RESEARCH ARTICLE

FMD AND PPR DISEASES MONITORING AND SURVEILLANCE IN ALGERIA: APPLICATION OF GEOGRAPHIC INFORMATION SYSTEM

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ABSTRACT

The study aimed to describe the evaluation and implementation of spatial databases that are directly related to animal health in GIS and web-GIS by visualization of the spatio-temporal distribution of animal diseases such as peste des petits ruminants (PPR) and foot-and-mouth disease (FMD) in Algeria. A methodology has been adapted based on the classical steps of GIS and performed using freely available Qgis 3.10. Such methodology can be largely applied to different types of diseases. We have also created a model of website-based «VETALGIS» (Veterinary Algerian GIS) in order to digitalize the veterinary sector and minimize the problemof thelack of data, organize data and facilitate access, which will improve networking and communication between institutions responsible for livestock disease management. GIS spatial analysis techniques have proven to be a useful tool that can support the decision-making process in planning, implementing and monitoring FMD and PPR control strategies in endemic and high-risk areas.

Keywords: Geographical Information System (GIS), peste des petit ruminants, foot and mouth disease

INTRODUCTION

The livestock sector is one of the most important agricultural sectors, particularly in developing countries. However, the subsistence of pastoral livestock is limited by the frequent presence of trade-sensitive diseases that can affect the economic aspect of any country. This canmake their potential for infection a further challenge to control. Some of those diseases are PPR and FMD (Paton et al., 2009; Knight-Jones and Rushton, 2013; Gitonga, 2015; Amaral et al., 2016).

In recent years, new and modern tools haveproven essential for monitoring and surveillance of these diseases. The geographic

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information system (GIS) is one of those tools which has been used for a wide variety of purposes in different fields, including veterinary sciences, especially epidemiology (Hay, 2000, Rinaldi et al., 2006).

The study aimed to describe steps in the evaluation and implementation of a spatial database directly related to animal health usingGIS/web-GISforthe visualization of the spatio-temporal distribution of animal diseases, such as FMD and PPR in Algeria. It also aimed to show the utilisationof GIS/Web GIS techniques in the planning and implementation of disease monitoring and control programs in endemic and high-risk PPR and FMD areas in Algeria.

MATERIAL AND METHODS

Study area

The selection of areas to be included in the study was made intentionally and on the basis of available financial resources and the following criteria: (1) The area is classified as an endemic or high-risk area for PPR on the basis of Director of Veterinary Services(DVS) recordings and official disease reports (Elsawalhy et al., 2010; Gitao et al., 2014; FAO and OIE, 2015); (2) The inhabitants are pastoralists with high sheep and goat populations (KNBS, 2009); (3) Is an important route for small ruminant stocks to neighbouring countries (Aklilu, 2008). Study has been divided intotwo scales: the small scale and the large scale. The large scale represents entire country of Algeria (Figure 1), while the daïra of Kser El Boukhari was selected for the small scale (Gitonga, 2015).

Administrative data

Data wascollected from the Ministry of Agriculture and Rural Development (MADR) of the People's Republic of Algeria (http://madrp.gov.dz/). These records include information such as animal population and disease outbreaks, which are linked to geographical data by being captured at a particular address or region (hence, the usefulness of relational databases). In this study, the detailed information contained in the reports was structured in the databases and divided into two scales (large and small scale).

Large scale

In order to investigate the distribution characteristics of FMD and PPR in Algeria, the data on FMD and PPR cases from different years (2014-2015-2016-2018 for FMD and 2011- 2012-2013-2016-2018 for PPR) were collected from the DVS of the Ministry of Agriculture of Algeria.

Small scale

Number of affected animals in the daïra of Ksar El Boukhari in 2019 was collected from the Agriculture Directorate of media province, Kasar El Bukhari subdivision.

Survey data

Data were collected for a specific purpose, often in a single procedure. Updating the data requires significant effort and can only be performedoccasionally. One of the main difficulties with the survey data is that information quickly becomes obsolete, especially in countries with rapidly growing development and populations (Vinodhkumar et al., 2016). In the present stady, datawere represented by geographical coordinates (x,y) derived from the addresses obtained from the Agriculture Directorate of media province, Ksar El Bukhari subdivision.

Internet data

Data on FMD and PPR cases reported in the last few years were collected from the World component and transformed from its existing form into a form that can be used by GIS. Data for use in GIS may be available in a variety of formats:

In this case, the vector layer "DZ Admin" was downloaded from the National Institute for Mapping and Remote Sensing (INCT) (http://www.inct.mdn.dz/webinctsim/telechargement.php). The second vector layer is in the form of a point, contains the information collected on the ground and/or acquired from the Minister of the MADR concerning the fields of information shown.

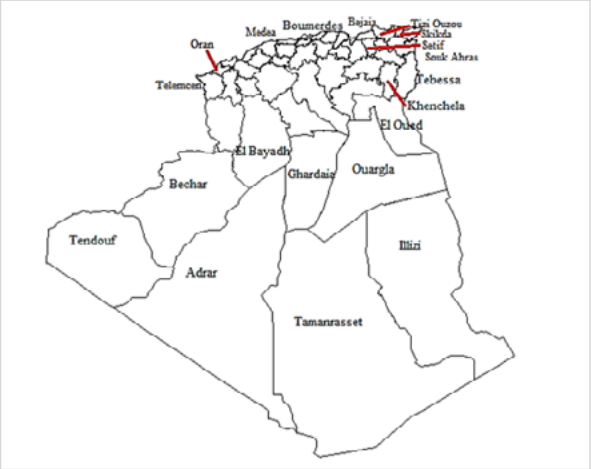

Figure 1 Presentation of study area

RESULTS

Large scale

PPR results Goat PPR

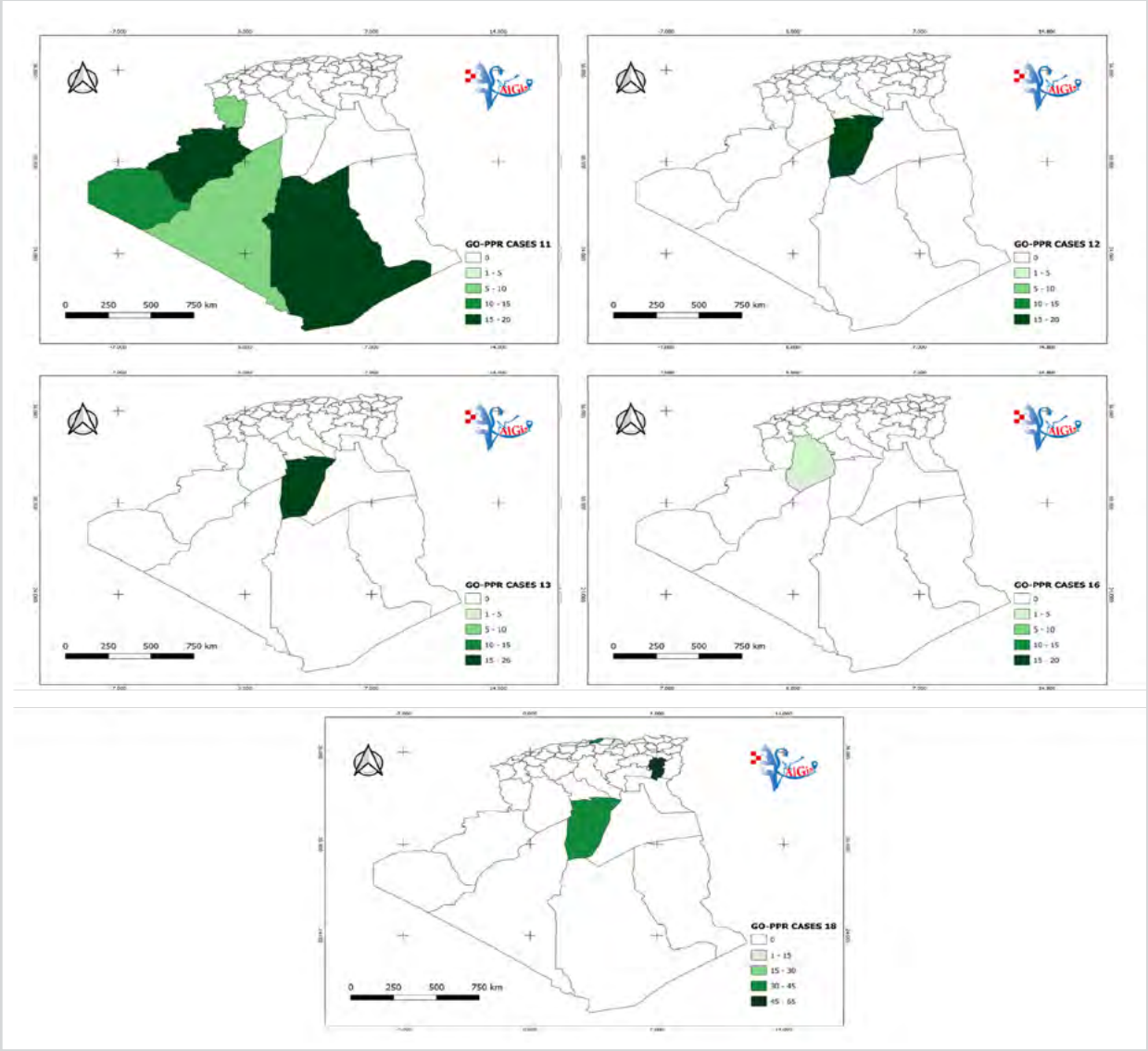

Figure 2 PPR in goats in Algeria

The maps (Figure 2) show that goat PPR cases in Algeria were concentrated in the Saharian states (Tamanrasset, Bechar, Tindouf, Adrar) in 2011, while some cases have been reported in Ghardaia in 2012 and 2013, as well as Beyedh in 2016. For 2018, wehave recorded the highest level of cases in Khenchela, Ghardaia, Bejaia and Boumerdas.

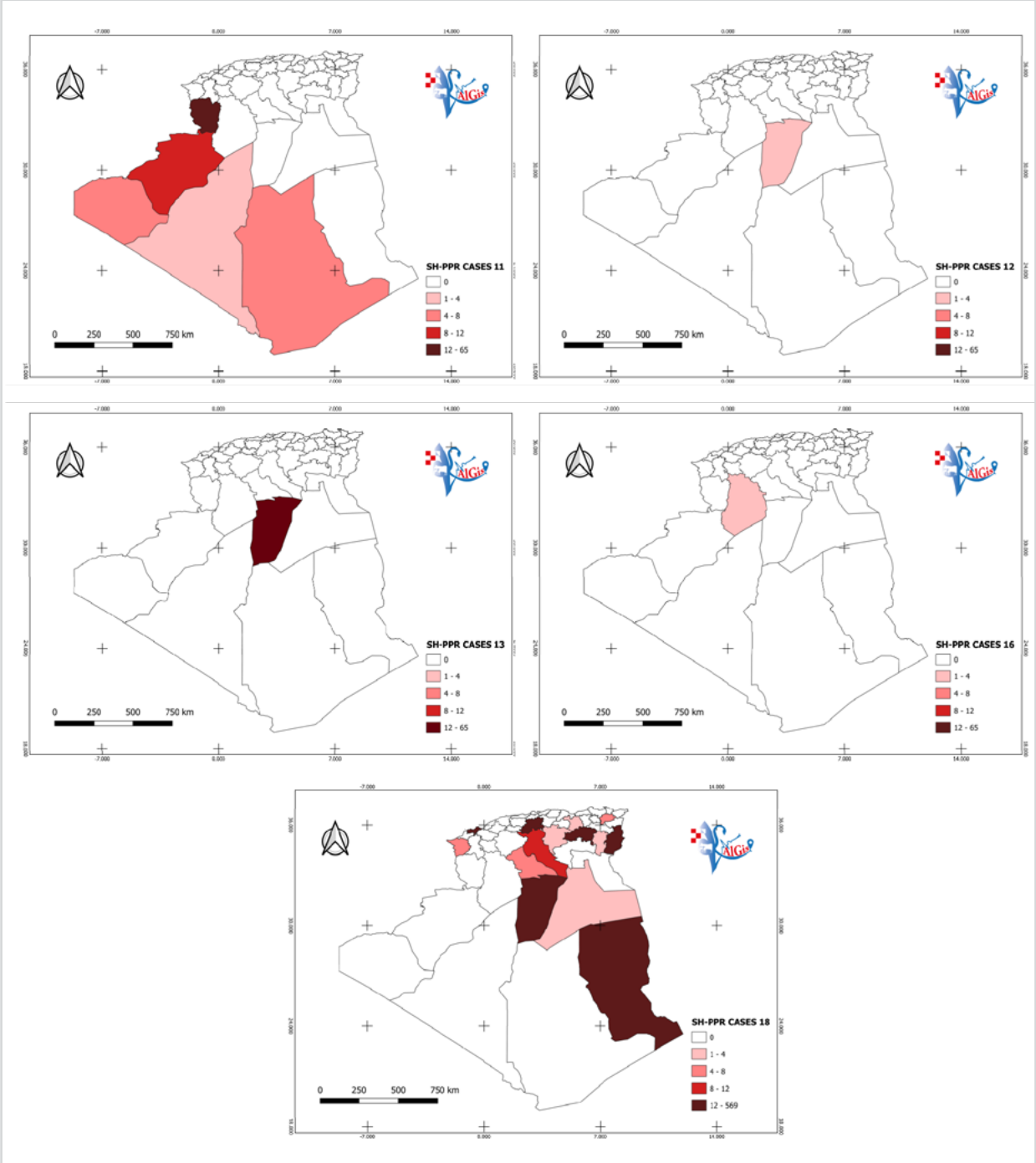

Figure 3 Distribution of PPR cases in sheep in Algeria

Sheep PPR

The figure 3 shows a random distribution of cases over the years (2011, 2012, 2013, 2016 and 2018, respectively). The highest number of cases was reported in 2018 in Illizi, Ghardaia, Tebessa, Khenchela, Medea and Oran.

Cattle FMD

Cattle FMD cases were recorded in the northern and interior states in 2014 while we record just one case in El Oued in 2015. In the years 2017 and 2018 cases wererecorded from different states of the coast, the interior and the north of Sahara. The highest number of cases was reported in Setif (Figure 4).

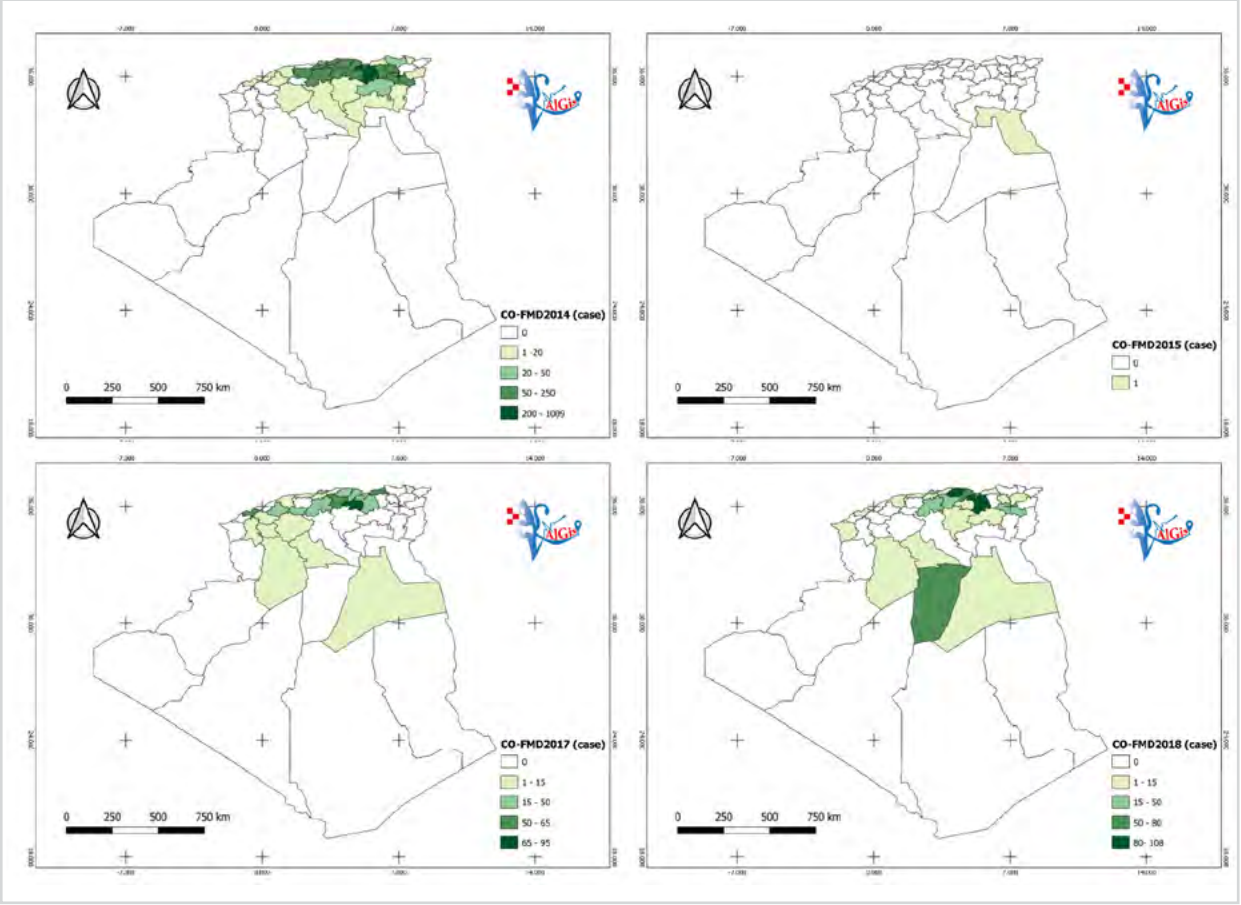

Figure 4 Distribution of FMD cases in cattle in Algeria

Ovine FMD

No sheep FMD cases were registered in 2014, while thehighest number of cases was recorded in El Oued in 2015. In the years 2017 and 2018, caseswere recorded from different states of the interior and Sahara (Figure 5).

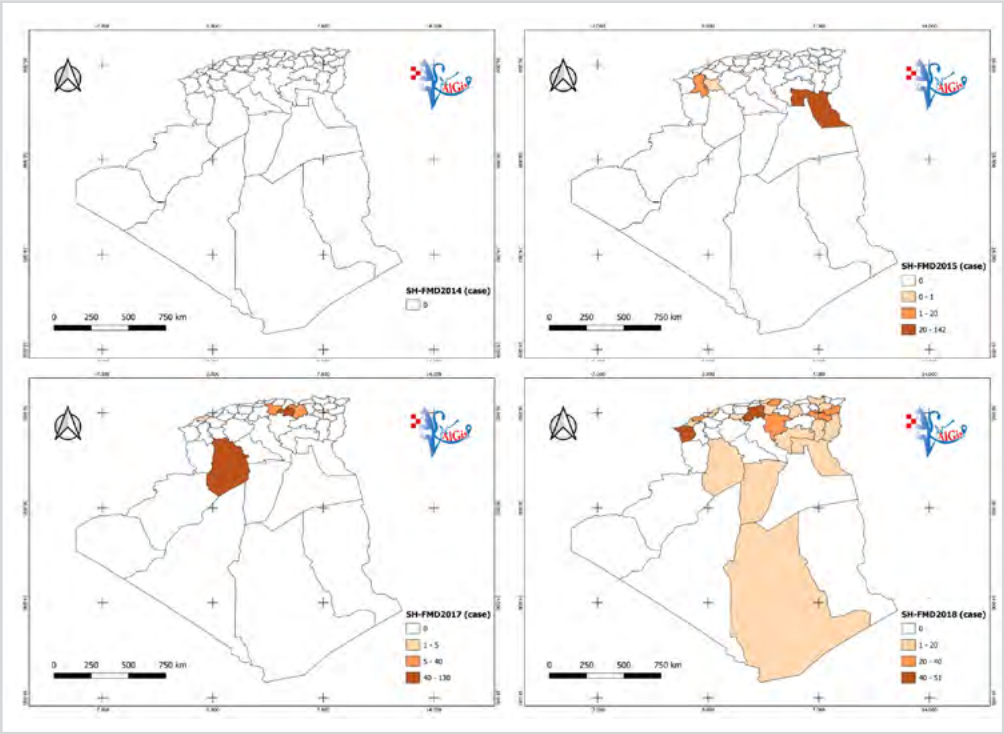

Figure 5 Distribution of sheep FMD in 2014, 2015, 2017 and 2018

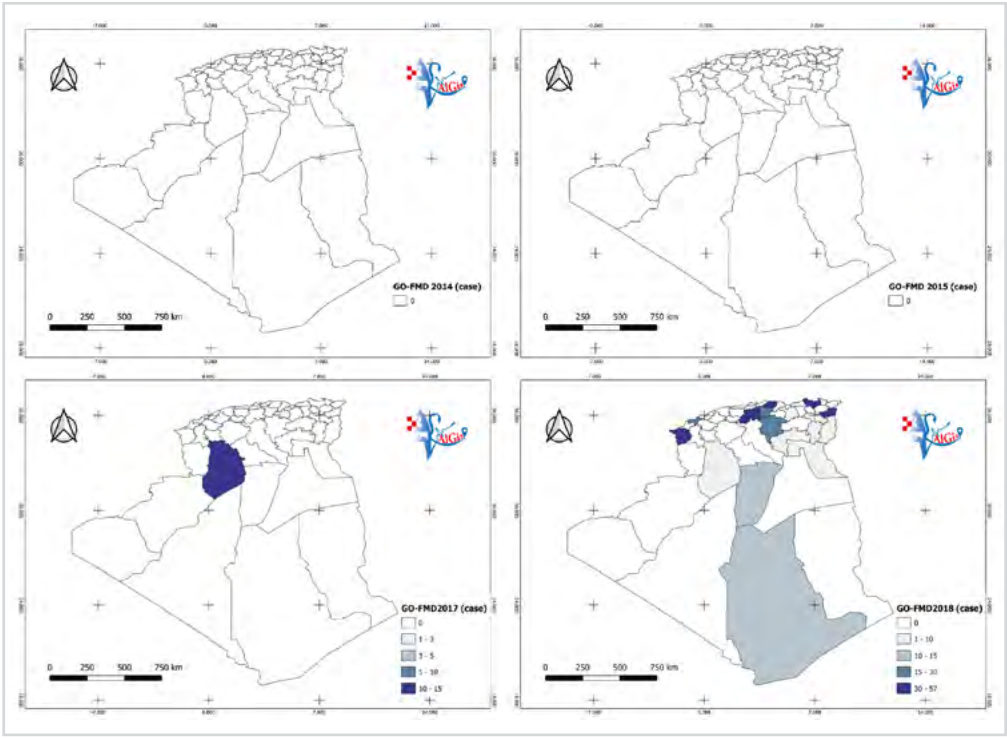

Figure 6 Distribution of goat FMD in 2014, 2015, 2017 and 2018

Goat FMD

Case of goat FMD was not registered in neither 2014 nor 2015. In the year 2017, several cases were registered in Beyedh, and the highest number of caseswere recorded in 2018 in Souk Ahras, Skikda, Medea, Tizi Ouzou and Tlemcen (Figure 6).

E/ Web map results

Figure 9 shows the map completed and exported in the web and accessibility to the outbreak information by a click.

Small scale

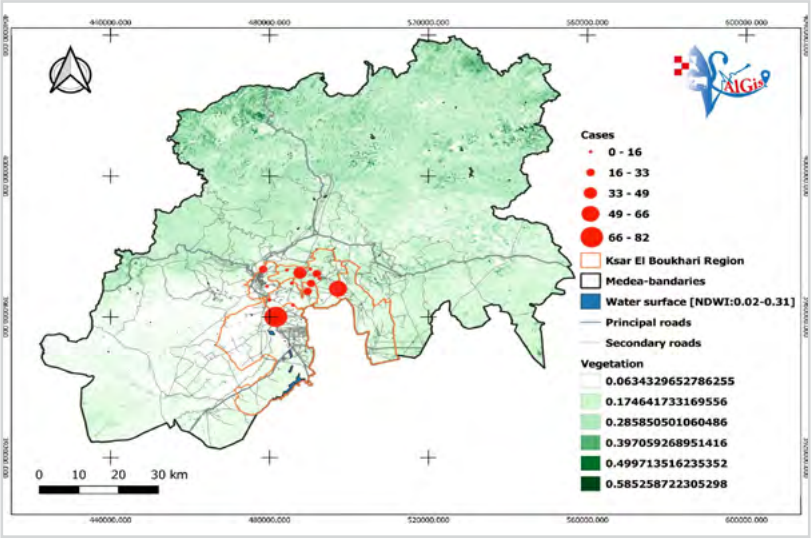

Figure 7 Medea's map showing FMD outbreaks declared in January and February, 2019

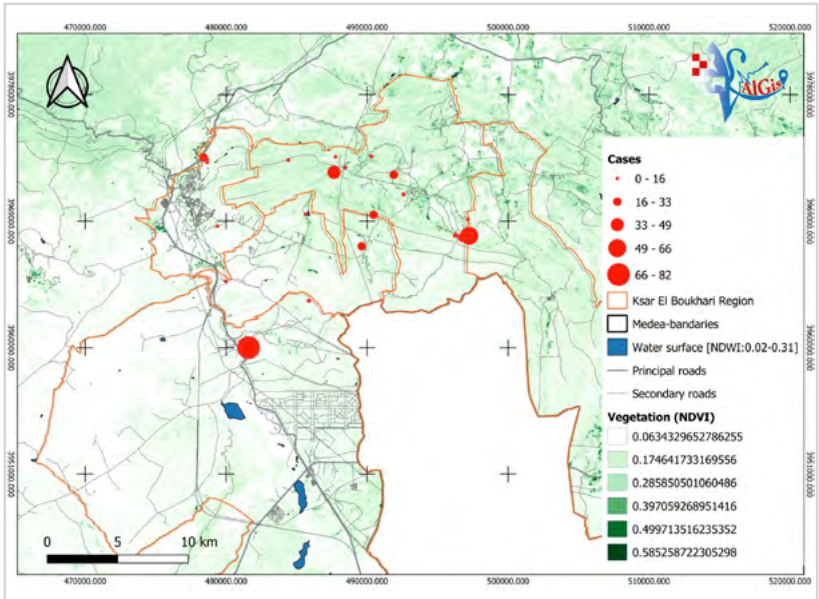

Figure 8 FMD outbreaks in Kser El Boukhari region declared in January and February, 2019 The FMD outbreaks were declared in Saneg, Mfatha, and Kser El Boukhari (Figure 7, 8)

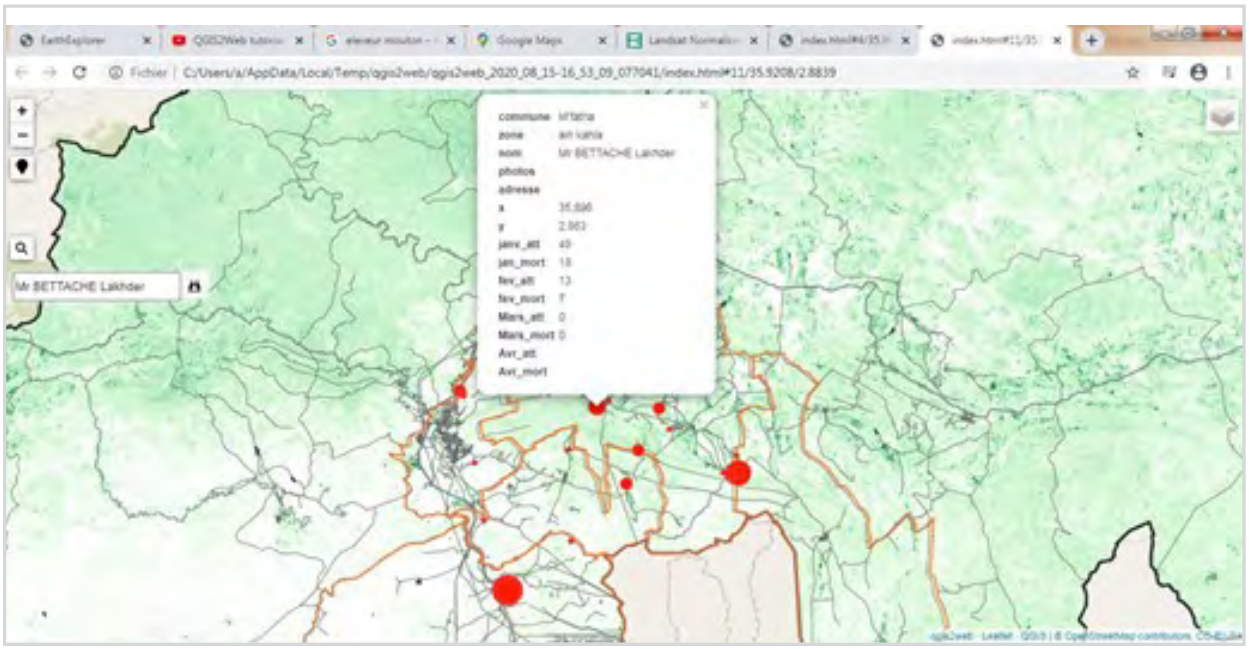

Figure 9 Medea's web map exported by the plugin QSGis2Web

DISCUSSION AND CONCLUSION

Small-scale results revealed that most FMD cases werere located along the main road, pasture and communal water points. Therefore, it can be estimated that the directional distribution of the disease may be related to animal transport from breeding areas, shared pastures and watering points. It is also well known that biological, ecological and meteorological factors can influence the emergence of infectious diseases.

Algeria is a vast country, and there are obvious climatic differences between the different regions. Thus, the weather conditions may also influence the transmission of FMD virus and PPR virus. The specific factors that explain this directional transmission pattern need to be further investigated (He et al., 2015; Ma et al., 2017).

The lack of information on notifiable diseases in any country has been largely attributed to the lack of notification of these diseases; this has led to a failure of the already weak surveillance and reporting structure (Catley et al, 2012), which wasthe case in the present study.

The VETALGIS digital platform is a website that allows easy and rapid access to available information on livestock diseases.

PPR and FMD outbreaks and cases were reported by the Ministry of Agriculture of the People's Republic of Algeria. As shown in the results, the number of FMD outbreaks reported in 2018 was lower than the previous years, which is a reminder that more effective measures have tobe implemented to prevent future outbreaks. The number of PPR cases washigh compared to previous years, which means that there were some gaps at the level of the prevention system.

In fact, this study has revealed a great amount of information, particularly on the distribution and contribution of different species to disease transmission, between and within farms. But, it is difficult to determine to what extent these findings can be generalized to other situations, with different animals, livestock systems, livestock and human networks, climates and pre-existing levels of immunity.

The three main limitations constraining the livestock disease control efforts in Algeria are the lack of inclusion and correlation when planning livestock disease control programs, underreporting, and the lack of veterinary services and a frail livestock identification system.

The first difficulty faced was due to underreporting of the PPR and FMD epidemics at the county level. This affected the information available in the offices of the DVS. Reports were only available for a few years (2014-2015-2016-2018 for FMD and 2011- 2012-2013-2016-2018 for PPR). Due to these limitations, maps of the spatial and temporal distribution of PPR and FMD outbreaks in Algeria could not be well generated, showing heterogenity in the analysis. The other challenge was to identify the areas to be included in the study, without official outbreak reports.

Accordingly, the following recommendations are made:

The appropriate government agency should develop and support the application of GIS in veterinary science to prevent and reduce the spread of disease and to evaluate its economic impact;

The clinical veterinarians and their staff should know how to use GIS in the office and in the field;

It is strongly recommended that GIS tools and their applications be used to produce maps for slaughter site selection in urban areas of Algeria;

The policies for livestock disease control should not be applied as general interventions, but need to be based on the ecological, social, cultural and economic context of the target communities;

It is strongly recommended that the government strengthens prevention and control measures for the sensitive areas, and that the export of animals and livestock products be strictly limited;

Veterinary surveillance can reinforce by several actions implemented in the region, such as the geo-localization of holdings and the individual identification of all animals in the region;

One of the main problems in obtaining the status of ‘free zone with vaccination’ is the maintenance of this health status, due to the permanent surveillance procedures required;

As eradication of FMD is not feasiblein many endemic countries, henceit is necessary to assess the cost-effectiveness of control if the incidence of the disease can be reduced by continuous mass vaccination There is a need to explore opportunities to share GIS applications and innovations specifically focused on veterinary science;

Enforcement of transportation restrictions on animals from both FMD-affected and high-risk areas is deemed an imperative.

The application of GIS in veterinary science is progressing rapidly, and it is necessary for every veterinarian to understand the basics of GISto support and advance its use in veterinary science. For this purpose, the potential of GIS applications in this field is recognized to be enormous. However, the community of users of GIS in veterinary science is rather small compared to the other sectors;

Due to the transboundary nature of FMD and PPR, a single country in an endemic area is unable to control and progressively eradicate PPR unless its neighboring countries share a similar objective. The Global Strategy also recommends the establishment of regional roadmaps for PPR. These strategies aim to reduce the PPR burden in endemic countries while developing strategies to prevent the PPR introduction into countries free of the disease;

The following recommendations should be taken into account, as PPR control strategies in pastoral areas of Algeria should be adapted to specific geographical regions taking into account prevalent diseases of small ruminants, existing disease control practices, the socio-economic status of communities and access to veterinary services. PPR annual vaccination program should also include CCPP vaccination of goats as well as target animals aged 6 to 12 months. Policy makers should

adopt the use of GIS and post-vaccine serological surveys to monitor the effectiveness and coverage of PPR vaccination campaigns in pastoral areas of Algeria;

For endemic areas, it is necessary to examine the current impact of FMD and then to evaluate possible control measures, their effectiveness and cost. A costbenefit analysis can then assess the impact over time; when control measures are in place, benefits and costs will vary between the groups over the long term of a control program. More investigators need to adopt the use of GIS spatial analysis techniques in the design, impact monitoring and development of control strategies for infectious livestock diseases; Other studies should be conducted using GIS techniques to monitor the evolution and distribution of animal diseases in Algeria, detect the different problems, and solve them later in order to preserve the public health and livestock resources in Algeria.

GIS represents a new technology in veterinary sciences, which provides significant added value in animal health, by studying, reporting information and modeling animal disease problems. As routine data are usually taken into low consideration for either epidemiological or management purposes in veterinary sciences, GIS can considerably increase the efficacy of communication to exploit those data. In the field of veterinary science, this methodology can be largely applied to different types of diseases. There are several situations in which it is suggested that GIS will play an increasingly important role in the future: the need to solve epidemiologically complex disease problems, and the need for rapid surveillance of highly contagious transboundary diseases. However, applying sophisticated spatial techniques to poor-quality data will not create an insightful investigation. The people working with GIS should keep in mind that maps cannot be an alternative for better data collection and recording. The maps will never be better than the original input data. It's a mere translation of information in a language which is easy to understand.

Impact of FMD and PPR is high for some regions, but low for others. This impact varies according to the incidence of the disease and also the positive and negative impact of control measures, levels of access to veterinary services, animal health inputs and livestock markets.

GIS spatial analysis techniques have proven to be a useful tool that can support the decision-making process in planning, implementing and monitoring FMD and PPR control strategies in endemic and high-risk areas.

CONFLICT OF INTEREST

The authors declared that there is no conflict of interest.

AUTHOR CONTRIBUTIONS:

Concept - DA, KTNA, BRL, ON, BA, CA; Design - DA, KTNA, BRL, ON, BA, CA; Supervision - KTNA,ON; Resources - DA, BA, CA; Materials - DA, BA, CA; Data Collection and/or Processing - DA, KTNA, BRL, ON; Analysis and/or Interpretation - DA, KTNA, BRL, ON; Literature Search - DA, BRL, BA, CA; Writing Manuscript - DA, KTNA, BRL; Critical Review - KTNA, ON.

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PRIMJENA GEOGRAFSKOG INFORMACIJSKOG SISTEMA (GIS) I WEB-GIS ZA NADGLEDANJE I PRAĆENJE SLINAVKE I ŠAPA I BOLESTI MALIH PREŽIVARA U ALŽIRU

SAŽETAK

Cilj istraživanja je evaluirati i implementirati prostorne baze podataka koje su izravno povezane sa zdravljem životinja u GIS-u i web-GIS-u vizualizacijom prostorno-vremenske distribucije bolesti životinja, kao što su kuga malih preživara (KMP) te slinavka i šap (SiŠ) u Alžiru. Usvojena je metodologija koja obuhvata klasične korake GIS-a, a primijenjena je korištenjem besplatno dostupnog Qgis 3.10. Ova metodologija je široko primjenjiva na različite tipove bolesti. Kreirali smo i model web stranice "VETALGIS" (Veterinarski alžirski GIS) sa ciljem digitalizacije veterinarskog sektora I minimiziranja problema nedostatka podataka, organizacije podataka i olakšavanja pristupa podacima, kako bi poboljšali razmjenu podataka i komunikaciju između institucija odgovornih za upravljanje stočnim bolestima. Tehnike prostorne analize GIS-a su dokazano sredstvo koje može olakšati donošenje odluka u planiranju, implementaciji i nadgledanju SiŠ i BMP, kao i u strategijama kontrole u endemskim i visokorizičnim područjima.

Ključne riječi: Bolesti malih preživara, geografski informacijski sistem (GIS), slinavka i šap