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Knowledge, attitude, and practices on human myiasis with spatial modeling of human risk of exposure to *Oestrus ovis* among shepherds/ people in Ilam province, southwest of Iran

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Abstract

Background: Myiasis is the infestation of humans or other animals with the larvae of flies that occurs in the tropical and subtropical regions, worldwide. The objectives of the present study were to evaluate knowledge, attitude, and practice of the population at risk about myiasis and to infer potential risk areas of human myiasis due to the environmental suitability for *Oestrus ovis* in the Ilam province of Iran.

Methods: This study was conducted from April to June 2020 among the myiasis-infested shepherds in Ilam province. The data were collected by a questionnaire. Maximum Entropy (Maxent) niche modeling was used to predict the environmental suitability for *O. ovis*.

Results: The level of awareness of the people of Ilam province on myiasis was generally good, while a small percentage of them had poor information about this disease (1.62%). Mean Diurnal range and isothermality revealed the highest and lowest share on the MaxEnt model, respectively. The elevation variable had the most permutation in the model for predicting the environmental suitability for *O. ovis*. The best ecological niches for this fly were in the northern parts of the study area.

Conclusion: It can be concluded that due to background knowledge of the involved people in exposure to oral myiasis agent, *O. ovis*, conducting some preventive measures based on improving their knowledge, attitude, and practices could be useful for reducing the risk of the disease in the area. On the other hand, the suitable areas for the establishment of *O. ovis* which has been clarified with the model could be used for focusing on the preventive measures in the area.

Introduction

Myiasis is the infestation of humans or other animals with the larvae of flies that live for a while and use their living or dead tissue, body fluids, or digested food [1]. This occurs mostly in tropical and subtropical regions worldwide [2,3]. According to the entomological viewpoint, myiasis occurs obligatory, facultative, and accidentally which is classified based on the levels of relationship between host and parasite [4]. It is known as a zoonotic disease and is also seen as an occupational disease that is more common in shepherds and herders [5]. *Oestrus ovis* (Diptera: Oestridae) larvae are obligatory parasites that only develop in the body of living vertebrates which usually infests sheep and goats and occasionally in other species of vertebrates [6]. Females of this species are viviparous which sprays the larvae in the nostrils and sometimes in the ears, pharynx, or eyes of the host [7]. Human myiasis caused by O. *ovis* has been reported from different parts of Iran [8-13] including Ilam province [14]. Knowledge, attitude, and practice of the population at risk about disease play a major role in the implementation of control measures and reducing the burden of the disease (14). The results of KAP studies could help to attract the participation of the people in future preventive measures, especially for educational programs.

Due to the special climatic conditions, this province is one of the most important livestock areas in Iran and many people in this region are engaged in animal husbandry. According to previous studies conducted in this province, the prevalence of oral myiasis was very high among shepherds, especially during the fly seasonal activity. According to statements of the patients and the flies which were caught by some of them, the agent of the disease in this province was *O. ovis* [13].

The time and place of the intervention are very important to control the disease. Geographical Information System (GIS) and predictive models are an emerging and evolving field of landscape epidemiology. This field is increasingly used to answer many questions about potential species distributions and how to design programs for surveillance, prevention, and control of diseases to save money and time [15]. There are various methods for modeling Grinnellian niches and predicting the spatial distribution of species such as those requiring presence-only data, regression models requiring presence plus true absences, or pseudo-absence data, and algorithms requiring presence-background data including Maximum Entropy (MaxEnt). The possibility of error is higher in models that use absences data and may also be unreliable. Presence-only species distribution models using environmental variables and occurrence localities species' presence has widely been used for biogeographic research [16]. MaxEnt is the most common method applied in the ecological niche modeling of vector-borne diseases [17].

The objectives of this study were to evaluate knowledge, attitude, and practice of the population at risk about myiasis and to infer potential risk areas of human myiasis due to the environmental suitability for *Oestrus ovis* in the Ilam province of Iran.

Methods

Study area

Ilam province is one of the western provinces of Iran, between 32º03´ and 34º02´ North longitude and 45º40´ and 48º03´ East latitude. It is situated along the foothills of the southwestern edge of the Zagros mountains and shares a long border, 425 km, with Iraq. It shows two distinct natural areas in the north and south of the province. Northern mountainous areas have a temperate climate, while the southern and southwestern plains have a very hot climate. The population of this province is 579,707, of which 395,263 (63%) live in urban and 184,444 (37%) in rural areas. Ilam province is one of the important zones of animal husbandry in Iran. There are 2.2 million light and heavy livestock in this province, and this has provided suitable conditions for the high abundance and diversity of myiasis-causing flies.

KAP study

A KAP study was carried out from April to June 2020 among the infested shepherds who got the disease at least once. The sample size (n) = $\frac{Z1-\frac{\alpha}{2}pq}{d2}$ =290 was calculated where p=0.775, q=0.225, d=0.05 at 95% confidence and 5% level of significance. The data were collected by a questionnaire that included a total of 43 questions regarding general Knowledge, Attitude, and Practices (KAP) about human myiasis. The answer options for the knowledge part of the questionnaire include: yes, no, and I do not know. For attitude, the options based on these were: Agree, Disagree, and neither agree nor disagree; and for practice questions, the answer was yes or no. Cronbach's alpha was used for the reliability and validity of a questionnaire. All statistical analyses were done using Microsoft Excel 2010 and SPSS version 22 software.

Ecological niche modeling

Maximum Entropy (MaxEnt) [18] niche modeling was used to predict the environmental suitability for *O. ovis* based on bioclimatic/environmental variables, and occurrence records of this species in Ilam province. To determine the presence points of *O. ovis*, data were collected during fieldwork and converted into CSV format using Microsoft Excel 2010. Climatic variables

and elevation were obtained from the World-Clim dataset (www.worldclim.org) with a spatial resolution of 1km^2, clipped based on the border of the study area, and then converted to the ASCII format in ArcMap ver 10.3 for running in the MaxEnt software. For calibration of the model, 80% of the records of *O. ovis* were used as training data, and 20% were used for model validation as test data. Band collection statistics analysis was used to find variables that were more than 80% similar which were removed from the final model. MaxEnt was run ten times to get an average prediction. The potential geographical distribution of *O. ovis* displayed with the model as an output. The Jackknife analysis was used to determine which climatic/environmental variables had the greatest impact on the distribution of *O. ovis*.

Results

As many as 290 individuals were randomly selected and questioned from 6 counties of Ilam province which most of the participants (40.02%) were in the age group of 49-59 years. Of these, 61% were male and 39% were female. Most of the participants had primary education (53.5%) followed by Illiterate (31.7%) and university degree (14.8%). About 93.4% of participants were sheep breeders and 83.1% had goats. By lifestyle, most of the participants were lived close to livestock (93.6%) (Table 1). About 73.03% of participants had good knowledge about myiasis, followed by 25.35% moderate information and 1.62% poor information. Dehloran and Eyvan counties had the highest and lowest levels of knowledge on myiasis, respectively. About 72.44% of participants believed seeing a physician is effective for treating the disease and 62.8% said that they visit a physician if they get myiasis. All participants believed that the disease was more prevalent in some seasons, and 98.42% of them believed that infestation was more likely in some places. About 87.8% of participants said that they use a suitable face/ headcover to prevent infestation, especially in fly season activity. About 62% stated that they use repellents to prevent infestation while 42% believed that the application of a repellent is effective in preventing the disease. About 80.2% of participants declared using traditional methods to treat the disease while 73.21% believed that traditional methods can be used to treat this disease. About 90.48% of participants haven't used to rest near livestock and 93.8% believed that the barn must be separate from the household. About 23.73% of participants believed spraying the barn with insecticide does not affect fly control (Table 2). Among the various environmental factors on the MaxEnt model, the Mean Diurnal range (Bio2) was the most important, and precipitation of the The output of the MaxEnt model for *O. ovis* is shown in

Variable	Number	Percent (%)
Age (in years)		
18-26	42	14.48
27-37	68	23.5
38-48	41	14.42
49-59	116	40.02
≥60	23	7.76
Gender		
Male	177	61
Female	113	39
Education		
Illiterate	92	31.7
Elementary degree	155	53.5
University degree	43	14.8
Type of livestock		
Sheep	271	93.4
Goats	241	83.1
Lifestyle		
Close to livestock	272	93.6
Away from livestock	18	6.4

Table 1: Socio-demographic characteristics of the study population (n=290), Ilam province of Iran.

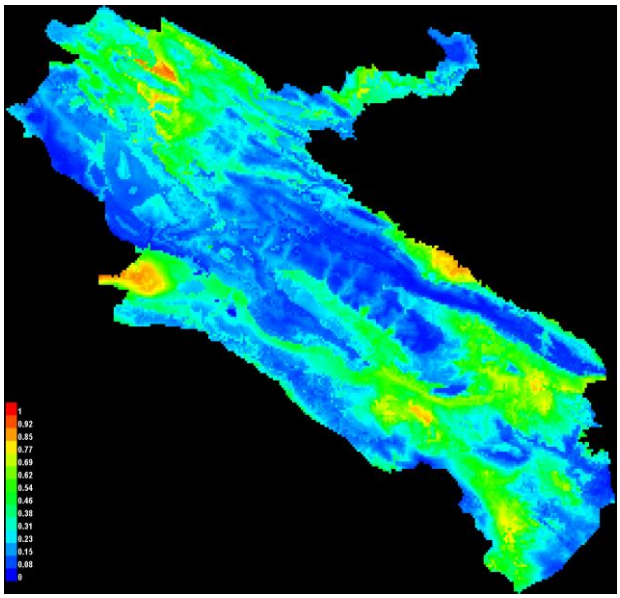

Figure 1: Maxent model for environmental suitability of *Oestrus ovis* in Ilam province, Iran. The color scale from blue to red indicates the habitat suitability value from 0 to 1.

warmest quarter (Bio18) had the lowest important variable for distribution of *O. ovis* (Percent contribution 18.4% and 0.6% respectively). The Elevation was the most important variable for predicting the environmental suitability for *O. ovis* (permutation importance 33.5%) (Table 2). Figure 2 shows the results of the Jackknife tests of variable importance for 10 replicate models that were performed using only single variables (blue), without each variable (green), and finally with all variables (red). The environmental variable that when omitted has the greatest effect on the model was Elevation. Values shown are averages over 10 replicate runs. The environmental variable with the highest gain, when used in isolation, was bio7 (Temperature Annual Range). Temperature is one of the

Factors		The study area (county)						Total (%)
		Ilam	Eyvan	Abdanan	Darehshahr	Dehloran	Mehran	
Knowledge								
Awareness on myiasis	Good	78.4	60.5	73	78.6	81	66.7	73.03
	Medium	20.5	38.3	24.3	21.4	19	28.6	25.35
	Poor	1.1	1.2	2.7	0	0	4.7	1.62
Attitudes								
Visiting a physician is effective for treating the disease	Agree	53.3	71.9	75.9	80.7	81.4	71.4	72.44
	Disagree	25.3	19.8	12.4	14.3	14.3	19	19.18
	Neither agree nor disagree	11.4	8.3	11.7	5	4.3	9.6	8.38
In some seasons the risk of disease is higher	Agree	100	100	100	100	100	100	100
	Disagree	0	0	0	0	0	0	0
	Neither agree nor disagree	0	0	0	0	0	0	0
In some places the risk of disease is higher	Agree	98.0	98.8	97.3	96.4	100	100	98.42
	Disagree	0.0	0.0	0.0	0	0	0	0
	Neither agree nor disagree	2.0	1.2	2.7	3.6	0	0	1.58
The barn must be separate from household	Agree	97.1	93.8	94.6	96.4	90.5	90.5	93.8
	Disagree	1.0	0	0	0	0	0	0.17
	Neither agree nor disagree	2.0	6.2	5.4	3.6	9.5	9.5	6.03
Traditional methods can be used to treat this disease	Agree	72.7	63	72.2	77.9	71.5	82	73.21
	Disagree	11.8	21.1	15.4	13.6	14.7	14.7	15.22
	Neither agree nor disagree	15.5	15.9	12.4	8.5	13.8	3.3	11.57
The use of repellents is effective in preventing disease	Agree	75.3	65.7	73.2	72.8	66.7	77.2	71.82
	Disagree	10.6	17.4	21.6	12.8	23.3	15.8	16.92
	Neither agree nor disagree	14.1	16.9	5.2	14.4	10	7	11.27
Spraying the barn with insecticide has no effect on fly control	Agree	26.3	22.2	35.1	25	14.3	19.5	23.73
	Disagree	60.4	62.1	55.2	59.3	71.9	72.4	63.55
	Neither agree nor disagree	13.3	15.7	9.7	15.7	13.8	8.1	12.72
Practice								
I go to the physician after infestation	yes	42.4	65.6	65.9	72.1	69.4	61.4	62.8
	No	57.6	34.4	34.1	27.9	30.6	38.6	37.2
I use a suitable cover to prevent infestation	yes	93.1	86.4	86.5	89.3	90.5	81	87.8
	No	6.9	13.6	13.5	10.7	9.5	19	12.2
I use repellents to prevent infestation	yes	43.7	38	42.2	44.3	41.9	41.9	42
	No	56.3	62	57.8	55.7	58.1	58.1	58
I do not rest near livestock	yes	83.3	94.6	90.5	92.9	93.3	88.3	90.48
	No	16.7	5.4	9.5	7.1	6.7	11.7	9.52
I use traditional methods to treat the disease	yes	84.2	71.4	81.5	80.7	83.2	80.2	80.2
	No	15.8	28.6	18.5	19.3	16.8	19.8	19.80

Table 2: A cross-sectional assessment of the knowledge, attitude, and practice (KAP) towards the study participants regarding human myiasis in the Ilam province of Iran (n = 290). The survey population was determined by the objectives of the survey.

Variable	Percent contribution	Permutation importance
Bio2 (Mean Diurnal range)	18.4	4.6
Elevation	16.1	33.5
Bio8 (Mean Temperature of Wettest Quarter)	16.1	20.7
Bio7 (Temperature Annual range)	11	3.4
Bio15 (Precipitation Seasonality)	7.5	3.3
Bio19 (Precipitation of Coldest Quarter)	7.3	11.6
Bio5 (Max Temperature of Warmest Month)	6.3	1.6
Bio13 (Precipitation of Wettest Month)	3.7	0.9
Bio14 (Precipitation of Driest Month)	3.5	7.5
Bio4 (Temperature Seasonality)	3.3	1
Bio3 (Isothermality)	2.3	2.4
Bio10 (Mean Temperature of Warmest Quarter)	1.5	2.7
Bio12 (Annual Precipitation)	1.3	0.3
Bio16 (Precipitation of Wettest Quarter)	1.1	1.7
Bio18 (Precipitation of Warmest Quarter)	0.6	5

Table 3: Relative contribution and importance of the environmental variables to the MaxEnt model.

most important environmental factors that affect the growth and development of insects. As a result, the maximum probability of the presence of *O. ovis* is 37°C, and with increasing temperature (more than 37°C), the probability of the presence of this species decreases (Figure 3).

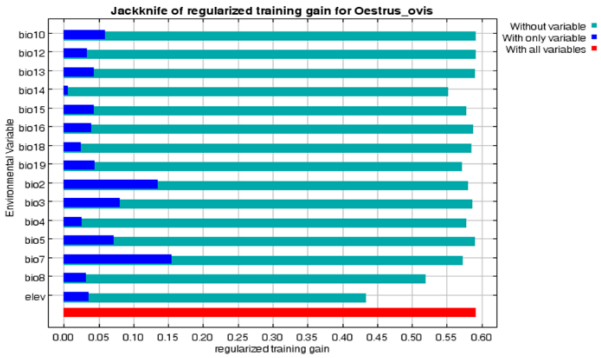

Figure 2: Jackknife analysis for individual environmental variable importance (blue bars) relative to all environmental variables (red bar) for the MaxEnt model. Values shown are averages over 10 replicate runs.

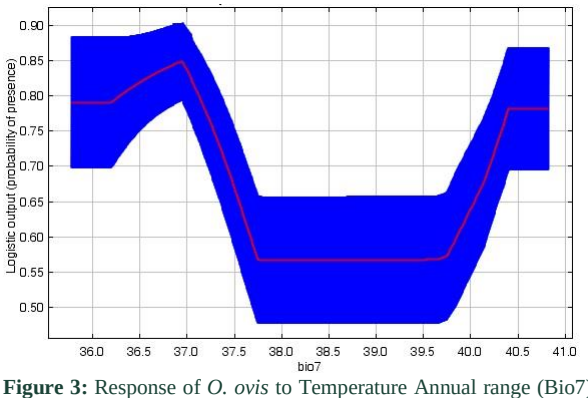

Figure 3: Response of *O. ovis* to Temperature Annual range (Bio7). The curves show the mean response of the 10 replicate Maxent runs (red) and the mean +/- one standard deviation (blue, two shades for categorical variables).

Discussion

The level of awareness of the people of Ilam province about myiasis was generally good and a small percentage of them had poor knowledge (1.62%). It seems that long time close contacts of the involved people with animal husbandry processes have had positive effects on their knowledge about livestock pests, including flies. Some of the participants believed that visiting a physician has little effect on the treatment of the disease, which shows their belief on the disease was drug/ treatment-free, i.e. the course of the disease must be completed, and some believed that prescribed drugs did not result in any recovery. In a study in Fars province, 62.8% of participants believed that visiting a physician was effective in treating the disease [5]. However, Pampiglione et al. (1997) reported that just 1% of shepherds in Etnean counsulted a physician [19]. Due to the lack of effective drugs that cause the death of fly larvae in the human body, drugs are mainly prescribed to alleviate clinical symptoms and sometimes do not have much effect, which in turn reduced people's trust in the treatment of the disease by physicians. Findings of another study conducted on myiasis in Ilam province, showed that the disease is seen in spring, summer, and autumn seasons, and the highest prevalence was seen in summer [14]. All of the participants in this study were aware of the prevalence of myiasis in different seasons. In a study conducted in Fars province, more than 80% of the participants knew the breeding habitat of flies and more than 70% of them stated that they had been attacked by flies in barns [20]. In Ilam province, 43.8% believed that they were infested while grazing, 22.1% infested while resting near to the livestock, and 34.1% infested while rearing the animals [14]. In the current study, most participants believed that the risk of myiasis is much more higher in some places. The use of traditional methods is common among the shepherds, especially among the nomads because they are far from medical and health centers, and so they prefer to treat diseases with traditional methods. In a study conducted in Fars province, 39% of participants believed that the use of traditional methods is effective in treating the disease. In the present study, about 73.21% of the participants believed that traditional methods are effective in treating the disease and 80.2% use such traditional methods/ remedies. Lots of participants in this study believed that the use of repellents is appropriate to prevent this disease, but only 42% used repellents to prevent infestation which could be due to the unavailability of such substances and their afordability as well. Using insecticides to control insect pests is common, but in myiasis, because the larval stages are in the body of living organisms, and adult insects are more away from human places, insecticide spraying does not applied in disease control. In this study, 63.55% of participants believed that spraying could not affect controlling the disease. The mean diurnal range (Bio2) was the most important variable for the distribution of *O. ovis* on the MaxEnt model. The most permutation importance for predicting the environmental suitability for *O. ovis* was an elevation. The output of the model indicated that low-altitude points were more suitable for the establishment of this species. The environmental variable with the highest gain, when used in isolation, was bio7 (Temperature Annual Range), which therefore appeard to have the most useful information by itself. The temperature annual range refers to the difference between the hottest and the coldest months by taking monthly mean temperatures in each case. The environmental variable that decreases the gain the most when it is omitted was elev (Elevation), which therefore appears to have the most information that isn't present in the other variables. In this study, invaluable information about the knowledge, attitude, and practice

of the people of Ilam province in different counties was obtained. Some of the behaviors of the participants in this study seem high risk, and in some areas, public awareness of the disease was poor. Because this disease has a high prevalence in this province, the health officials of the province should take the necessary measures to increase public awareness and reduce the burden of the disease in the community. In this study, suitable areas for the establishment of *O. ovis*, the most important cause of human myiasis in Ilam province, were identified that can be used for preventive and control measures by concerned officials.

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Author Contributions

All authors contributed equally to this study.

Competing Interests

The authors declare that there is no conflict of interest in this paper.

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