A Comparison of Pistachio Trees and
Atriplex Vegetation in Reducing Leishmaniasis

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Information	Abstract
  Corresponding Author: **Mohammad Sadegh Eshaghpanah** **Email:** sfallah.eshagh@yahoo.com **Tel:** +98-9132514403	**Introduction:** Cutaneous leishmaniasis is one of the endemic parasitic diseases in central Iran. The rural type of this disease is transmitted from rodents to humans by *Phlebotomus papatasi*. This study aims to investigate the role of vegetation in the existence of rodents in the study area. **Materials and Methods:** The current descriptive-analytical study investigates prevalence of leishmaniasis in the Esfandabad Abarkooh City from 2019 to 2020. ArcGIS 10.2.2 and the layer overlay technique were used to examine effects of vegetation on the development of rodent activity, being regarded as *leishmania* reservoirs **Results:** A total of 20 and 23 cases of leishmaniasis were diagnosed in 2019 and in the first seven months of 2020, respectively. The findings revealed that the primary vegetation of the Esfandabad Abarkooh City included two species of *Atriplex* and pistachios. The layer overlay technique and the areas containing rodent nests showed that *Atriplex* encompassed 81.45% of the nests, and only 0.37% of the active nests were found in pistachio fields. **Conclusion**: In addition to preventing soil erosion, pistachio cultivation has a significant role in reducing rodent activity in the region. In addition, it positively impacts the residents' economy through its positive role in sustainable development in the region.

1. Introduction

Cutaneous leishmaniasis is a parasitic disease caused by different species of *leishmania* parasites [1]. This disease is considered one of the major health problems in many countries, especially in tropical and subtropical regions of the world, including Iran. Besides, it is one of the most common parasitic diseases in Iran after malaria. About 20,000 annual cases of leishmaniasis are reported in Iran. Cutaneous leishmaniasis exists in two rural (wet) and urban (dry) forms in Iran, with each having several foci [2]. The leishmaniasis carrier is a type of urban sand fly called *Phlebotomus sergenti* that transmits the parasite from person to person. The rural type of leishmaniasis is transmitted by a sand fly named *Phlebotomus papatasi* that transmits the parasite from some rats to humans [3]. Four species are identified as the main reservoirs of the rural type of cutaneous leishmaniasis, including *Rhombomys opimus*, *Mariones horiane*, *Tatra indica*, and *Mariones libicus* that exist in the central and northeastern regions, southeast regions, central regions, as well as western, southern, and central regions of Iran, respectively [2].

Numerous factors are involved in distributing rodents known to be reservoirs of this disease [4], with the major factor affecting rodent activity being vegetation.

Vegetation plays a central role in providing access to food for rodents and being used as a source of food [5].

Esfandabad Abarkooh is a city in the Yazd province with a population of 2,937 and is one of the centers of this disease. Desertification and changes in the natural ecosystem have led to the spread of rodent habitats in the disease reservoir, resulting in abundance of vectors and an increase in human disease cases [4]. Based on trapping, biological, and zoological studies, *Phlobutomus papatasi* is the most active reservoir in the Esfandabad region, being a *leishmania* carrier in rodent Rhombomys opimus. About 6,800 hectares of lands undergo rodent monitoring and elimination operations per year within a radius of 1.5 km from Esfandabad residential districts to control leishmaniasis.

Many studies have been conducted using statistical analysis via computer software [6, 7]. In recent years, geographic information systems (GIS) or ArcGIS software is widely employed in determining the extent of surface factors as separate layers, as well as their overlaying impacts and mutual effects [8, 9]. ArcGIS software is highly effective in simulating effects of various variables and environmental assessments [10, 11]. The layer overlay technique is one of the practical techniques used in simulating and examining environmental variables, by

which different layers of surface and environmental features are simulated in ArcGIS, and their possible mutual effects are studied [12]. This study aims to investigate the relationship between vegetation and rodent activity using the layer overlay technique, vegetation status, and the size of the rodent nesting area. The layer overlay technique allows the researcher to investigate effects of different layers on a quantitative variable in the study area.

2. Materials and Methods

In this study, the incidence rate of leishmaniasis was studied statistically during the 12 months of 2019 and the first 7 months of 2020 in Abarkooh City. To this end, rodent activity was examined when visiting the area. The radius of the rodent activity zone was determined in each area by examining the existing nests of *Rhombomys opimus* rats. In addition, the types of vegetation and agriculture were determined in the rodent activity area. Next, ArcGIS polygon software was used to simulate different types of vegetation in the area containing active nests. This software allows the user to simulate the geographical location of a complication on the ground in the computer environment and evaluate effects of various variables using specific techniques. In the study area, by overlaying vegetation layers of the region and the variable of rodent activity in the region, the overlay status of the vegetation and rodent activity of the *leishmania* reservoir was determined.

3. Results

Based on the study conducted during 12 months of 2019, 20 cases of rural leishmaniasis were identified in villages of the study area. In the first 7 months of 2020, the number increased to 23 cases. Fig. 1 shows the number of leishmaniasis cases during 12 months of 2019 and the first 7 months of 2020.
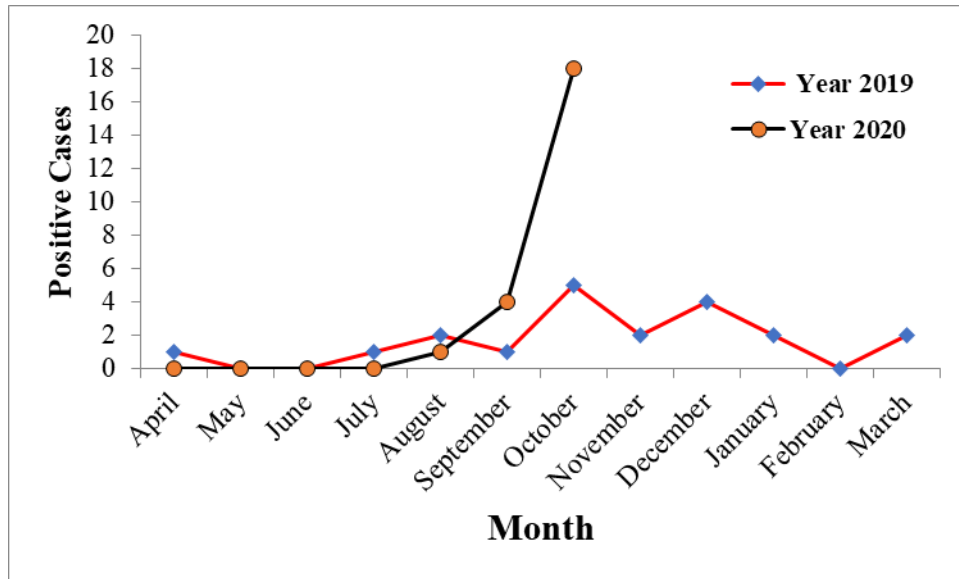
Fig. 1- Number of leishmaniasis cases per month in 2019 and 2020

According to the findings, an area of 3,105,893.77 m^2 (81.8%) was covered by vegetation out of the five areas, which totaled 3,796,089 m^2 with active rodent nests in the Esfandabad City in 2020. Table 1 shows vegetation status in the eight study areas with active nests.

Trapping and zoological studies show that active nests belong to Rhombomys opimus rats that are the reservoir of rural leishmaniasis in this area. The sand fly *Phlebotomus papatasi* transmits the *leishmania* parasite when biting rats and then humans.

Table 1- Vegetation status in the area containing rodent nests

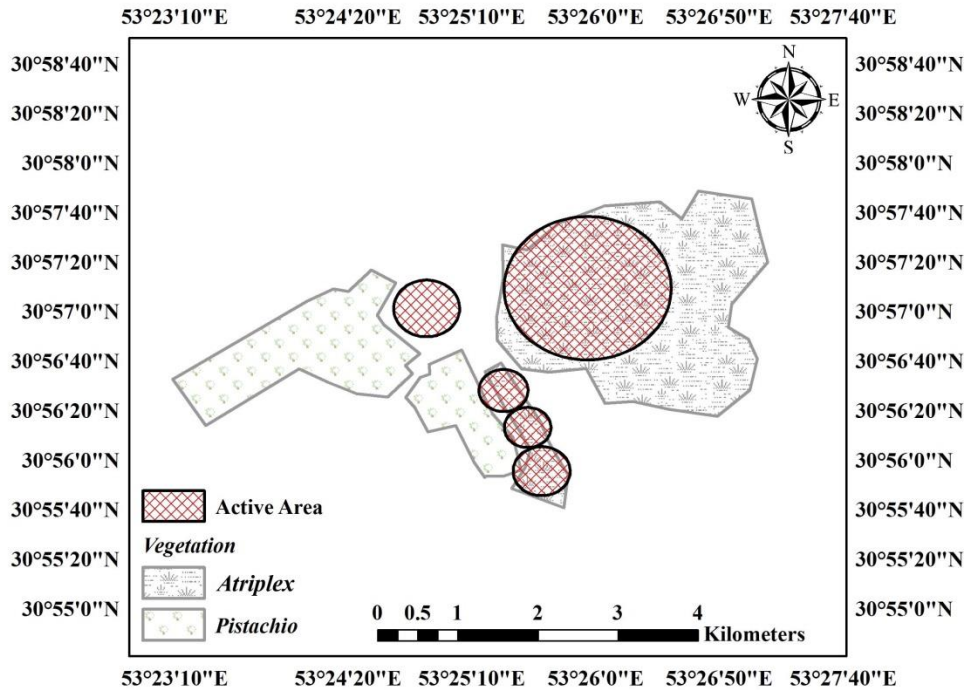| Area Cod	Active Area (m²)	Atriplex Area (m²)	Pistachio Area (m²)
A1	2238581	2193809	0
A2	201740	110957	6052.2
A3	179768	107861	3595.36
A4	271934	203951	2719.34
A5	349176	0	0
B1	251609	203803	0
B2	128599	105451	0
C1	174682	165948	1746.82
Total	3796089	3091780.05	14113.72
Percent (%)	100.00	81.45	0.37

Fig. 2- Geographical locations of active nests, *Atriplex*, and pistachio plants in the A1-5 area

Fig. 2 to 4 demonstrate areas containing rodent nests and the type of vegetation. The images were prepared by the layer overlay technique. In these images, the circular environment shows the nests of *Rhombomys opimus* rats. According to the prepared maps, vegetation of the Esfandabad region includes two types of *Atriplex* and pistachio plants. *Atriplex* has been cultivated for combating desertification in the area. Pistachios are the dominant agricultural product of this region, which are cultivated according to its climatic conditions. Rodent nests are more abundant in the vegetated areas. The images show that areas not covered by vegetation are without rodent nests. Based on the simulated images of the region, rodent nests were more frequently found in areas covered by *Atriplex*. In contrast, the rate of rodent activity was very limited in pistachio fields.
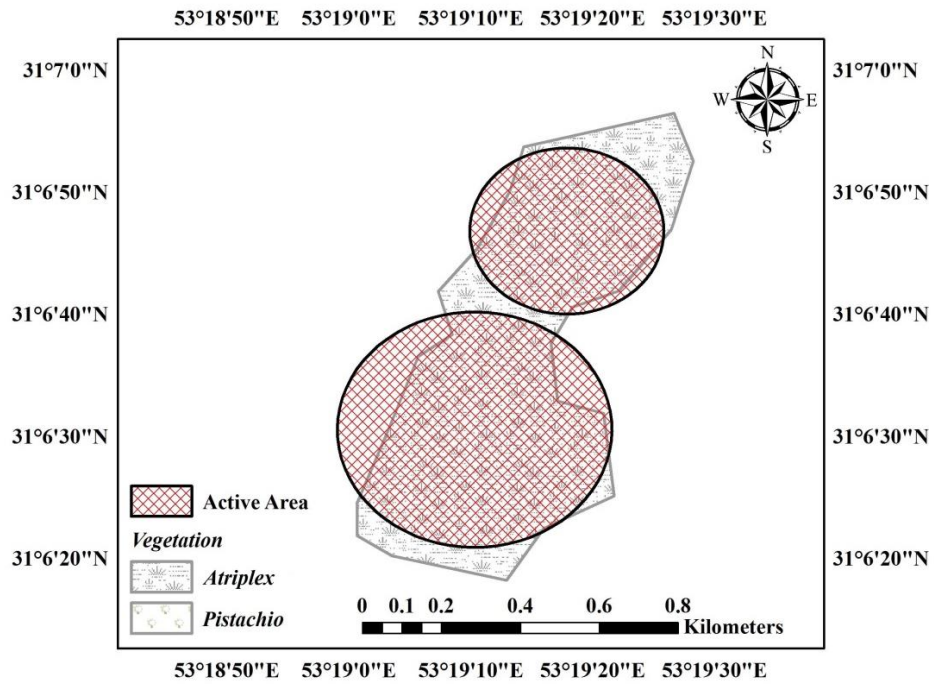
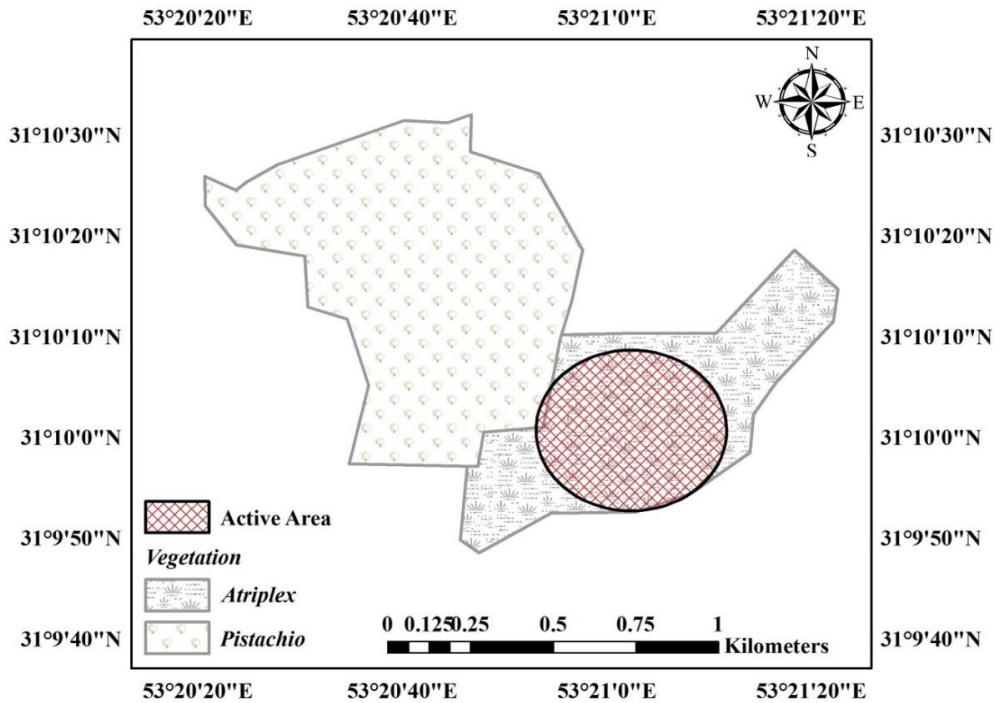**Fig. 3-** Geographical locations of active nests, *Atriplex*, and pistachio plants in the B1-2 area

Fig. 4- Geographical locations of active nests, *Atriplex*, and pistachio plants in the C1 area

4. Discussion

4.1. Evaluation of the number of leishmaniasis cases

According to Fig. 1, the most considerable increase in leishmaniasis cases was observed in October by 360% compared to 2019. As the region's population has not changed, influential factors, such as climatic changes and the extent of vegetation, could be possible reasons for this increase. Past research shows that as the wet season goes ahead, vegetation increases accordingly, thereby leading to more rodent access to food [13]. The incidence rate is expected to rise in the coming months, with the number of cases increasing significantly compared to the previous year. Since rural leishmaniasis is common in the study area, its prevalence is fully dependent on the activity and birth rate of *Rhombimys opimus* rats. Accordingly, any factors improving living and birth conditions in rats could increase the number of leishmaniasis cases [13]. Nutrition and access to food are among these conditions that are dependent on vegetation in the region [14].

4.2. Vegetation survey of the region

The Geographic Information System (GIS) is a digital data-based management system designed to manage various types of data from different sources [15]. The GIS is considered an ideal tool in site-related studies for having the desired ability to create, store, combine, and analyze layers of information according to user needs and definitions [16]. Over the years, the GIS has been widely used in natural resource management as well as in economic and environmental assessments. The main purpose of feasibility studies is to determine ecologically suitable areas. Integration of GIS tools with the layer overlay technique is one of the best methods employed in ecological studies [12]. The use of the layer overlay technique made it possible for studying variables of the types of vegetation in the study area.

Results of examining the maps extracted from the layer overlay technique revealed that the dominant vegetation in the region with rodent nests were *Atriplex* and pistachio trees. *Atriplex* has been developed in recent years to combat desertification. Pistachio trees are widely cultivated in the region for their climatic and economic capacity as an agricultural product.

The vastest area with active nests was area A1 with an area of 2,238,581 m^2. Images prepared using ArcGIS show that vegetation containing *Atriplex*, with an area of 3,091,780.05 m^2, covers 81.45% of the region with rodent nests. Pistachio trees with an area of 14,113.72 m^2 cover 0.37% of the region with rodent nests. According to Figs. 2 to 4, rodent nests are only observed in marginal strips of pistachio fields, which could be due to their proximity to *Atriplex*. Most of the infected foci containing rodent nests were observed in the areas covered by *Atriplex*. The results of this study suggest the presence of a symbiotic relationship between *Rhombomys optimus* and *Atriplex*. This coexistence is maintained due to the fact that the rats consume plant roots as a food source [14]. According to past research, nests of *Rhombomys opimus* are abundant in areas covered by *Atriplex* [17]. Previous

studies show that an increase in the wet year duration leads to *Atriplex* growth, which provides favorable conditions for rat populations [18]. Although *Atriplex* is a drought-tolerant species suitable for combating desertification, in areas where rural leishmaniasis is endemic, this plant is not a suitable option for combatting desertification because it increases reservoir fertility [19]. According to the results, pistachio cultivation did not affect the birth rate in *Rhombomys opimus* rats, and the nests were rarely observed in such areas. Pistachios are drought-tolerant plants. By developing pistachio fields, anti-desertification programs and soil stabilization operations are realized. As a result, it will be possible to improve economic status of the residents and take a significant step towards sustainable development.

5. Conclusion

Rural cutaneous leishmaniasis is a disease transmitted to humans from *Rhombomys opimus* rats by *Phlebotomus papatasi* mosquitoes in residential areas of the Esfandabad Abarkooh City. A rodent control program is executed every year to reduce reservoirs of this disease around residential areas. Controlling rodent populations and reducing their numbers have a direct impact on the number of leishmaniasis cases. Vegetation is one of the significant factors affecting the number of rodents and their reproduction. Our findings showed that the nests of *Rhombomys opimus* rats were more in areas covered by *Atriplex*. In contrast, in areas covered by pistachio trees, the nests were fewer. Accordingly, development of pistachio fields could reduce rat activity and be economically beneficial, thereby contributing to sustainable development in the region.

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Conflict of Interest

No conflict of interest was stated by the authors.

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