Original Article

Ecology of *Anopheles dthali* Patton in Bandar Abbas District, Hormozgan Province, Southern Iran

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ABSTRACT

Ecology of *Anopheles dthali* was studied in Bandar Abbas County, where there is indigenous malaria. *Anopheles dthali* plays as a secondary malaria vector in the region. It is active throughout the year in mountainous area with two peaks of activity, whereas in coastal area it has one peak. There is no report of hibernation or aestivation for this species in the region. Precipitin tests on specimens from different parts showed that 15.6-20.8% were positive for human blood. This species usually rests outdoors. It has different larval habitats. Insecticides susceptibility tests on adult females exhibited susceptibility to all insecticides recommended by WHO. LT_{50} for the currently used insecticide, lambda-cyhalothrin, is measured less than one minute. The irritability tests to pyrethroid insecticides, showed that permethrin and lambda-cyhalothrin had more irritancy compared to deltamethrin and cyfluthrin. Larval bioassay using malathion, chlorpyrifos, temephos and fenithrothion did not show any sing of resistance to these larvicides at the diagnostic dose. It is recommended that all the decision makers should consider the results of our study for any vector control measures in the region.

Keywords: Ecology, *Anopheles dthali*, Malaria vector, Iran, Resistance

INTRODUCTION

Anopheles dthali is a malaria vector in some parts of the world. This species has been suspected as a vector of malaria in Saudi Arabia (Patton 1905). In 1961 Rishikesh reported that *An. dthali* was a secondary vector in the northern region of Somalia. *Anopheles dthali* Patton is widespread in north Ethiopia and Somalia, Socotra, north Africa to north west of Pakistan, Southwest of Saudi Arabia, around the Red sea and Adan Gulf (Christophers 1933, De Meillon 1947, Stone et al. 1959, Gillies and De Meillon 1968) and Eritrea (Shililu et al. 2003).

This species in also one of the malaria vectors in Iran and has been found in southern parts of Zagros chain (Manouchehri and Rohani 1975). Bandar Abbas County is contained within the Hormozgan area of the Iran where malaria was prevalent in hyperendemic in the region up to 1958 before the national malaria eradication program was started in Iran. *Anopheles dthali* is one of the malaria vectors in Hormozgan. This species is responsible for maintaining malaria transmission in the area when *An. stephensi* is absent (Manouchehri et al. 1972). In October 1965, during entomological studies in highland area of Bandar Abbas out of 143 *An. dthali* dissected, two were found with infected salivary glands to sporozoites (IHR 1965).

Therefore the study on the ecology of *An. dthali* might be valuable for planning and management of malaria control in the areas concerned.

In Iran, *An. dthali* has been found in southern parts of the Zagros chain, in the provinces of Hormozgan, Baluchestan, Kerman, Fars, Yazd, Khuzestan, Kermanshah, Khorassan and coastal area of the Persian Gulf up to 1410 m altitude

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in Hamadan (Manouchehri et al. 1972). In Hormozgan province *An. dthali* is widespread throughout the coastal and mountainous areas from southwest to the southeast. It has been reported from coastal areas of Hormozgan from Bandar Lengeh to Jask county and Qeshm island.

This species can be found mainly outdoors in animal houses, as well as human dwelling. Manouchehri and Rohani (1975) found that this species is more prevalent in animal shelters, tent and human dwellings. This species rests in water reservoir, warehouse, septum of well, cave and natural shelters such as holes in riverbanks. The adults are very sensitive to light and often disturbed by torchlight. It has been reported (Gillies and De Meillon 1968) that in southern Arabia, Mauritania and Somalia the adults are not uncommon indoors.

This species is a secondary vector in some parts of southern Iran especially in mountainous areas of Hormozgan province (Manouchehri 1972). In hilly areas and valley of Hormozgan it is associated with *An. fluviatilis* and *An. stephensi* (Manouchehri et al. 1972). In the coastal areas of the province the density of *An. dthali* is negligible. In Qeshm island this species is active in early May reaches a high peak in August, and then gradually decreases (Fig.1). In mountainous area of province *An. dthali* is active during the autumn season and absent during the cold winter (December-February) and hot weather (Jun-August).

In southern Iran two Magoon traps with human and cow bait were used for the collection of anopheline from May to December, the results showed that 87.5% of *An. dthali* were collected from the trap with cow bait and only 12.5% from the trap with human bait (Manouchehri and Rohani 1974).

Precipitin tests on 517 specimens of this species, showed that 12.5% were positive for human blood (Edrissian et al. 1985). Another precipitin tests on females caught in houses from the north Bandar Abbas, showed 20.8% positive for human blood. From 4165 blood smears taken from *An. dthali* have been examined only 15.6% were positive for human blood, it should be emphasized that anthropophilic index depends on the area, varying from 1% in Izah, a sheep rearing area, to 25% in Bandar Abbas. The results of precipitin tests from this species caught in houses from mountainous area of Bandar Abbas showed that 20% were positive for human blood (Manouchehri et al. 1972).

In Arabia areas, Patton (1905) found the larvae of *An. dthali* in springs and wells. At Muscat, Gill (1916) found them in pools, and especially in holes of volcanic rock fed by underground water. In Hormozgan this species breeds in pebbly margins of rivers, springs, pits around the springs with or without vegetation, pools in dried-up river beds and palm irrigation canal. In Bandar Abbas county larvae were also found in mineral water. It is also found in water with high salinity (2.7 parts per 1000). The temperature ranging was between 13 ºC and 28 ºC with a pH of 6.9-8.0. Larvae were more abundant during September and October, which is the end of the hot season in southern Iran (Manouchehri and Rohani 1975).

MATERIALS AND METHODS

Study area

Hormozgan province has two different areas, coastal bond in south and mountain area in north. The study area is located in mountainous part of Bandar Abbas county with surface area of 65379 km^2 located in south of Iran (between 25° 24'-28° 57' N latitudes and 52° 41'-59° 15' E longitudes). Hormozgan Province located in south and eastern south part of Iran; its eastern neighbors are Kohkiloye and Boyerahmad Province. In the east boarder it is adjacent to Sistan and Baluchestan and in the southern boarder it is adjacent to Persian Gulf and Oman Sea and it has Kerman Province in northern boarder and Fars Province in western north boarder. This province has subtropical climate and a suitable place for preserving and transmission of malaria disease. The total annual rainfall was 100-150 mm and the mean annual relative humidity is 59.5%.

The maximum and minimum mean annual temperatures are 52 and 6 °C, respectively.

Seasonal activity

In order to find the seasonal activity of vectors, the standard method of WHO (1992) based on total catch were performed in the study area

Susceptibility to insecticides

Adult and larval susceptibility tests were carried out according to WHO method (World Health Organization 1981). Female mosquitoes were exposed to a diagnostic dose of DDT 4%, dieldrin 0.4%, malathion 5%, fenitrothion 1%, propoxur 0.1%, bendiocarb 0.1%, permethrin 0.75%, deltamethrin 0.05%, lambdacyhalothrin 0.05% and cyfluthrin 0.15%. The room temperature and Relative Humidity was 25-29 ºC and 65-80%, respectively. The following larvicides were used in this investigation; malathion (3.125 mg/lit), temephos (0.25 mg/lit), fenitrothion (0.125 mg/lit) and chlorpyrifos (0.025 mg/lit) at the diagnostic dose. Butanone 2% in absolute ethanol was used as control. All the concentrations were provided by WHO. Larvae were collected from mountainous area of Bandar Abbas County (Siahoo rural district) during 2002, and larviciding tests were carried out on them. In each test there was two control and 4 replicates beakers for testing a single diagnostic dose of larvicides. Mosquito larvae were tested at the late third and early 4^{th} instar according to the method described by WHO 1981. The larvae were exposed to a diagnostic dose of larvicides. At each concentration, at least 100 larvae representing four replicates of 25 were tested. The larvae were fed with Bemax and mortality counts were made after 24 h exposure period. The irritability to lambda-cyhalothrin, permethrin, cyfluthrin and deltamethrin by WHO insecticides impregnated paper were determined. The number of takes off was recorded for 15 min in one min intervals.

RESULTS

This species is widespread throughout the coastal and mountainous areas with high density in mountain areas. In these areas *An. dthali* is active throughout the year with two peak, first in September-October and the other in April (Fig.1). This species is associated with *An. stephensi* and *An. fluviatilis* in Hormozgan Province. This species has different larval habitats. Anthropophility index is varied between 1-25% depend on locality. A total of 1602 *Anopheles dthali* were collected in study areas and tested by WHO method with 10 insecticides and 4 larvicides. The results are shown in tables 1 and 2. Although the Hormozgan Province had been sprayed with DDT since 1952 and subsequently with malathion from 1968, but *An. dthali* remained susceptible to DDT 4% and dieldrin 0.4%. Furthermore, this species is highly susceptible to organophosphates, carbamat and pyrethroides insecticides. The LT_{50} and LT_{90} of lambda-cyhalothrin in sprayed area of Bandar Abbas District were estimated to be 0.74 min and 2.86 min, respectively.

The results showed that *An. dthali* is susceptible to diagnostic dose of these insecticides.

DISCUSSION

Anopheles dthali is widespread in semi-arid regions from the Atlantic coast of north Africa to Baluchestan, northwest Pakistan and southern Iran. It is common in many areas boarding the Red sea and the Gulf of Aden and extends from the Sudan coast through Ethiopia, southwestern Arabia and Somalia almost to Mogadishu (De Meillon 1947, Stone et al. 1959, Gillies and De Meillon 1968). In Iran, *An. dthali* has been suspected as a vector of malaria. In October 1963 during entomological studies in Bandar Abbas County of Hormozgan Province a number of *An. dthali* dissected which three were found with infected salivary gland (Manouchehri et al. 1972).

Anopheles dthali has a wide distribution in Hormozgan areas and was collected in all inspected rural districts. The species showed two peaks of density in Fig.1 and one peak in coastal area of Bandar Abbas area. In Bandar Abbas

County which is a mountainous area, *An*. *dthali* is associated with *An. stephensi*. Larvae of this *Anopheles* were found in water with high salinity (2.7 part per 1000) in rural areas. The anthropophilic index of this species has been reported between 12.5 and 20% from south of Iran (Manouchehri et al. 1972, Edrissian et al. 1985, IHR 1966). Precipitin tests on specimens from Morocco and Saudi Arabia carried out by the Lister Institute of Preventive Medicine in England showed that 4-18.7% were positive for human blood (Bruce-Chwatt et al. 1966).

The results showed that the biting time of *An*. *dthali* on human bait started at 18.00 h and continued until 04.00 h, with a peak between 20.00 h, and 21.00 h. About 90% of the bites took place in the first half of the night (18.00-24.00 hours) and only 2.5% in the three hours before sunrise (IPHR 1970). In total, 1602 *An. dthali* larvae collected from the study area and tested with ten insecticides and four larvicides. Results are shown in tables 1 and 2.

According to the latest WHO recommendation on the diagnostic dose of insecticides for adult malaria vector in 1998, the susceptibility level of adult and larvae of *An*. *dthali* to DDT 4%, dieldrin 0.4%, malathion 5%, fenitrothion 1%, propoxur 0.1%, bendiocarb 0.1%, permethrin 0.75%, deltamethrin 0.05%, lambda-cyhalothrin 0.05%, cyfluthrin 0.15% were measured and exhibited susceptibility to all insecticides.

Different larvicides including malathion, temephos, fenitrothion and chlorpyrifos were used for their larvicidal activities.

The results of the susceptibility tests of *An. dthali* to these insecticides showed that this species is susceptible to diagnostic dose of all larvicides mentioned.

Irritability level of *An. dthali to* lambda-cyhalothrin, permethrin, cyfluthrin and deltamethrin revealed that this species is more irritant to permethrin than other pyrethroids.

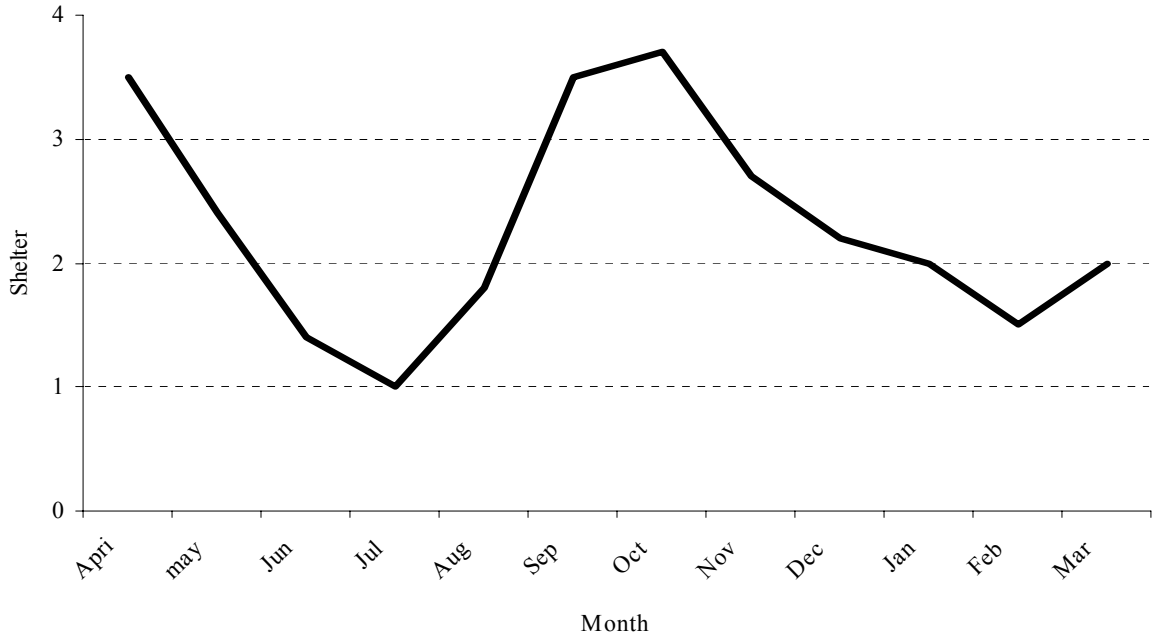

Fig. 1. Monthly average density of *An. dthali* in mountainous area of Bandar Abbas County, Hormozgan Province, southern Iran, 2002

Table 1. The mortality rate of adult *An. dthali* to diagnostic doses of different insecticides, Bandar Abbas, Hormozgan Province, Iran, 2002

Insecticides	Replicates	No. mosquito tested	No. dead	Mortality (%)	SE
DDT 4%	4	99	99	100	0.00
Dieldrin 0.4%	3	73	73	100	0.00
Malathion 5%	4	86	86	100	0.00
Fenitrothion 1%	3	94	94	100	0.00
Propoxur 0.1%	4	96	96	100	0.00
Bendiocarb 0.1%	4	88	88	100	0.00
Permethrin 0.75%	3	71	71	100	0.00
Deltamethrin 0.05%	4	96	96	100	0.00
Lambdacyhalothrin 0.05%	4	100	100	100	0.00
Cyfluthrin 0.15%	4	94	94	100	0.00
Control	8	204	13	6.3	1.7

Table 2. The mortality rate of larvae *An. dthali* to diagnostic doses of different larvicides with 24 hours exposure time, Bandar Abbas County, Hormozgan Province, Iran, 2002

Larvicides	Replicates	No. Larvae	No. dead	Mortality (%)	SE
Malathion	4	99	99	100	0.00
Temephos	4	102	102	102	0.00
Fenitrothion	4	99	98	99	1.00
Chlorpyrifos	4	101	101	100	0.00
Control	4	100	11	11	3.12

Table 3. The mean number of take-off /adult/ min by *An. dthali* to different pyrethroid insecticides, Bandar Abbas County, Hormozgan Province, Iran, 2002

Insecticide	Lambdacyhalothrin 0.05% (n=30)			Premethrin 0.75% (n=30)			Cyfluthrin 0.15% (n=30)			Deltamethrin 0.05% (n=30)		
Time (Min.)	No. Take off	Mean	SE	No. Take off	Mean	SE	No. Take off	Mean	SE	No. Take off	Mean	SE
1	2	0.05	0.08	1	0.03	0.06	2	0.06	0.08	1	0.03	0.06
2	3	0.1	0.10	3	0.1	0.10	3	0.1	0.10	3	0.10	0.10
3	6	0.2	0.16	5	0.16	0.12	7	0.23	0.16	5	0.16	0.15
4	8	0.26	0.17	10	0.33	0.18	9	0.3	0.17	7	0.23	0.16
5	11	0.36	0.20	16	0.53	0.20	11	0.36	0.20	9	0.30	0.19
6	16	0.53	0.24	28	0.93	0.27	14	0.46	0.25	10	0.33	0.25
7	23	0.76	0.35	38	1.26	0.39	17	0.56	0.33	15	0.50	0.27
8	38	1.26	0.36	41	1.36	0.35	22	0.73	0.30	13	0.43	0.28
9	27	0.9	0.30	25	0.83	0.26	17	0.56	0.22	14	0.46	0.24
10	19	0.63	0.26	21	0.7	0.27	12	0.40	0.18	11	0.36	0.22
11	13	0.43	0.24	18	0.6	0.20	10	0.33	0.19	8	0.26	0.17
12	7	0.23	0.16	11	0.36	0.18	13	0.43	0.20	6	0.20	0.16
13	4	0.13	0.10	8	0.26	0.21	7	0.23	0.14	4	0.13	0.11
14	3	0.1	0.11	6	0.2	0.13	5	0.16	0.12	3	0.10	0.10
15	2	0.06	0.08	4	0.13	0.11	3	0.10	0.10	3	0.10	0.10
Average	13.13	0.40	0.19	16.66	0.51	0.20	10.13	0.33	0.18	7.4	0.24	0.17

Table 4. The mean number of take-off/ adult/min of *An. dthali* in control test, Bandar Abbas County, Hormozgan Province, southern Iran, 2002

Time (Min)	No.of take-offs	Mean	SE
1	2	0.04	0.04
2	2	0.04	0.04
3	3	0.07	0.05
4	1	0.02	0.01
5	3	0.07	0.05
6	2	0.04	0.04
7	1	0.02	0.01
8	5	0.10	0.09
9	1	0.02	0.01
10	2	0.04	0.04
11	2	0.04	0.04
12	3	0.07	0.05
13	3	0.07	0.10
14	1	0.02	0.10
15	2	0.04	0.04
Average	2.2	0.04	0.03

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