, the most bites occurred in the period from 11:00 to 12:00 am, with a total of 86 attacks (13.45% of reported cases), while in the period from 05:00-06:00 am, not a single case was reported. In addition, according to the distribution of bites by day, there are 118 bites on Monday, 100 bites on Tuesday, 114 bites on Wednesday, 93 bites on Thursday, 78 bites on Friday, 76 bites on Saturday and only 60 bites on Sunday. According to the months, December has the most bites with 67 reported cases, followed by June with 66 reported cases and March with 62 reported cases. Months with the fewest bites are January with 40 reported cases and August with 45 reported cases. Based on the examined years, in 2018 84 cases were registered in the Centar, in 2019 there were 161 reported cases of stray dog bites, in 2020 there were 117 reported cases, in 2021 there were 96 registered cases, in 2022 there were 80 reported cases and in 2023 there were 101 cases. We can state that the daily, monthly and annual figures vary, and that they have no seasonal connection with the seasons. All the attacks took place in the urban part of the municipality, namely 71 reported cases on the "Macedonia" Square, then the path on the quay of the Vardar River with 51 reported cases, then the City Park with 40 bites from stray dogs, then the "Mother Teresa" clinic complex " with 35 reported cases, Boulevard Goce Delchev with 17 reported cases and etc.

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