

1.4 Impact of irrigation change on the prevalence of malaria in arid and non-arid parts of Rajasthan

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OBJECTIVES

1. To study the impact of irrigation change on the ecological conditions with respect to vector prevalence and malaria incidences.
2. To determine key factors influencing vector/malaria prevalence and distribution using RS and GIS.

PROGRESS

Prevalence of malaria vector species: In Banswara district, 04 anopheline species viz., *Anopheles culicifacies*, *An. stephensi*, *An. annularis* and *An. subpictus* were recorded (Table 1), whereas, in Jaisalmer district from canal irrigated area only three species, viz., *An. Culicifacies*, *An. stephensi* and *An. subpictus* were collected and from non-canal irrigated areas all four species (Table 1). In Banswara, *An. culicifacies* was recorded only in Post-monsoon and winter seasons, whereas other species, *An. stephensi*, *An. annularis* and *An. subpictus* were collected during all the seasons from canal irrigated areas, however in non-canal irrigated areas *An. stephensi* was not recorded in post-monsoon season. In Banswara district the Per Man Hour Density (PMHD) of the anophelines were recorded higher from canal irrigated area in comparison to non-canal irrigated areas during pre-monsoon and winter seasons, but during post-monsoon season, the density in non-canal irrigated areas was reported higher (PMHD: 56.4) in comparison to canal irrigated areas (PMHD: 48.1). The reason being that *An. culicifacies*, which breeds in rain-fed seasonal water bodies builds up its density during post-monsoon months.

Table 1. Showing density of different anopheline species collected during the studies in different seasons.

Study District	Irrigation facilities	Anopheline Species Collected	Mosquito Density in different seasons (PMH*)		
			Pre- monsoon	Post-monsoon	Winter
Banswara	Canal Irrigated	<i>An. culicifacies</i>	0.0	17.6	20.1
		<i>An. Stephensi</i>	4.5	0.6	3.2
		<i>An. Annularis</i>	2.5	7.9	26.0
		<i>An. Subpictus</i>	1.8	22.0	0.4
		Total	8.8	48.1	49.7
	Non-canal Irrigated	<i>An. culicifacies</i>	0.0	43.7	3.0
		<i>An. Stephensi</i>	5.6	0.0	0.1
		<i>An. Annularis</i>	0.2	5.7	16.7
		<i>An. Subpictus</i>	0.1	7.9	0.3
		Total	5.9	56.4	20.1

Jaisalmer	Canal Irrigated	<i>An. culicifacies</i>	0.5	7.0	0.0
		<i>An. Stephensi</i>	1.1	1.5	0.0
		<i>An. Annularis</i>	0.0	0.0	0.0
		<i>An. Subpictus</i>	0.0	1.8	0.0
		Total	1.6	10.3	0.0
	Non-canal Irrigated	<i>An. culicifacies</i>	0.04	1.0	0.0
		<i>An. Stephensi</i>	1.3	3.5	0.9
		<i>An. Annularis</i>	0.0	0.1	0.0
		<i>An. Subpictus</i>	0.1	1.2	0.0
		Total	1.44	5.8	0.9

In general, the PMHDs of all the reported anopheline species in Banswara district, in both the study areas, canal irrigated and non-canal irrigated ones, were reported higher in both post-monsoon and winter months in comparison to pre-monsoon months, which may be attributed to the environmental conditions of prevailing temperature and relative humidity.

In Jaisalmer district due to prevailing environmental conditions, the PMHDs of all the reported anopheline species were found lower than the Banswara district. From canal irrigated areas, the PMHDs were higher than the non-canal irrigated areas in both pre-monsoon and post-monsoon seasons, however, in winter months, in canal irrigated areas no anopheline vector species were recorded and in non-canal irrigated area also only *An. stephensi* with very low PMHD i.e. 0.9, was recorded, which may be attributed to extreme environmental conditions in these areas.

In canal-irrigated areas of Jaisalmer district *An. annularis* was totally absent. *An. stephensi* and *An. subpictus* were also recorded in low densities (PMHDs: 1.1 & 1.5; PMHDs: 0.0 & 1.8). In non-canal irrigated areas the densities of all the reported anopheline species were found very low, however, of *An. stephensi*, which is an intra-domiciliary breeder, the densities (PMHDs: 1.3, 3.5 & 0.9) were found higher among other species (Table 1).

The season-wise PMHDs determined during the studies reveal that in Banswara as well as in Jaisalmer, the PMHDs of all the reported species were found higher in post-monsoon months than pre-monsoon and winter months, which indicates that the prevailing atmospheric conditions of temperature and relative humidity are more favourable during these seasons in comparison to other seasons. The PMHDs also indicate that in Banswara the environmental conditions are more supportive to anopheline fauna during winter months in comparison to Jaisalmer where these anophelines during winter were found near to almost nil.

The data on the prevailing temperature and relative humidity, both inside and outside the house-holds, was also recorded during the field investigations. Table 2 indicates the prevailing temperature ranges in the study areas during different seasons inside and outside the houses during the survey hours i.e. 7.00 to 10.30 AM.

The records of temperature variation: In Banswara district the temperature variation in canal irrigated area was recorded less than the non-canal irrigated areas. However, in Jaisalmer district the temperature variation was not uniform in comparison to non-canal irrigated areas as in winter season it was reported more than the non-canal irrigated areas. The temperature variation in canal irrigated areas of Banswara the variation was between 4 to 8 °C, whereas, in non-canal area it was between 8 to 10 °C. In Jaisalmer the temperature variation was reported between 8 to 14 °C in canal irrigated areas and 6 to 11 °C in non-canal irrigated.

The intra-domiciliary temperature variation was recorded 4 to 5 °C in canal irrigated areas of Banswara in all the seasons, which in non-canal irrigated was 8 to 9 °C . In Jaisalmer the intra-domiciliary temperature variations in canal irrigated areas was 8 to 13 °C, whereas, in non-canal irrigated 6 to 9 °C. The data indicates that in Banswara in canal irrigated area the variation of 4 to 5 °C less than to non-canal irrigated area ((8-9 °C), whereas, in case of Jaisalmer the temperature variation is higher (8-13 °C) in canal irrigated area than non-canal irrigated one (6-9 °C), which needs further analysis to determine the factors involved.

Table 2. Showing temperature ranges recorded inside and outside the houses during survey in different seasons

Location	Seasons	Temperature Range (°C) in study areas			
		Banswara		Jaisalmer	
		Canal Irrigated	Non-canal Irrigated	Canal Irrigated	Non-canal Irrigated
Outside houses (Atmospheric)	Pre-monsoon	30-35	29-37	29-37	25-36
	Post-monsoon	27-35	27-35	22-32	21-31
	Winter	17-22	15-25	09-23	18-25
Inside houses (Intra-domiciliary)	Pre-monsoon	30-35	29-37	26-37	26-35
	Post-monsoon	28-33	27.35	23-31	22-31
	Winter	17-21	16-25	09-22	18-24

Table 3. Showing RH ranges recorded inside and outside the houses during survey in different seasons

Location	Seasons	Relative Humidity (RH) Range (%) in study areas			
		Banswara		Jaisalmer	
		Canal Irrigated	Non-canal Irrigated	Canal Irrigated	Non-canal Irrigated
Outside houses (Atmospheric)	Pre-monsoon	29-66	19-59	32-65	27-61
	Post-monsoon	55-78	45-78	40-67	52-70
	Winter	49-61	43-63	45-66	47-63
Inside houses (Intra-domiciliary)	Pre-monsoon	29-60	20-52	31-61	27-54
	Post-monsoon	54-77	45-78	40-67	51-71
	Winter	49-65	43-63	45-66	46-63

Records of RH Variation: The variations in Relative Humidity(RH) range in Banswara district in canal irrigated area outside houses was recorded between 12 to 37%, whereas, inside houses – 16 to 31, which is less than the outside variations. In non-canal irrigated areas too the variations inside houses was less (20-33%) in comparison to outside houses (20-40%). In Jaisalmer district too the RH variations in canal irrigated areas the inside house variations (21-30%) was found less than the outside house variations (21-33%), however, in non-canal irrigated areas, the variation outside houses was recorded less (16-35%) than inside houses (17-27%). Season-wise the RH variations were observed less in winter months in case of both outside and inside the houses, followed by post-monsoon and pre-monsoon months (Table 3).

Observations on the physiological conditions: The observations on the physiological conditions of the collected anopheline females with respect to gravid conditions have been given species-wise in Table 4, which indicates the epidemiological importance of the vector species. The highest gravid females season-wise were reported in pre-monsoon months in canal irrigated areas of Jaisalmer district, followed by non-canal irrigated areas of Jaisalmer district and canal irrigated area of Banswara (Table 4). Species-wise *An. culicifacies* exhibited highest percentage of gravid females in non-canal irrigated area of Jaisalmer district (35.3%), whereas, *An. stephensi* (32.8%) from the same area and *An. annularis* (6.1%) in canal irrigated area of Banswara district.

Important Observations:

In Banswara district, though in both canal irrigated and non-irrigated villages, four anopheline species were recorded, however, in canal irrigated villages, the density of all the species, except *An. stephensi*, which is a vector of water scarcity area, was recorded higher in comparison to non-irrigated villages. It indicates that the environmental conditions prevailing in canal irrigated area are more supportive to anopheline fauna than prevailing in non-irrigated villages.

The intra-domiciliary temperature-range recorded district during the survey in canal irrigated villages was found more suitable for the survival of the malaria vector species than recorded in non-canal irrigated villages.

The intra-domiciliary relative humidity (RH) range in canal irrigated villages was recorded comparatively in higher range during the survey period in comparison to non-irrigated villages, which indicates that the RH range recorded during the investigations in canal irrigated villages is more favourable for the survival of the malaria vectors than recorded in non-irrigated villages. Owing to the higher percentage of gravid females in canal irrigated areas of Banswara and Jaisalmer districts these areas need to be given more attention for malaria control.

Table 4. Showing physiological conditions of malaria vector species in different seasons in study areas.

Study District	Irrigation facilities	Anopheline Species	Percentage of gravid females (%)		
			Pre-Monsoon	Post-Monsoon	Winter
Banswara	Canal Irrigated	<i>An. Culicifacies</i>	0.0	31.1	25.0
		<i>An. Stephensi</i>	16.9	0.0	29.2
		<i>An. Annularis</i>	3.4	6.1	1.6
		Total	21.3	37.2	55.8
	Non-canal Irrigated	<i>An. Culicifacies</i>	0.0	8.8	33.3
		<i>An. Stephensi</i>	18.8	0.0	0.0
		<i>An. Annularis</i>	0.0	1.7	4.7
		Total	18.8	10.5	38.0
Jaisalmer	Canal Irrigated	<i>An. Culicifacies</i>	18.2	13.2	0.0
		<i>An. Stephensi</i>	21.7	29.6	0.0
		<i>An. Annularis</i>	0.0	0.0	0.0
		Total	39.9	42.8	0.0
	Non-canal Irrigated	<i>An. Culicifacies</i>	0.0	35.3	0.0
		<i>An. Stephensi</i>	8.7	32.8	33.3
		<i>An. Annularis</i>	0.0	0.0	0.0
		Total	8.7	68.1	33.3