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Entomological and epidemiological attributes for malaria transmission and implementation of vector control in southern Iran

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ABSTRACT

Bashagard is an important malaria endemic area in south of Iran. An epidemiological and entomological survey was performed during 2002–2010. The aim of study was to determine malaria situation, species composition of anopheline mosquitoes and susceptibility status of main vectors to insecticides/larvicides. A total of 13,490 malaria cases were recorded, *Plasmodium vivax* (99.64%), *P. falciparum* (0.35%) and mix cases (0.01%). The highest and lowest Annual Parasite Incidence (API) were observed in 2007 (145.72/1000) and 2009 (6.29/1000), respectively. *Anopheles culicifacies*, *An. dthali*, *An. stephensi*, *An. superpictus*, *An. fluviatilis*, *An. moghulensis*, *An. turkhudi* and *An. apoci* were collected from the area. Two peak activities occur in April and October. The first five species were confirmed as malaria vectors in Iran. No indication of sporozoite in mosquitoes using molecular method was performed. Susceptibility tests using diagnostic dose of insecticides and larvicides showed only resistance of *An. stephensi* to DDT. Tolerance in *An. stephensi* to deltamethrin and bendiocarb is reported. The same phenomenon was observed in *An. culicifacies* to DDT, propoxur and deltamethrin, and in *An. dthali* to malathion and deltamethrin. Larvae of vectors were susceptible to all larvicides, except for *An. stephensi* that exhibited tolerance to fenthion. In conclusion it should be emphasized that malaria transmission is a complex process in Bashagard. This event is attributed to five proven vectors with different behaviors which are active in the area. Regarding tolerance of vectors to deltamethrin, resistance management is suggested by using new insecticide with novel mode of action.

1. Introduction

Malaria is one of the most important vector-borne diseases in Iran. The total population at risk is 2,714,648 persons, who mainly live in endemic foci of the disease including provinces of Kerman, Hormozgan, and Sistan and Baluchistan. First report of malaria situation in Iran is back to Gilmour (1925) who had estimated that 60% of the total population was living in highly endemic areas for malaria, with 4–5 million cases annually. The national malaria eradication program was started in 1958 and renewed to malaria control in 1987 and the changing policy is due to the existence of serious technical problems and administrative difficulties (Manouchehri et al., 1992). Since 1988, malaria control activities have been integrated in primary health centers. According to the Ministry of Health of the country (unpublished data) the total number of malaria cases in Iran had been declined to 2900 cases in 2010.

Over the past 85 years, many investigators have worked on malaria and their findings were used to manage the control programs. Altogether a total of 33 *Anopheles*, including siblings, biological forms and genotypes were recorded, among which a total of 7 (including 17 siblings, biological forms and genotypes) have been implicated as main vectors. *An. stephensi*, *An. dthali*, *An. culicifacies*, *An. fluviatilis*, *An. superpictus*, *An. sacharovi* and *An. maculipennis*, while *An. pulcherrimus* is also reported as a suspected vector (Jalali-Moslem, 1956; Manouchehri et al., 1975, 1992; Eshghi et al., 1976; Zaim et al., 1993; Yaghoobi-Ershadi et al., 2001; Zahirnia et al., 2001; Naddaf et al., 2003; Oshaghi et al., 2003a, 2006; Sedaghat

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Fig. 1. Map of Bashagard district in Hormozgan province, southern Iran.

et al., 2003a,b; Edrissian, 2006; Vatandoost et al., 2006a, 2007; Azari-Hamidian, 2007).

Insecticide/larvicide resistance status of vectors has been monitored under laboratory and field conditions. Resistance to DDT, dieldrin and malathion is reported in a number of species, however almost all vectors are susceptible to larvicides (Manouchehri et al., 1992; Zahirnia et al., 1998; Vatandoost, 2001; Salari Lak et al., 2002; Enayati et al., 2003; Vatandoost et al., 2004, 2005, 2009a; Vatandoost and Borhani, 2004; Vatandoost and Vaziri, 2004; Vatandoost and Hanafi-Bojd, 2005; Hanafi-Bojd et al., 2006; Edrissian, 2006; Davari et al., 2007; Abai et al., 2008; Vatandoost and Zahirnia, 2010). Different repellents have been evaluated to find the suitable compound for travelers to the endemic area of the disease (Oshaghi et al., 2003b; Vatandoost and Hanafi-Bojd, 2008; Vatandoost et al., 2008). Bed-nets are also tested under field and laboratory conditions (Vatandoost et al., 2006b, 2009b; Kayedi et al., 2008; Rafinejad et al., 2008). There are some reports on the olfaction of *An. stephensi* to different chemicals for potential use in magnet traps (Omrani et al., 2010a,b).

Around 68% of malaria positive cases belonged to provinces of Sistan and Baluchistan, Hormozgan, and Kerman in 2002, whereas it increased to 95% in 2007 (Raeisi et al., 2009). Hormozgan province is highly endemic area for malaria. It constitutes 38% of all country malaria cases (Raeisi et al., 2009). In this province approximately 625 cases of malaria were reported during 2009. Bashagard district constitutes only 2.18% of the total population of Hormozgan province. Its malaria cases contributed 33% of total malaria cases solely (Hormozgan Health Center, unpublished data). Tropical climate and socio-economic conditions make appropriate situation for occurrence and persistent transmission of malaria in this district. Active and passive case detection, indoor residual spraying, larviciding, and long lasting impregnated bed-nets, Olyset® are the main malaria control activities in this area.

The purpose of this study was to review the current malaria situation. The results could be used to vector control interventions cost-effectively.

2. Materials and methods

2.1. Study area

Bashagard district is located in the north-east of Hormozgan province, southern Iran. Latitude and longitude of the center of this district, called Sardasht, is 26°21′N and 57°54′E (Fig. 1). Bashagard had a total population of 31,292 in 2009. The area is mountainous with low precipitation. It has hot and dry climate. Rainfall usually occurs during the year in shower type. During the study period relative humidity was ranged between 30 and 65%. Average annual rainfall was 265 mm with two peaks in August and January (Fig. 2). The minimum and maximum temperatures were 7 and 45 °C in January and June–July, respectively (Hormozgan Meteorological Center). There are different seasonal and perennial rivers in the area which provide suitable breeding places for mosquito. The soil texture is mainly sandy and hence is not able to preserve the surface water for long time. People are living in houses built by cement blocks. Main sheds are made of palm leaves and barks.

2.2. Malaria information

Bashagard is divided into 6 regions for malaria detection and treatments. Each region reports total population, total blood slides, total positive slides, species of parasite, age and sex of patients and other relevant information to the district health center. Required

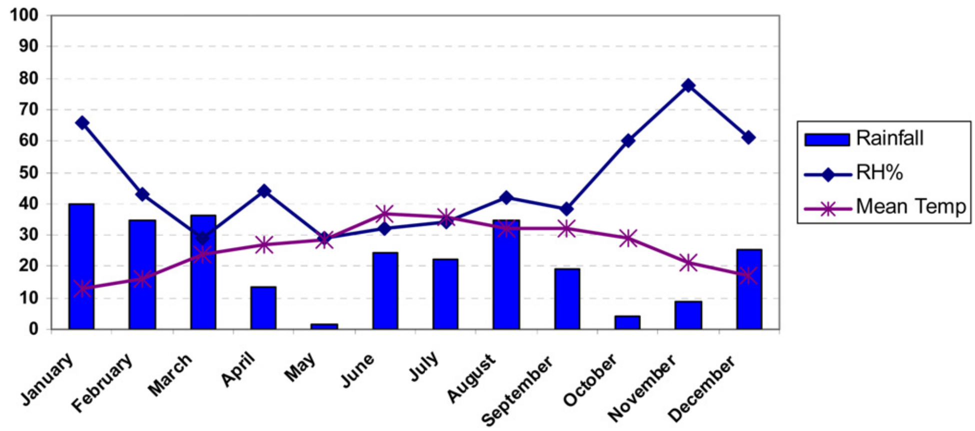

Fig. 2. Average of meteorological parameters during 2002–2009 in Bashagard district, southern Iran.

data were collected directly from the case registering documents as well as monthly reports.

2.3. Entomological survey

To determine fauna and species composition of mosquitoes one year period investigation was conducted. The main collection was larval collection. It is started at November 2009. The study area has two types of villages: hilly types, and some located in river valley. Five villages with different geographical positions were selected as fixed places for entomological survey (Sardasht, Dargazan, Chowkhun, Molkan and Bolbolabad). Larvae were also collected from some other villages as random places (Biskav, Poshtgar, Daranar, Kooh-heidar, Jakdan). For determination of Anopheline fauna larvae were collected once a month by standard dipping method from riverbeds, riversides and other water bodies as WHO (2003). All specimens were mounted and identified using identification keys of Iranian mosquitoes (Shahgudian, 1960; Azari-Hamidian and Harbach, 2009). *Chemical analysis of water of breeding places from 4 fixed villages* (*Sardasht*, *Molkan*, *Chowkhun and Dargazan*) was measure in the environmental chemistry laboratory, Hormozgan Province Health Center.

2.4. Adult bioassay

Five imagicides were tested at the diagnostic doses as recommended by WHO. They were DDT 4%, malathion 5%, propoxur 0.1%, bendiocarb 0.1% and deltamethrin 0.05%. All the insecticide test kits were provided by World Health Organization. Tests were carried out using WHO standard test kit for adult mosquitoes (1998) on 2–3 days old unfed females. The adults were reared from the larvae which had been collected from the study area. The exposure period was 1 h at diagnostic dose. Following exposure, mosquitoes were kept in the insectary and then provided with cotton pads soaked in 10% sugar. Mortality was scored after 24 h recovery period.

2.5. Larval bioassay

Four larvicides of temephos 0.25 mg/l, fenthion 0.05 mg/l, malathion 3.125 mg/l and fenitrothion 0.125 mg/l were used. All the larvicide test kits were provided by World Health Organization. Late III and early IV instars larvae were exposed to the diagnostic concentrations of the larvicides WHO (1981). At most experiments, 100 larvae representing four replicates of 25 were tested. The larvae were fed on fish food. Mortality counts were made after 24 h exposure. Abbott's formula was used to correct the observed mortality of adults and larvae. All the data were corrected if the control mortality is between 5 and 20% (Abbott, 1925).

2.6. Sporozoite infection

Female *Anopheles* mosquitoes were collected during spring and summer 2010 from Sardasht village. The spray sheet and direct collection method from human dwellings and pit-shelters were performed. Collected samples were prepared for DNA extraction individually in 1.5 μl microtubes. After removing of wings and legs the whole body was homogenized using suitable pestle. They were processed for DNA extraction using G-Spin kit (Korea) according to the procedure provided by manufacturer. Six primers were used for amplification of *Plasmodium* (Snounou et al., 1993). rPLU5 (5′-CCTGTTGTTGCCTTAAACTTC-3′) and rPLU6 (5′-TTAAAATTGTTGCAGTTAAAACG-3′) were used for the first stage for detection of *Plasmodium* spp. in mosquitoes. The next two set primers were used in positive cases for determination of the parasites species, rFAL1 (5′-TTAAACTGGTTTGGGAAAACCAAATATATT-3′) and rFAL2 (5′-ACACAATGAACTCAATCATGACTACCCGTC-3′) for *P. falciparum*, and rVIV1 (5′-CGCTTCTAGCTTA ATCCACATAACTGATAC-3′) and rVIV2 (5′-CTTCCAAGCCGAAGCAAAGAAAGTCCTTA-3′) for *P. vivax* (Snounou et al., 1993). In all PCR reactions a positive sample (*Plasmodium* spp. DNA provided from cultured parasites) was used to check the assurance of PCR process. PCR reactions were conducted using Maxime Pre Mix Kit (Intron, Korea) in Ependorf master cycler.

2.7. Statistical analysis

A databank was created in excel 2003 software. All data were introduced in the databank and then analyzed. Z test was used for comparing infection rate between male and female.

3. Results

3.1. Malaria situation

A total of 13,490 malaria cases were recorded and treated in Bashagard district during the study period. *P. vivax* (99.64%) was the main causative agent, although *P. falciparum* (0.35%) and mix infection (0.01%) were reported. Epidemiological evidence showed the majority of cases of indigenous, while the imported cases were rare (0.13%). Males were infected more than females. Population under 14 years old had the highest infection rate (Table 1). Z test showed significant difference between male and female infectivity

Table 1
Malaria information in Bashagard County, southern Iran, 2002–2009.

Years	At risk population	Nationality		Sex		Age groups			Species			Total slides	Total cases	API	SPR	ABER	SVR	SFR	Type of transmission	
		Iranian	Non-Iranian	Male	Female	<5	5–14	14<	*P. vivax*	*P. falciparum*	Mix								Local	Imported
2002	27,741	353	1	192	162	58	174	122	326	28	0	59,425	354	12.76	0.596	214.2	0.549	0.047	351	3
2003	28,157	1203	0	636	567	114	560	529	1196	7	0	73,244	1203	42.72	1.642	260.1	1.633	0.009	1203	0
2004	28,581	714	1	329	386	66	344	305	714	0	1	77,340	715	25.02	0.924	270.6	0.923	0	714	1
2005	29,094	2407	1	1246	1162	218	1039	1151	2408	0	0	92,427	2408	82.77	2.605	317.7	2.605	0	2408	0
2006	29,564	3089	6	1591	1503	336	1388	1370	3089	6	0	99,203	3095	104.69	3.119	335.6	3.114	0.006	3089	6
2007	29,947	4349	16	2351	2014	598	1702	2064	4364	0	0	98,178	4364	145.72	4.444	327.8	4.444	0	4357	7
2008	30,184	1154	0	613	541	308	368	478	1151	3	0	57,855	1154	38.23	1.995	191.7	1.989	0.005	1154	0
2009	31,292	197	0	113	84	37	57	103	194	3	0	26,982	197	6.29	0.730	86.2	0.719	0.011	196	1
Total	213,114	13,466	24	7071	6419	1735	5632	6122	13,442	47	1	579,870	13,490	–	–	–	–	–	13,472	18

Annual Parasitic Incidence (A.P.I.) = total no. of positive slides for parasite in a year × 1000/total population.
Slide Positivity Rate (S.P.R.) = total positive × 100/total slides examined.
Annual Blood Examination Rate (A.B.E.R.) = smears examined in a year × 100/total population.
Slide Falciparum Rate (S.F.R.) = total positive PF × 100/slides examined.
Slide Vivax Rate (S.V.R.) = total positive PV × 100/slides examined.

($P < 0.05$). This gender differences may be attributed to the type of males' clothes and occupation which make them more exposed to mosquito bites.

Monitoring system, including active and passive case detection and treatment, had an acceptable level with total slides of 579,870, i.e., 2.72 slides per capita. The rate of Annual Blood Examination Rate (A.B.E.R.) has been increased from 214.2 in 2002 to 335.6 in year 2006 (Table 1). The figure reduced to 86.2 in 2009. This rate has relatively the same pattern with API. The peak of malaria occurs during September–October, however it has occurred at August in 2007 (Fig. 3). Malaria incidence had an increasing rate from 2002 up to 2007, when more than 14.5% of population of the area were positive, and then declined (Table 1). More than 99% of recorded cases were Iranian, and the few foreign cases were Afghani workers, who had been employed by road construction firms in the area.

3.2. Entomological data

A total of 3967 *Anopheles* larvae were collected. They were active during the year with two peaks in April and October. The average of larval density in different breeding places of the studied villages in different months was calculated. They are 18, 29, 30, 86, 44, 28.8, 25, 20.2, 56, 58.7, 52 and 32 per 10 dippers from January to December. The maximum and minimum of frequency were observed in April and August, respectively.

A total of 8 species including 5 proven vectors of malaria were identified (Fig. 4). *Anopheles culicifacies* had the most frequency with 37.5%, followed by *An. dthali* (18.3%), *An. moghulensis* (15.5%), *An. stephensi* (12.1%), *An. superpictus* (7.5%), *An. turkhudi* (5.9%), *An. apoci* (3.1%) and *An. fluviatilis* (0.1%). The breeding places for *An. culicifacies*, *An. dthali*, *An. apoci*, *An. superpictus* and *An. stephensi* are clay or sandy beds, whereas *An. moghulensis*, *An. turkhudi* and *An. fluviatilis* were collected mostly in waters containing vegetation specially algae. Chemical analysis of water samples of breeding sites showed a pH of 7.14–8.9. Water salinity was 180–392 mg/l.

A total of 49 female *Anopheles* (6 *An. fluviatilis*, 2 *An. dthali*, 1 *An. stephensi* and 40 *An. culicifacies*) were collected from indoor resting places and pit-shelters. All samples do not produce expected band in PCR reactions using general *Plasmodium* genus detection primers (rPLU5 and rPLU6), but positive control sample produced the 1200 bp band.

3.3. Malaria control activities

Malaria control activities during the study period were indoor residual spraying (IRS) using pyrethroid insecticides, lambdacyhalothrin 10% WP (2003) and deltamethrin 5% WP (2004 up to now); larviciding using *Bacillus thuringiensis* (Bioflash 10% GR) from 2007 up to now, larvivorous fish and mechanical methods (management of the surface water) as well as distributing of insecticide impregnated bed-nets. Up to 2007 the main control activity was IRS, twice yearly (March and August). In 2008, the extensive distribution of long lasting impregnated bed nets (Olyset®) was started and the IRS coverage was reduced from 100% of 183 villages of Bashagard district in 2002 to 83.8 and 84.6% in 2008 and 2009, respectively. This is due to initiating of LLITNs distribution in the area and reducing the malaria incidence.

3.4. Susceptibility status to insecticides and larvicides

Results on susceptibility status of female mosquitoes showed that *An. stephensi* is resistant to DDT, susceptible to malathion and propoxur, and tolerant to bendiocarb and deltamethrin (Table 2). In the case of *An. culicifacies*, 100% mortality was observed when they were exposed to malathion and bendiocarb, but this figure

Table 2
Susceptibility status *An. stephensi*, *An. culicifacies* and *An. dthali* to diagnostic dose of insecticides/larvicides, Bashagard district, Hormozgan Province, southern Iran, 2010.

	Species		
	*An. stephensi*Mortality ± SD (%)	*An. culicifacies*Mortality ± SD (%)	*An. dthali*Mortality ± SD (%)
Insecticides (%)			
DDT 4%	22.77 ± 1.86	97.9 ± 1.41	100 ± 0
Malathion 5%	100 ± 0	100 ± 0	95.1 ± 2.41
Bendiocarb 0.1%	95.4 ± 1.02	100 ± 0	100 ± 0
Propoxur 0.1%	100 ± 0	97.4 ± 1.82	100 ± 0
Deltamethrin 0.05%	94 ± 1.97	97.6 ± 0.84	95.5 ± 1.82
Control	1	0	0
Larvicides (mg/l)			
Fenthion 0.05	85 ± 1.80	98.7 ± 0.93	100 ± 0
Temephos 0.25	100 ± 0	100 ± 0	100 ± 0
Fenitrothion 0.125	100 ± 0	–	–
Malathion 3.125	100 ± 0	100 ± 0	100 ± 0
Control	0	2.7	0

was more than 97% for DDT, propoxur and deltamethrin. *An. dthali* was completely susceptible to DDT, bendiocarb and propoxur, and had more than 95% mortality after exposure to malathion and deltamethrin (Table 2). Diagnostic dose of larvicides resulted in 100% mortality when temephos and malathion were used against *An. stephensi*, *An. culicifacies* and *An. dthali*, whereas fenthion killed 100, 98.7 and 85% of *An. dthali*, *An. culicifacies* and *An. stephensi* larvae, respectively. Fenitrothion caused complete mortality in *An. stephensi* larvae (Table 2).

4. Discussion

The API showed an increasing rate from 2002 to 2007, except for 2004. This increasing trend has interrupted after 2005 in

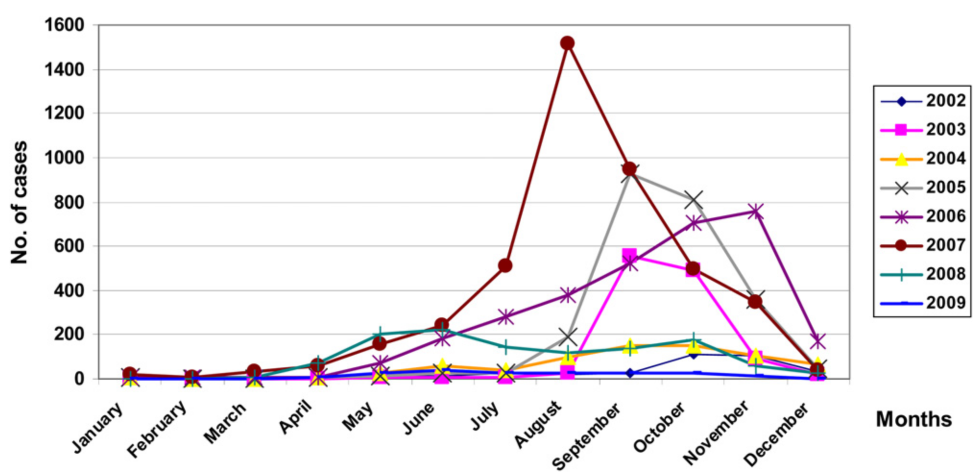

Fig. 3. Malaria cases during 2002–2009 in Bashagard district, southern Iran.

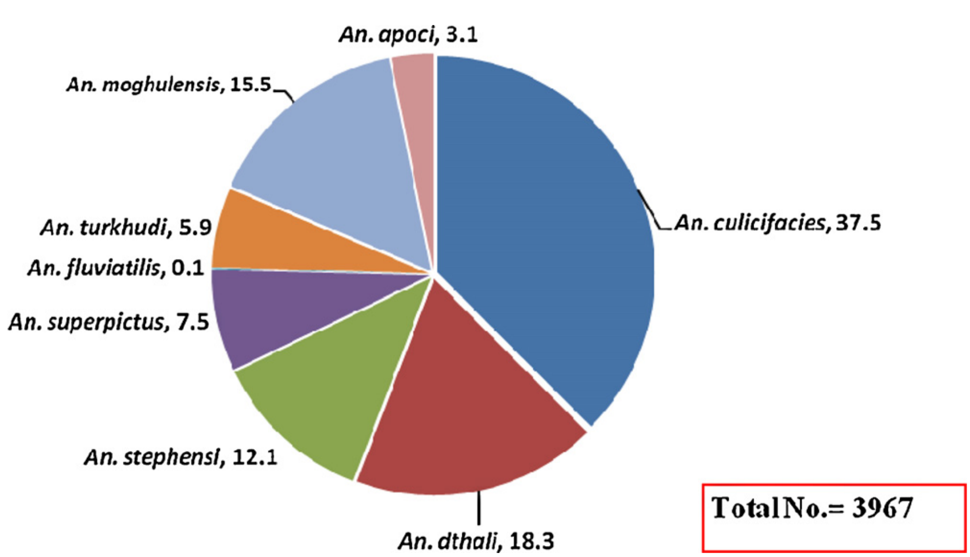

Fig. 4. Fauna and species composition of Anophelinae mosquitoes of Bashagard district, southern Iran, 2009–2010.

Bandar Abbas County, another malaria focus in Hormozgan province, by management of control activities (Hanafi-Bojd et al., 2010). The malaria incidence had the same trend with rainfall prior to 2007, when the implication of impregnated bed-nets was not the control activities. Only in 2004 total amount of precipitation is not followed the pattern. In this year a heavy rainfall occurred during the winter, when conditions were not suitable for transmission and there was no rain during remaining of that year. Although no statistical significant correlation was found between rainfall and malaria cases, the similarity of these two patterns may be due to nature of Anopheline breeding places in the area and other unknown factors. Salehi et al. (2008) reported the positive correlation between humidity, temperature and increasing on malaria risk in Sistan and Baluchistan province, southeast of Iran. They concluded that rainfall had a negative correlation. In our study area the soil texture is primarily sandy therefore is not able to preserve water for long times after rainfall. Therefore the riverbeds and riversides are the main breeding places. Additionally rain in the area occurs showery in short-time, therefore washes the main breeding places. As it has shown in Fig. 2, rainfall usually occurs during the year and provides numerous breeding places around the rivers. The valley of each river provides natural shelters for adult mosquitoes. Villages are usually established close to rivers providing blood source for mosquitoes. Either endophilic or exophilic species can take blood meal and are able to transmit malaria. During July and August, people usually rest and sleep under sheds outdoor and are more exposed to mosquito bites. The exophilic species such as *An. culicifacies*, *An. dthali*, *An. superpictus*, and *An. fluviatilis* can act as effective vectors. During March–June and September–November a strong vector, *An. stephensi*, is playing an important role in indoors. Four other exophilic–exophagic species which are active outdoors also play as secondary vector. Accordingly the transmission process is complex and can occur from March to November, although we found few indigenous cases during December–February (Fig. 3). These cases are attributed mainly due to treatment failure or relapse. In addition, drug resistance of *P. falciparum* is reported from Iran (Edrissian, 2006).

Bashagard was an undeveloped and remote area up to recent years. People of the area were poor and most of them lived in sheds. There was no electricity and constructed road, so that the access to this area with scattered villages was difficult. During the last two decades government as well as NGOs had special attention to improve the life quality. At present most of villages have electricity, well-constructed roads, access to health facilities, schools, and cement block houses. Although some peoples use sheds for sleeping in warm months and there are few villages that have houses totally made of sheds.

An. culicifacies is the dominant species in the study area (37.5%). It has been introduced as the main malaria vector in Baluchistan, southeast of Iran (Zaim et al., 1993; Zahirnia et al., 2001). Our study area is also adjacent to this region. The partially exophilic and exophagic habits of this species protect it from indoor residual spraying. Therefore, it can play an important role in malaria transmission even after IRS application. Due to improper control of those methods, distributing impregnated or long lasting bed-nets may help to control malaria transmission. *An. culicifacies* showed some indication of tolerance to DDT, propoxur and deltamethrin in our study. This species had shown resistance to DDT, dieldrin and malathion (Herath et al., 1987, 1988; Subbarao et al., 1988; Raghavendra et al., 1991, 1992; Sharma, 1999; Surendran et al., 2006; Raghavendra et al., 2010; Singha et al., 2010), resistance DDT in Afghanistan (Eshghi and Nushin, 1978) and Iran (Zaini and Manouchehri, 1973). Vatandoost et al. (1997) reported resistance of *An. culicifacies* to dieldrin, tolerance to propoxur, and susceptibility to DDT, malathion and bendiocarb from southeast of Iran at diagnostic concentrations recommended by WHO. We found this species exhibited less than 100% mortality against DDT, propoxur and deltamethrin. More studies are recommended to confirm the tolerance to these insecticides.

An. stephensi, is one of the main malaria vectors in south of Iran, especially in coastal flat area of the Persian Gulf. This species is considered to be endophagous and endophilic (Manouchehri et al., 1976; Vatandoost et al., 2006a,b). It has an important role in malaria transmission even in low population, indoor residual spraying is appropriate for control. Our results confirmed the resistance of *An. stephensi* to DDT, while it shows tolerance to deltamethrin, the only insecticide that is now using for IRS in the study area. This species is reported to be resistant to DDT, dieldrin and malathion in Iran (Mofidi et al., 1958, 1960; Manouchehri et al., 1974, 1979; Eshghy, 1978; Vatandoost, 2001; Davari et al., 2006, 2007; Abai et al., 2009). Although *An. stephensi* was reported resistant to malathion in 1975, but it became susceptible after changing insecticides in malaria control program (Iranpour et al., 1993). This susceptibility also confirmed in our study. We found tolerance to fenthion in *An. stephensi*. Other studies in southern Iran show resistance to discriminative dose of fenitrothion in Kahnooj, but susceptibility in other parts (Vatandoost and Moinvaziri, 1999; Vatandoost and Hanafi-Bojd, 2005; Vatandoost et al., 2005).

Our results show three secondary vectors: *An. dthali*, *An. superpictus* and *An. fluviatilis* are also active in the study area. *An. dthali* had endophilic and exophilic behaviors; *An. superpictus* has exophagous and endophilic habits, and *An. fluviatilis* as exophilic and exophagic species. Our results show 100% susceptibility of *An. dthali* to larvicides, while diagnostic doses of malathion and deltamethrin induced less than 96% mortality, so it may be due to weak tolerance. This species is mainly exophilic and exophagic and therefore has low contact with insecticides in indoors. Similar studies have also reported this species susceptible to insecticides and larvicides in Iran (Hanafi-Bojd et al., 2006; Vatandoost et al., 2007).

We were not able to find sporozoite infection in the examined species, however the five proven malaria vectors which are active in this area are attributed the maintenance of malaria in the region.

During the winter, when the weather is rather cold, *An. moghulensis* was the dominant species. It can be found during the year usually with *An. turkhudi* in algal water bodies. Few specimens of *An. apoci* were also collected. Although these three species comprise more than 20% of the collected larvae, but there is no report of malaria transmission by those species in the world.

Based on monitoring and evaluation of insecticide resistance on malaria vector as recommended by national health policy, the expert committee decided to use insecticides judiciously, as rotation strategy applying irrelevant insecticides with different mode of action. These insecticides will be applied in the malaria transmission season, once or twice a year, depending upon the peaks of the vectors and disease. Mild tolerance of *An. stephensi*, *An. culicifacies* and *An. dthali* to deltamethrin is a serious warning alarm for malaria managers in the country. They need to monitor the status of pyrethroid resistance in different endemic foci of malaria, and make targeting IRS, promoting and advocating LLINTs use especially during the transmission season, and do an appropriate rotation in using insecticides for malaria vector control. During 2008 and 2009 pyrethroid impregnated bed-nets in addition to Olyset® were distributed to the community. Although the IRS coverage was reduced in comparison to the previous years, however, the trend of malaria started to be decrease. Suddenly after 2007 (Table 1) API was reduced to its lowest level (6.29 in 1000 population). According to the results we have found several species with different behavior in the region, so that Olyset LLINT is appropriate for both outdoor and indoor species. It is also accepted by people of the area. It has good effect against mosquitoes and distributed free of charge. Using bed nets is appropriate, safer and more economic than IRS for malaria control in the study area.

Rapid diagnosis and prompt treatment, monitoring of drug and insecticide resistance against agent and vector, evaluation and calculation of impact and outcome indicators for any intervention, strengthen of the educational programs to encourage people of the area to use LLINTs, health education and community participation are suggested for malaria management in this area.

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