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Studies on the Epidemiology of Malaria and Visceral Leishmaniasis in Jizan Area, Saudi Arabia

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Abstract. Malaria (M) and visceral leishmaniasis (VL) are endemic in Jizan, southwest of the Kingdom of Saudi Arabia. The present work aimed to determine the correlation between the incidences of the two diseases during the period from 1991 to 2002, in addition to the correlation between each of them and the relative humidity (RH), temperature (T) and precipitation (P) in Jizan area. The numbers of M and VL cases during the period from 1991 to 2002 have been studied and no significant correlation between the numbers of notified cases of the two diseases was observed. Also, the data on M and VL incidence and the relative humidity (RH), temperature (T) and precipitation (P) for the period from 1997 to 2002 were analyzed. The data showed a significant positive correlation between RH and M. On the other hand, a significant negative correlation existed between RH and VL and between T and M. The number of notified cases for both diseases decreased significantly after the year 2000, the year of the Rift Valley fever outbreak in Jizan, when great efforts were made to eliminate its vector. The present results herewith indicate that sanitary measures in addition to environmental managements are crucial for fighting these diseases.

Keywords: Malaria, Visceral leishmaniasis, Kingdom of Saudi Arabia, Jizan, Rift Valley fever control, Insect control.

Introduction

In this new millennium, parasitic diseases are still causing death, suffering, financial burden and enormous lost labor time, thus placing great constrictions on improving the quality of life in most developing countries. This is due to the lack of available treatments, effective methods to control vectors and parasites as well as the spread of drug and pesticide resistance, which hindered most of the efforts for successful control of parasitic diseases.

Leishmaniasis (L) and malaria (M) are among the most important six diseases on the World Health Organization (WHO)/Tropical Disease Research list. There are 2 million new cases of L diagnosed every year [1]. As for M, 300–660 million people become infected yearly with the malignant *Plasmodium faciparum*, and 200-300 children are dying every hour from this disease [2, 3].

All forms of L, whether cutaneous (CL), visceral (VL), mucocutaneous (MCL) or diffused cutaneous (DCL) are transmitted by the phlebotomine sandflies. Also, all forms of M whether caused by *Plasmodium vivax, P. ovali, P. malariae,* or *P. falciparum* are transmitted by *Anapheles* mosquito. Usually, the transmission of both parasites occurs when the female insect takes a blood meal.

Measures to combat these two diseases aim at interrupting the life-cycle of the parasite by destroying the parasite or its vector. Destroying the parasite could be achieved by vaccination or treatment. Destroying the vector could be achieved by many ways such as introducing an enemy of the vector to the environment, using the sterile male technique, destroying the habitat of the vector or spraying pesticides [4]. The latter is a common method of vector control and is the main method used for M control in the Kingdom of Saudi Arabia (KSA). This method is adopted by various governmental departments such as the Ministry of Health (MH), Ministry of Agriculture (MA), and the cities municipalities. As far as VL control, no national methods are adopted. This case is not restricted to KSA, but it seems to be the case world wide [5, 6]. When both M and VL coexist in a geographical area, combating them by applying the same insecticide is logical. These two diseases are endemic in Jizan Region, in the southwest part of KSA. In fact, the number of the reported cases of the two diseases in this province is by far the highest when compared to other regions of KSA as Table 1 indicates.

The aim of this work is to study the incidence of these two diseases during the period from 1991 to 2002 in Jizan region, and to determine the correlation between the incidence of M and that of VL, as well as between each of them and relative humidity (RH), temperature (T) and precipitation (P) in that region during the period from the year 1997 to the year 2002.

Table 1. Number of malaria (M) and visceral leishmaniasis (VL) cases in the year 2000 in some areas in the Kingdom of Saudi Arabia*

Region	Number of M cases	Number of VL cases
Makkah	417	NN**
Jeddah	536	NN
Al-Taif	139	1
Assir	606	8
Jizan	3528	21
Al-Baha	187	NN
Al-Qunfitha	167	1
Bisha	19	1

*Data obtained from the Department of Preventive Medicine, Ministry of Health.
** Not notified to the Ministry of Health.

Material and Method

Geographical area under study

Jizan Region lies in the southwest of KSA (16^{O} 20' and 18^{O} 25' horizontal and 41^{O} 48' and 43^{O} 29' vertical). It occupies an area of 16,000 km^2, where 455 villages are scattered.

The topography of the area varies and consists of: (a) mountains in the east that are extensions of Al-Sarawat Mountains, and are up to 2500 m above sea level, (b) the valley that extends from north to south and consists of a shore area with an altitude of less than 400 m, and contains some streams of water running from east to west, and (c) a hilly area that lies between the mountains in the east and the Red Sea coast in the west with an altitude between 400 and 600 m, and gradually slopes toward the west.

Weather data for the years 1997 to 2002 have been obtained from the Center of Information and Documentation in the Meteorology and Environmental Protection Section of the Ministry of Defense and Aviation in KSA. The climate is subtropical, being hot during summer with a range of temperature (T) between 30^{o} and 40^{o}C, while in winter it is warm with a mean T of 25^{o}C in January. Relative humidity (RH) is relatively high and usually between 50 and 70%, sometimes reaching 90%. Rain falls all year round, with a monthly average of precipitation (P) between 8 and 62.5 mm and a yearly rainfall of 165 mm in the valley while in the mountains it is up to 500 mm. An irrigation system consisting of basins is used to collect rain water during the months of July and August for use in agriculture. The main water reservoir can accommodate up to 70 million m^3 of water and branches into irrigation canals that feed an area of 6000 hectares. However, the main source of water for agricultural is the water of streams falling from mountains.

Data and statistical analysis

The numbers of notified M and VL cases have been obtained from the DPM-MH. The data were analyzed by EPISTAT and SPSS 11.5 using one way analysis of variance (ANOVA), Z-test of proportion drawn from one sample and correlation, with a level of significance at $p \leq 0.05$ or less.

Results

The numbers of notified cases of M and VL in Jizan during the period from 1991 to 2002 are presented in Table 2. The number of M cases during that period was 5,610 cases in 1991, fluctuated reaching a maximum of 19,630 cases in 1998, and declined reaching 1,157 cases in 2002. The mean number of reported M cases per year during that period was 8,003.5 cases (SD ±5,742.34). When the numbers of the reported cases during the period from 1991 to 1999 or from 1997 to 1999 were compared to those reported during that from 2000 to 2002, there was a significant decrease in the number of cases during the last period ($p<0.00001$).

Table 2. Number of malaria (M) and visceral leishmanaisis (VL) cases in Jizan during the period from 1991 to 2002

Year	Number of M cases	Number of VL cases
1991	5,610	152
1992	12,358	164
1993	8,445	131
1994	4,063	97
1995	9,638	103
1996	9,908	55
1997	10,003	68
1998	19630	75
1999	5838	54
2000	2756	21
2001	1407	26
2002	1157	21
Total	**96,042**	**967**
Mean ±SD	**8003.5 ±5742.34**	**80.6 ±47.4**

As for VL cases, the highest number of cases was in 1992 being 164 cases and the lowest number was in 2000 and 2002 being 21 cases. The mean number of cases was 80.6 cases/year (SD±47.4). When the numbers of VL reported cases during the period from 1991 to 1999 or from 1997 to 1999 were compared to those reported during that from 2000 to 2002, there was a significant decrease in the number of cases during the last period ($p<0.00001$).

On the other hand, no significant correlation existed between the incidences of the two diseases when the yearly figures were compared ($r = 0.412$, $p = 0.091$). However, when the monthly numbers of M and VL cases and the recorded T, RH and P during the period from 1997 to 2002 were compared (Table 3), a weak but significant correlation existed between M and VL (Pearson Correlation=0.311, $p \leq 0.004$). T had a significant negative relationship with M (Pearson correlation=-0.394, $p \leq 0.000$). On the other hand, RH had a significant positive relationship with M (Pearson correlation=0.307, $p \leq 0.004$), and a significant but a negative relationship with VL (Pearson correlation= -0.285, $p \leq 0.008$).

Table 3. Number of malaria (M) and visceral leishmaniasis (VL) cases* and temperature (T), relative humidity (RH) and precipitation (P) data in Jizan during the period from 1997 to 2002**

Year	Month	No.VL cases	No. M cases	T °C	RH %	P mm
1997	Jan	4	509	25.3	72	3.3
	Feb	6	983	26.2	73	T
	Mar	6	1004	27.5	70	0
	Apr	5	723	29.6	68	0
	May	5	386	31.9	65	49
	June	7	235	34.0	59	2
	July	8	275	33.8	58	1
	Aug	6	196	33.4	64	T
	Sept	6	380	33.1	67	T
	Oct	5	350	30.6	70	157.5
	Nov	3	1051	29.0	75	65
	Dec	7	5021	27.3	76	30
1998	Jan	7	6705	26.7	73	T
	Feb	6	6056	26.7	70	T
	Mar	6	3868	28.1	73	24.1
	Apr	6	1436	30.7	66	T
	May	5	512	32.5	62	T
	June	7	242	33.9	65	T
	July	6	103	34.0	59	30.2
	Aug	8	142	32.9	67	95.8
	Sept	8	483	33.1	67	1
	Oct	10	1022	31.3	70	71.9
	Nov	4	1334	20.7	67	T
	Dec	2	1074	26.0	74	0
1999	Jan	3	833	25.6	78	62.6
	Feb	4	1110	26.8	76	8.0
	Mar	7	578	20.0	70	1
	Apr	5	477	30.1	68	0
	May	7	156	32.5	66	0
	June	7	69	33.3	66	0
	July	6	49	33.2	61	6.3
	Aug	2	51	33.0	64	0
	Sept	4	269	32.9	67	23.2
	Oct	6	322	31.2	70	60
	Nov	2	798	29.3	69	0
	Dec	1	1126	26.8	72	0
2000	Jan	1	1197	26	75	0
	Feb	3	956	26.8	75	0
	Mar	1	512	28.3	72	0
	Apr	3	231	30.6	65	0
	May	1	71	32.2	69	58.0
	June	0	22	33.3	64	0
	July	4	28	34.2	59	1
	Aug	5	50	33.4	66	23.3
	Sept	1	80	32.6	68	42
	Oct	0	101	31.4	70	0
	Nov	1	77	28.9	75	68.3
	Dec	1	203	26.9	78	75.4

Table 3. *(Contd.)*

Year	Month	No.VL cases	No. M cases	T °C	RH %	P mm
2001	Jan	5	495	25.5	76	30
	Feb	2	312	26.5	77	2.1
	Mar	3	183	28.4	75	18.4
	Apr	3	102	30.5	69	0
	May	3	22	32.7	68	0
	June	2	10	33.6	61	0
	July	4	13	33.0	64	15.2
	Aug	2	49	33.0	70	81.7
	Sept	2	70	33.2	70	2
	Oct	0	48	31.9	67	0
	Nov	0	46	29.4	67	1
	Dec	0	57	27.8	72	0
2002	Jan	2	397	26.6	73	36.5
	Feb	2	313	27.0	74	0
	Mar	0	332	28.4	73	0
	Apr	1	243	30.3	68	4.3
	May	4	85	30.9	69	0
	June	4	36	33.2	66	0
	July	6	34	34.0	64	2
	Aug	1	44	33.7	64	9
	Sept	1	63	32.7	70	5
	Oct	0	101	31.3	69	26.2
	Nov	0	77	29.9	70	1
	Dec	0	203	27.9	70	24.8

When the monthly numbers of reported cases were compared each year separately, there was no consistent significant relationship between M and VL; a negative relationship occurred in the year 1999 (Pearson correlation= -0.549, $p \leq 0.032$) and a positive relationship in 2001 (Pearson correlation=0.5, $p \leq 0049$). The correlation coefficients of these relationships between M and VL, T, RH and P are shown in Table 4 and those between VL and T, RH and P in Table 5.

Table 4. Correlation coefficients of malaria (M) incidence with respect to visceral leishmaniasis (VL) incidence, temperature (T), relative humidity (RH) and precipitation (P)

Year		VL	T	RH	P
1997	r	0.169	-0.448	.581*	-0.50
	p	0.30	0. 072	0.020	0.450
1998	r	-0.018	-0.505*	0.602*	-0.236
	p	0.478	0.047	0.019	0.326
1999	r	-0.549*	-0.690**	0.838**	0.088
	p	.0320	.0060	.0000	.3920
2000	r	-0.016	-0.782**	0.535	-0.380
	p	.4800	.0010	0.036	0.112
2001	r	0.500*	-0.814**	0.783**	0.146
	p	.0490	.0010	.001·	.325·
2002	r	-0.325	-0.892**	0.793**	361
	p	0.151	0.0	.0010	0.125

*Correlation is significant at 0.01 level (1-tailed).

** Correlation is significant at 0.001 level (1-tailed).

Table 5. Correlation coefficients of visceral leishmaniasis (VL) incidence with respect to temperature (T), relative humidity (RH) and precipitation (P)

Year		T	RH	P
1997	r	0.463	0.599**	-0.337
	p	0.065	0.020	0.188
1998	r	0.549*	-0.090	0.626
	p	0.032	0.390	0.092
1999	r	0.086	-0.33	-0.014
	p	0.395	0.147	0.483
2000	r	0.252	-0.405	-0.197
	p	0.215	0.096	0.270
2001	r	-0.100	0.199	0.268
	p	0.378	0.267	0.200
2002	r	0.427	-0.457	-0.318
	p	0.083	0.068	0.157

Table 6 shows the number of M cases reported during the period from 1992 to 2002 as classified into 5 age groups: less than one-year old, 1-4 years old, 5-9 years old, 10-14 years old and more than 14 years old. The least number of M notified cases was that of the infants' less than one year old group (mean 304.3±241.6, $p \leq 0.001$). On the other hand, the largest number of patients was that of the age group of more than 14 years old (mean 3,183.8 ±2,146.8, $p \leq 0.000$). When VL cases of the same period were classified in the same age groups (Table 7), the highest incidence ($p \leq 0.00014$) was in the 1-4 years old age group (mean 30.72 ±30 p≤) while the lowest incidence was in 10-14 years old age group (mean, 2 ± 2.09 $p \leq 0.00001$).

Table 6. Number of malaria cases in Jizan classified according to age during the period from 1992 to 2002*

Year	Less than one year	1-4 years	5-9 years	10-14 years	>14 years	Total**
1992	317	2388	3571	2376	4219	12871
1993	449	2167	2089	1504	3384	9593
1994	103	639	1014	749	1325	3830
1995	349	1934	2409	1881	3812	10385
1996	411	2344	2466	2276	4257	11754
1997	393	1946	2211	2001	4128	11041
1998	913	3838	4199	4203	8488	21641
1999	221	1059	1046	987	2489	5802
2000	140	634	641	613	1499	3528
2001	25	204	242	189	747	1407
2002	26	138	151	168	674	1157
Total	**3347**	**17291**	**20039**	**16947**	**35022**	**93009**
Mean ±SD	**304.3 ±241.7**	**1571.9 ±1085.6**	**1821.7 ±1266.0**	**1540.6 ±1134.6**	**3183.8 ±2146.8**	**8455.4 ±5812.2**

*Data obtained from the Department of Preventive Medicine, Ministry of Health; data of 1991 unavailable.
** Some cases were not classified according to age, so were not included in this table.

Discussion and Conclusion

M and VL are endemic in Jizan region, and both diseases occur in this area in greater numbers than in any other regions of KSA [7-10]. This region consists of many villages scattered with a less advanced network of roads when compared with other regions of KSA. The presence of water reservoirs probably adds to the factors that help in the propagation of mosquitoes and other vectors through out the year.

MH records indicated that the notified M cases were 1,236 per 100,000 inhabitants in 1992, but dropped to 276 cases in 2000. The majority of M cases (>70%) was of the malignant type caused by P. falciparum, although P. vivax and P. malariae were also present. As for VL, 16 cases per 100,000 inhabitants were notified in 1992 and the number has decreased to only 2 cases in 2000. More than 70% of VL cases in KSA were recorded in Jizan, and the majority (82%) of the patients were local inhabitants of the area. The parasite that caused VL in Jizan, like all other parts of KSA, was L. donovani although the majority of the patients were children; however, L. infantum was isolated only from dogs in KSA [7].

Statistical analysis of the M notified cases that were classified according to age groups showed a significantly smaller number of patients in the age group less than one year old than in the other age groups. Also, the group of patients who were more than 14 years old showed a significantly higher number of patients than the other four age groups. This does not indicate that the one year old age group are not prone to acquire M, but simply because this group contained the least number of people from the whole population. The same thing applies to the age group of more than the 14 years old; this group contained the largest number of patients from the whole population. On the other hand, VL infection is nearly limited to children 14 years old and less which means a more concentrated effort should be given to educate children at schools about this disease, its vector and its time of activity (late in the afternoon and early night). Parents should be aware of the vectors activity and they should be encouraged to use pesticide impregnated bed-nets and window screens.

In KSA, M is transmitted by *A. arabiensis* [9], but the sandfly species that transmits VL in Jizan is not yet proven, although *P. bergeroti* is considered as the most probable species [11]. The reported T and RH in Jizan seem to be favorable for the development of sandflies and mosquitoes. This is recognized from the numbers of reported cases during late fall, winter and early spring. The numbers of reported cases were relatively great from November 1997 to April 1998 and from November 1999 to February 2000. This is probably owing to the suitable range of T and RH during these months. However, only relatively smaller numbers of cases were reported for later fall, winter and spring of 2000-2001 and similarly for those of 2001 and 2002. Also, when the numbers of reported cases for both diseases during the period from 1991 to 1999 were compared with those reported during that from 2000 to 2002, a significant decrease was observed. This is probably owing to the insecticide spraying campaign undertaken

by various governmental ministries during these years for the control of mosquitoes transmitting Rift Valley fever (RVF) virus [12-14]. The period from 2000 to 2002 was first compared with the period from 1991 to 1999 and then to that from 1997-1999 to show that the difference was due to intensive efforts against RVF, rather than due to development in health care system and the improvement of sanitary facilities which could have taken place during that decade.

Although reports on the efficacy of insecticide concomitant treatments for M and VL seem to be contradictory, such treatment seemed to be efficient in Jizan. Reports on the anti-malaria spraying campaign in north-eastern India led to a long-term reduction of kala-azar morbidity during the years of spraying, however, the kala-azar incidence rose after the cessation of antimalarial spraying [6]. Also, there was a temporary reduction in the incidence of zoonotic CL in Peru that coincided with anti-malaria DDD-spraying campaign [15]. On the other hand, in Greece, antimalarial measures resulted in the reduction of sandfly fever but not VL [16]. Furthermore, in the Islamic Republic of Iran, antimalarial spraying had a dramatic effect on anthroponotic CL but was less effective in the control of the zoonotic type [17].

It should be stated that during the RVF epidemic in Jizan, not only the insecticide spraying activities increased, but also all health sanitary measures were adopted to prevent the propagation of the insects and to interrupt its life-cycle. Epidemiologists from within KSA and outside were involved in evaluating these measures in Jizan. Although, the number of victims was high, the epidemic was controlled within three months; the effect of these measures was evident on other endemic diseases like M and VL indicating that when a serious, well organized strategy is undertaken, the control of infectious diseases is possible.

In addition to spraying techniques and sanitary measures, attention should be focused on the primary health care approach to vector control including the involvement of the community and the health service infra-structure. Application of environmental management with modification aiming at reducing and controlling M proved to be more efficient than the application of pesticides. In fact, such measures were implemented before the Global Malaria Eradication Campaign during the period from 1955 to 1969 which depended mainly on spraying DDT. These measures reduced the risk ratio of M by 88.0% [18]. Open dialogues and discussion groups and lectures between health workers and members of the society should take place. This could be achieved by the involvement of society structures like mosques, schools, women's groups or charity societies. This is a challenge by itself, and the recent establishment of a Public Health School in the region should help to promote these suggestions.

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دراسات وبائية على الملاريا والليشمانيا الحشوية في منطقة جيزان بالمملكة العربية السعودية

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ملخص البحث. إن الملاريا والليشمانيا الحشوية من الأمراض المتوطنة في جيزان جنوب غربي المملكة العربية السعودية، وتهدف الدراسة الحالية إلى تحديد العلاقة الإحصائية بين عدد الإصابات بهذين المرضين التي تم تبليغ وزارة الصحة عنها في الفترة من ١٩٩١م وحتى ٢٠٠٢م، وكذلك تحديد العلاقة الإحصائية بين عدد الإصابات بهذين المرضين وكل من الرطوبة النسبية ودرجة الحرارة ومعدل المطر تلك المنطقة. وقد أثبتت الدراسة الإحصائية لأعداد الإصابات المبلغ عنها في الفترة المذكورة عدم وجود علاقة إحصائية بين المرضين. وبالتحليل الاحصائي للمعلومات المسجلة عن عدد الإصابات بالملاريا والليشمانيا الحشوية والرطوبة النسبية ودرجة الحرارة ومعدل المطر في الفترة من ١٩٩٧م وحتى ٢٠٠٢م دلّت النتائج على وجود علاقة إيجابية بين الرطوبة النسبية وعدد الإصابات بالملاريا، بينما كانت هذه العلاقة سلبية بالنسبة للإصابة بالليشمانيا الحشوية، كما دلت النتائج أيضاً على وجود علاقة سلبية بين درجة الحرارة وعدد الإصابات بالملاريا. وقد لوحظ تناقص عدد الإصابات بكل من المرضين بعد عام ٢٠٠٠م، وهو العام الذي تفشت فيه حمى الوادي المتصدع في منطقة جيزان، حيث بذلت الأجهزة المختلفة بالمملكة جهودا كبيرة للقضاء على البعوض الناقل للفيروس المسبب للمرض. وتوجب الدراسة الحالية اتخاذ الإجراءات الصحية السليمة والعمل على تغيير الظروف البيئية بحيث تصبح غير ملائمة للعائل الناقل لكل من المرضين حتى يمكن القضاء عليهما.