ISSN: 0975-8585

Research Journal of Pharmaceutical, Biological and Chemical Sciences

Geographic Distribution of Foot and Mouth Disease (FMD) in Sheep in Duhok Governorate, Iraq by using GIS.

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ABSTRACT

Foot and mouth disease (FMD) is a viral disease of cloven-hoofed animals that causes low productivity consequently, causes highly economic loses. It is an endemic disease in Kurdistan Region, Iraq. The aim of the study is to distribute the FMD cases geographically by using Geographic Information System (GIS). Besides, the study assess the geographical relationship and prevalence rate between the areas having disease in Duhok Governorate, Kurdistan Region, Iraq (DGKRI) with other areas on borders of Iraq, and neighboring countries. Data of FMD in sheep in DGKRI have been used from three years 2013, 2014 and 2015 and obtained from Directorate of Veterinary in Duhok Governorate (DVDG). The results show that the highest prevalence rate of FMD cases found in areas of Duhok adjacent to other Arabs areas or countries. Among all the three years the areas Semel and Zaxo in 2015 which are located on borders with Turkey and Syria shows the highest number of cases. Whereas, in 2014 the highest cases of FMD is in Semel and Akre. While, in 2013 the highest prevalence rate of disease is in Zummer. To sum up, the study shows that the conflicted circumstances and war in the area have affected on spreading and increasing the rate of the disease in Duhok.

Keywords: FMD, Kurdistan Region, Duhok, Epidemiology, Disease distribution, GIS

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ISSN: 0975-8585

INTRODUCTION

Foot and Mouth Disease (FMD) is an endemic disease in Iraq [1], Kurdistan Region [2], It is an extremely contagious viral disease of cloven-hoofed animals; domestic and wild animals [10 and 18]. The disease is transmitted by direct contact with the infected animal through the oral or aerosol route, or by skin abrasions, particularly in pigs. Moreover, transportation or movement of animals has a great role to spread the infection from an infected area to a free area of infection [11]. Additionally, the disease can be prevented by vaccination [1], the infected animals with Foot and Mouth Disease Virus (FMDV) may demonstrate various signs and symptoms such as blisters on extremes, in and around the mouth and on the mammary gland in females [14]. The FMDV can be shed from all body discharges in early stages of disease including their breath. FMDA is shed in cattle and swine with the onset of clinical signs. In contrast, in sheep the shedding of virus occurs before lesion exists [11]. Consequently, infected sheep can pass the virus to other animals in the livestock before the appearance of signs and symptoms due to its short incubation period which is about two days [19]. It is worth mentioning that about 20% of infected sheep do not expose clinical signs like blisters beside, about the same percentage may show just single lesion [14]. Economic concerns should be taken into consideration with FMD disease particularly in outbreaks. FMD is related to huge economic loses as it effects on farming industry as it causes low animal productivity with low mortality in the adults livestock with high death rate in young stock [10, and 12]. For example, as it happened in 1998 when about 3 million ruminants have been affected and 'caused heavily losses in newly animals. That happened when emerging of new strain O1 Middle East for the first time and affected about 3 million ruminant and causes extreme economic loses [4]. Because of the veterinary quarantine and regulations, FMD inhibits the regional and international trade of animals and their products [10 and 12]. To control these loses especially in outbreaks; it needs essential data for prevention particularly by vaccination. This data can be utilized for epidemiological studies and this can be achieved by using geographic distribution of the disease for surveillance and monitoring of diseases [15].

Geographic Information System (GIS) is used as a modeling tool that can be used to create and evaluate data for epidemiological purposes for diseases. GIS and Remote Sensing (RS) give the ability to draw maps that can be utilized in disease control strategies [13]. GIS is used in different disciplines like agriculture and health among others [15]. In addition, GIS is used in veterinary epidemiology [3**,** 15**,** 18 and 19]**.** It has many applications in veterinary sectors. Firstly, it can be used to make connection between the onset of disease and the descriptive data [3] and determine the areas at risk [15]. Secondly, GIS has a notifiable role in the explanation and evaluation of disease spread through the use of 'dynamic map'. Thirdly, GIS can be used in critical situations like outbreaks or appearance of new infections. The availability of data of the infected areas will help in making decisions immediately [3 and 18], finally, it can be utilized in 'planning disease control strategies' [15].

Accordingly, in this study, an attempt is made to illustrate the geographic distribution of FMD cases in 2013, 2014 and 2015 in Duhok, Kurdistan region, Iraq (KRI) by using GIS and prevalence rate for each district in Duhok. Besides, the paper discusses some other factors that affect FMD distribution in the aforementioned area like the relationship between the infected areas and the security situation, economic factors and political issues in these areas.

METHODS AND MATERIALS

Data collection or resources

In the present study, the data of FMD cases in sheep in Duhok governorate in Iraq have been used which are obtained from the Directorate of Veterinary in Duhok Governorate (DVDG), KRI. Furthermore, the data have been used from different intervals of time which are 2013, 2014 and 2015. These data have been reported from different veterinary clinics among Duhok governorate. In addition, the data of number of population for each infected area have been obtained in order to find out the prevalence rate for each year of all districts. To achieve more adequate results, an interview was conducted with the Director of DVDG about the FMD disease in Duhok and surrounding areas on April, 2016 at his office.

ISSN: 0975-8585

Statistical analysis

Prevalence rate has been found for each district according to the provided statistics from DVDG by using the prevalence rate equation as following [20].

$$\text{Prevalence} = \frac{\text{Number of existing cases}}{\text{Size of population}}$$

Data coding

Landsat 8.0 OLI / TIR sensor-orbit (WRS-2)

Landsat 8.0 path (169) row (34, 35, 36) date to 19/04/2014 is integrated with Digital Elevation Model (DEM) for interpreting and delineating the different physiographic mapping units. Landsat is utilized for obtaining Duhok map.

ENVI

ENVI software VERSION 5.1 is used for remote sensing analysis [9].

ArcMap 10.1 for GIS analysis and mapping [7]

The software ArcMap 10.1 has been used to distribute the data. A shape file and DEM are used by ArcGIS Version 10.1. This map became the base for the rest of map files throughout the study. Different maps have been made to distribute the cases' records of FMD according to the geographical area individually for each year. Besides, a map has been created for all three different on the prevalence rate of the disease presenting that by using black spots on the infected areas.

Ethical statement:

Approval has been obtained from the DVDG to use all the data for academic purposes. Moreover, all records are used confidentially.

RESULTS

The results of the present study are demonstrated via maps, curves and tables. Different maps have been designed for showing geographic distribution and other maps for showing density of disease according to the prevalence rate. Figure 1 shows the distribution of FMD disease in sheep in Duhok, KRI by utilizing different colors for each infected area in 2013.

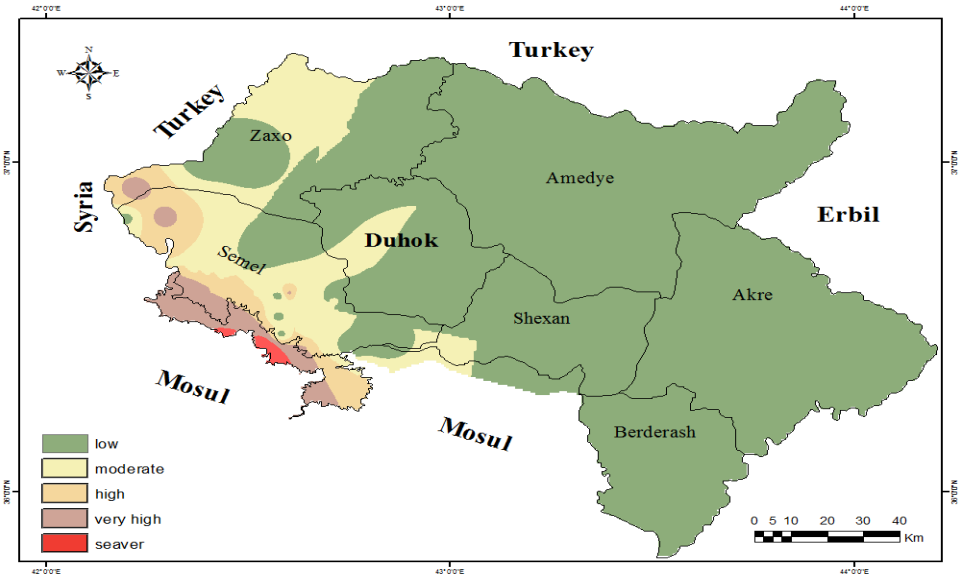

Figure 1: Distribution of FMD disease in sheep in Duhok, KRI in 2013

ISSN: 0975-8585

Whereas, figure 2 illustrates the geographic distribution of FMD cases in Duhok, KRI in 2014. It shows the distribution for each district in Duhok by using different colors.

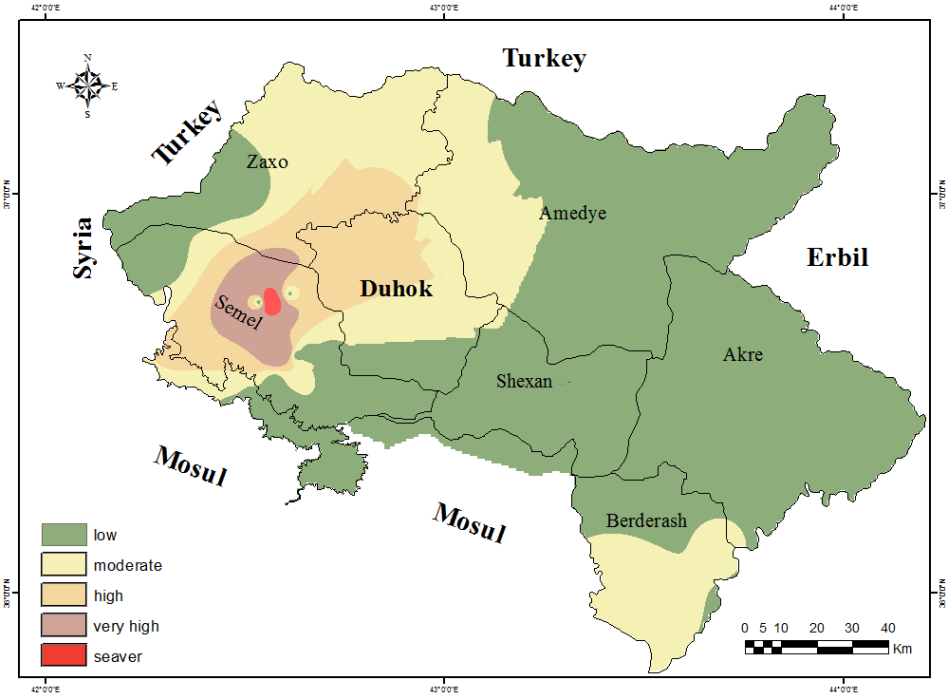

Figure 2: Distribution of FMD cases in Duhok, KRI 2014

Regarding 2015, figure 3 shows the geographical distribution of FMD in each area in Duhok by using colors for each infected area.

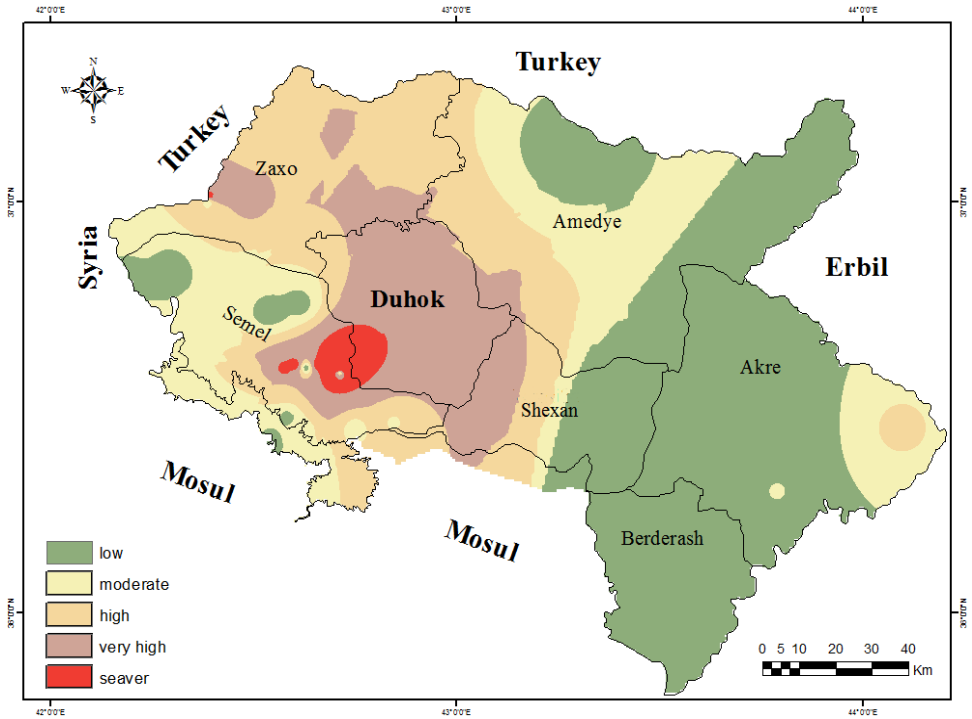

Figure 3: Distribution of FMD cases in Duhok, KRI in 2015

ISSN: 0975-8585

It is noticeable from figure 1,2 and 3 that the disease has been moved significantly (red color) started from Zummer in 2013 and then spread to Semel and surrounding areas in 2014 and 2015. On the other hand, the figure in appendix 3 presents the total of all three years together to show the infected areas with FMD disease in general in Duhok.

The maps in figure 4 illustrate the statistics in table 1 (prevalence rate) of FMD in sheep in Duhok, KRI. Each map demonstrates statistics for a year. Black spots are presenting the infected areas in each district in Duhok, KRI. It is worth mentioning that there is no data about Zummer in 2014 and few cases have been reported in 2015 as it locates in the conflicted areas [5].

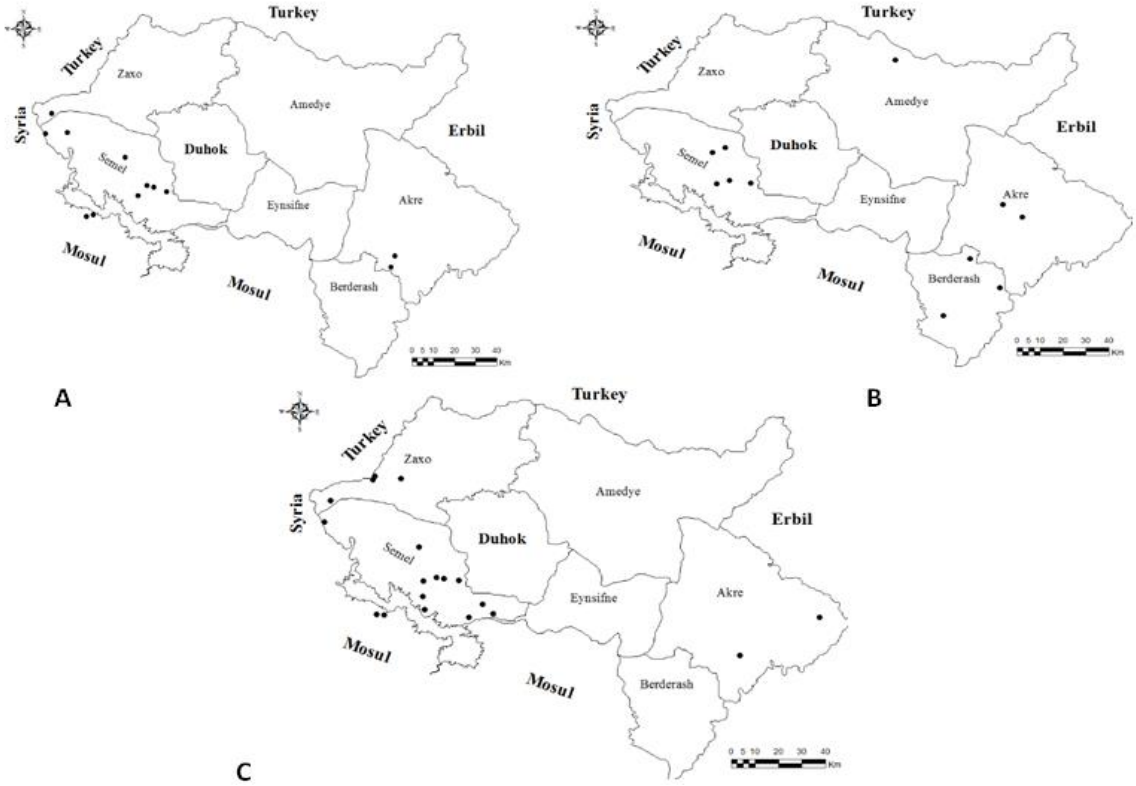

Figure 4: FMD distribution in sheep in Duhok, KRI. Maps A, B and C present FMD cases in 2013, 2014 and 2015 correspondingly

Table 1. Number of sheep population, FMD cases and prevalence rate for each district in Duhok, KRI in 2013,2014 and 4015. For more details about infected areas(villages and sub-districts) see table in appendix.1

District	Number of sheep population			FMD cases/year			Prevalence Rate/year		
	2013	2014	2015	2013	2014	2015	2013	2014	2015
Zaxo	52832	62735	58490	21	10	26	0.0004	0.00016	0.00044
Semel	82288	55600	78590	50	90	100	0.00061	0.00162	0.00127
Akre	164943	74856	117822	2	2	7	0.00001	0.00003	0.00006
Bardarash	61244	45800	72578	0	10	0	0	0.00022	0
Amedye	6215	6146	7387	0	1	0	0	0.00016	0
Zummar	77850	78230	92800	200	0	6	0.00257	0	0.00006

ISSN: 0975-8585

Overall, the following figure summarizes the number of cases for each year (2013, 2014 and 2015) for each district. The curve demonstrates the fluctuation in the number of cases between areas during time intervals. It shows the highest number of FMD case is in 2013 in Zummer. Then Semel comes next according to the number of cases. Later on, the FMD cases are close to each other in other districts of Duhok which are between (0 and 26) cases. For more details about villages with infected cases see appendix 2.

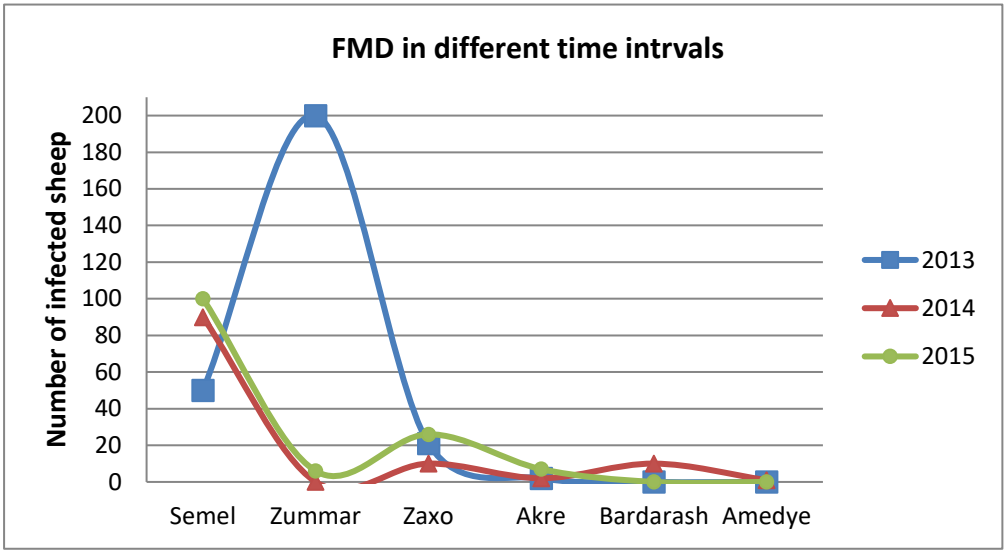

Figure 5. The trend of FMD cases in Duhok, KRI during the three years

DISCUSSION

The results confirm that Iraq is an endemic area with FMD as well as Kurdistan Region. Besides, the geographical distribution of FMD has not explored efficiently in Duhok [5] as there is a limited collaboration between Kurdistan Region and the Iraqi authorities concerning FMD [1]. Therefore, it is found essential to put a specific emphasis on Duhok Governorate. In addition, sheep have been taken as the study model among other cloven-hoofed animals because the nature of the disease is different in both according to signs and symptoms. As the FMDV in sheep is shedding before even the appearance of sign and symptoms [11 and 14] and sometimes it is characterized to be without manifestation [14]. Thus, it needs more considerations and speed response in emergency.

It could be seen in figure1,2,3 and 6 the trend of disease movement as it moved from Zummar with the highest number of cases which has the highest prevalence rate about 0.00257 in 2013 (see table 1). Subsequently, it spread to Semel with its surrounding and Duhok in the later years. In 2013, Semel has prevalence rate about 0.00061 while it is increased into 0.00162 in 2014 which confirms the dynamic of disease. Accordingly, the distribution of FMD in Duhok governorate shows an increase in number in areas adjacent to the areas with war conflicts areas such as Zummar bordering Syria and Mosul governorate. Due to the current conflicts and running war in these areas, many factors have resulted in this increase. First, in 2015, the vaccination campaigns did not cover these areas as they were under the fire of war [5]. The report of conference about FMD in Iraq (Arabs areas) for 2014- 2016 at 7th West Eurasia meeting in Kyrgyzstan for evaluating FMD control shows that numerous of Iraqi governorates have not been vaccinated in 2014 including Shingal and Shixan which are on borders to Duhok [1], This raises the possibility of spreading disease in these areas to Duhok especially from Shingal [1 and 5] see the trend of disease figure1, 2, 3. Secondly, due to the bad security situations in the conflicted areas and with insufficient quarantine on these borders, illegal trade has been practiced there [1, 5 and 11]. Accordingly, animal movement has been increased there without veterinary quarantine which has led to the raise of a number of FMD cases. Finally, Because of the humanitarian crisis in the region hundreds of refugees and displaced people have fled to Duhok bringing their animal flocks with them which are not vaccinated. This has also played a tremendous role in elevating the number of FMD cases in Duhok [1, 5 and 21]. For instance, FAO conducted emergency vaccination campaigns in Lebanon's areas on borders with Syria in order to control the spread of disease in the hosting areas [21]. However, it is excepted the number of FMD cases will be increased in 2016 based on the expectations of the Director of DVDG as from the beginning of 2016 Kurdistan Region is lack of vaccine against FMD due to the bad

economic status in Kurdistan Region and this has been announced to publicity and the concerned authorities. In addition, FMD has declared to be one out of three diseases that are threatening the health in Duhok Governorate in 2016 [5, 6 and 16]

Furthermore, Zaxo comes after Semel according to the number of cases as it is located nearby Syria and Turkey and it is close to Zummar; therefore, cases are increased over time as it has prevalence for all the three years correspondingly 0.0004, 0.00016 and 0.00044 (table 1).

Concerning the increased cases on borders of Duhok (Akre and Bardarash) with Erbil and Iran are due to several reasons. One of them, there are a number of rural areas far from cities that are not covered by vaccine programs. The other expected reason is the existence of new strains in those areas which are not controlled by vaccination which is most likely because of illegal animal trade [5]. For the aforementioned reasons, Kurdistan Region needs to put more restrictions on borders to prevent and control the entrance of new stains into the area. Because, according to the 7th West Eurasia meeting in Kyrgyzstan for evaluating FMD control programs in 2016, Iran, Turkey and Armenia consider a threats to the region; especially with emerging a new strain FMD A/Ind/G VII in Iran, Turkey and Armenia, due to the free and uncontrolled animal movement in the borders [8].Nevertheless, the areas located far away from borders and closer to the center of Duhok are with few cases because of the less animal movement and the availability of veterinary services there (see figure 1, 2 and 3).

CONCLUSION AND RECOMMENDATIONS

To sum up, FMD is an endemic disease in Duhok Governorate, Kurdistan Region, Iraq. The geographical distribution of the disease shows the dynamic of disease moves from areas on borders with areas having war and bad security situation and the prevalence rate increases over the time. Zummar has the highest prevalence rate of the disease in 2013. This resulted in the increase of the prevalence rate in Sumel in all 2013, 2014, and 2015. Also, Zaxo on Turkey borders has a moderate prevalence rate. Besides, other districts such as Akre and Bardarash are on borders of Erbil that is adjacent to Iran have significant numbers of FMD. It is worth mentioning that the areas far away from the borders and closer to the center of Duhok are free or have limited cases because of limited animal movement, less security issues and vaccine coverage.

The data of this paper can be implemented in various veterinary purposes in Duhok. For example, they could be used to manage critical situations in the area easier and faster like outbreaks, emerging of new strains, vaccination campaigns and to prevent and study of the disease spread and planning control strategies. Besides, they could be used for research purposes.

Moreover, several points are highly recommended in this study. The most important thing is to increase the collaboration between Kurdistan region and Iraqi Arabs areas with neighboring countries as there is a limited collaboration between these areas [1], this can be achieved by exchanging data or reporting the emergence of new strains in these bordering areas that could decrease the risk of disease spread between them. The other important thing is the data recording and reporting system of DVDG needs to be improved and pay more attention to the regular reporting; weekly, monthly or annually. As a result, the availability of data about the location of cases will help to provide good surveillance and monitory program that will help to keep up-to-date about the disease control and spread. Lastly, epidemiology department at DVDG needs to build a firm connection with international organization of animals like World Organization for Animal Health (OIE) as Iraq is belong to countries and zones without an OIE official status for FMD [17] and implementation of Quarantine import protocols conform to OIE standards. KRI needs to control the illegal trade on the borders and animal movement by putting more restricted regulations on borders.

Limitations

This paper has some limitations. For instance, there is a lack of data about FMD cases in some villages in Duhok and records about FMD serotypes from DVDG. Also, there are no records about mortality rate and methods of laboratory diagnosis for FMD in Duhok. Besides, there is no data about Zummer in 2014 and limited number in 2015 because of the security conditions there so that, the data have not been collected there. Additionally, there are no data about Shixan as a large part of it is under the Arabs authorities.

Authors' contribution

All authors contributed to this work. DTB collect and provide the data. PMS apply the data on GIS and RS programs that did satellite images analysis and extracting the maps and is the corresponding author. NAR planned the study, analyzed the data and write up the manuscript.

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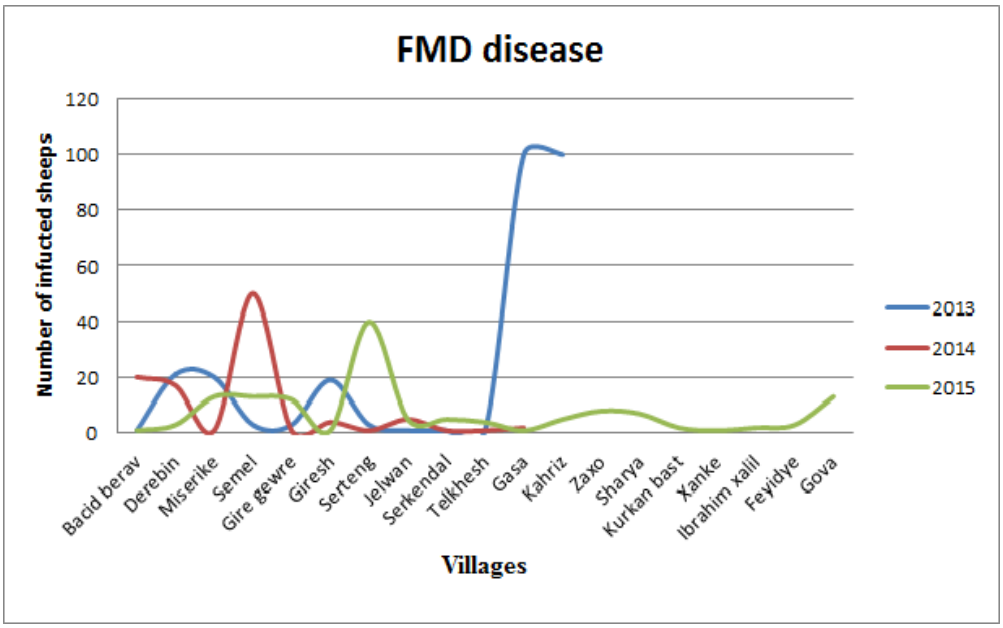
Appendices

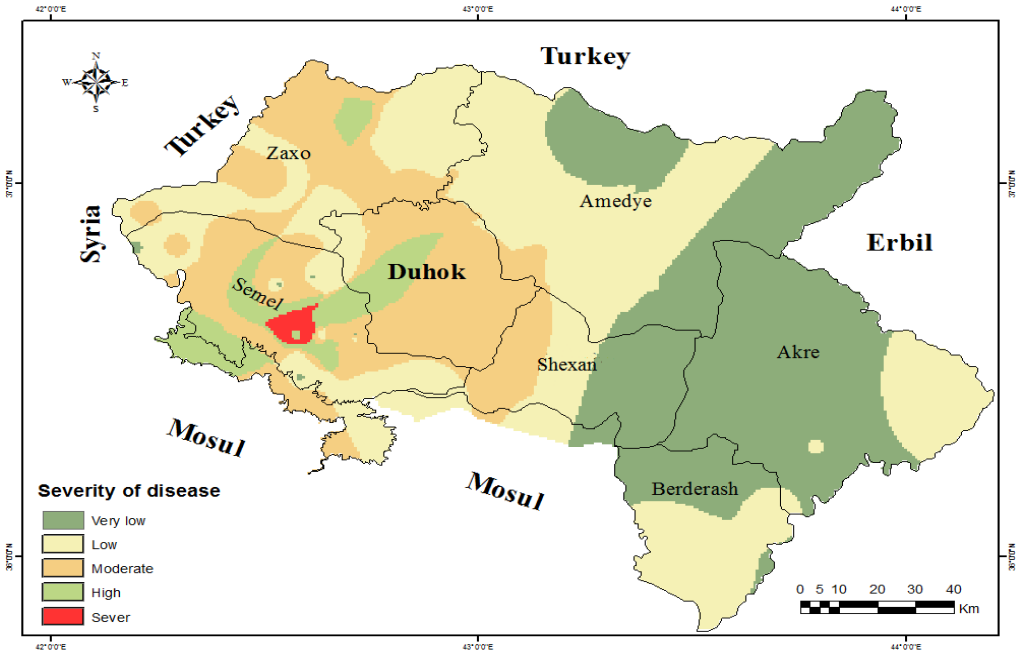
Appendix 1. Number of cases of FMD in 2013, 2014 and 2015 in Duhok Governorate, Kurdistan, Iraq and the names of districts and villages.

OBJECTID_1	Name	Name of village	FMD2013	FMD2014	FMD2015
1	SEMEL	Bacid berav	1	0	1
2	ZAXO	Derebin	21	0	3
3	SEMEL	Pebizne	20	0	0
4	SEMEL	Seyd zarjeri	3	0	0
5	SEMEL	Dilib	3	0	0
6	SEMEL	Miserike	19	20	13
7	SEMEL	Semel	3	0	13
8	AKRE	Malke	1	0	0
9	AKRE	Girdesin	1	0	0
10	SEMEL	Gire gewre	0	17	12
11	AMEDYE	Derishk	0	1	0
12	SEMEL	Giresh	0	50	1
13	SEMEL	Serteng	0	1	40
14	BERDERSH	Berdasor	0	4	0
15	BERDERSH	Ruvya	0	1	0
16	BERDERSH	Shexal;	0	5	0
17	AKRE	Xerdis	0	1	0
18	AKRE	Akre	0	1	0
19	SEMEL	Kawshe	0	2	0
20	SEMEL	Basitke	1	0	0
21	SEMEL	Jelwan	0	0	5
22	AKRE	Serkendal	0	0	5
23	SEMEL	Telkhesh	0	0	4
24	ZUMMAR	Gasa	0	0	1
25	ZUMMAR	Kahriz	0	0	5
26	ZUMMAR	Bardea	100	0	0
27	ZUMMAR	Jissa	100	0	0
28	ZAXO	Zaxo	0	0	8
29	SEMEL	Sharya	0	0	7
30	AKRE	Kurkan bast	0	0	2
31	SEMEL	Xanke	0	0	1
32	ZAXO	Ibrahim xalil	0	0	2
33	SEMEL	Feyidye	0	0	3
34	ZAXO	Gova	0	0	13

ISSN: 0975-8585



Appendix 2 The trend of FMD cases in Duhok, KRI during the three years in subdistricts



Appendix 3 FMD cases in Duhok, KRI for all three years together; 2013, 2014 and 2015