P O L I S H J O U R N A L O F E N T O M O L O G Y
P O L S K I E P I S M O E N T O M O L O G I C Z N E

VOL. **82**: 49-58 Gdańsk 31 March 2013
DOI: 10.2478/v10200-012-0022-y

Invasion of the predatory mosquito *Culex* (*Lutzia*) *fuscanus* in the western desert parts of Rajasthan, India

HIMMAT SINGH[1], ROBIN MARWAL[2], ANUSHA MISHRA[3], KARAM VIR SINGH[4]

Desert Medicine Research Centre, New Pali Road, Jodhpur, India,
e-mails: [1]hspawar@rediffmail.com, [2]robinmarwal@gmail.com, [3]anumishra.5@gmail.com,
[4]karamvs@gmail.com

ABSTRACT. The breeding of *Culex* (*Lutzia*) *fuscanus* WIEDEMAN was recorded during entomological surveys in Jodhpur, Bikaner, Jaisalmer and Bikaner. A detailed study of its biology has been carried out with reference to seasonal variation and breeding. Stable breeding populations of *Culex fuscanus*, a mosquito whose larvae are predacious and feed on other mosquito larvae, were found at seven localities in Jodhpur. Its larvae were found breeding in association with *Anopheles, Aedes* and *Culex* species in outdoor cemented tanks, mostly in the shade of trees. This is the first report of this species from the desert district of western Rajasthan.

KEY WORDS: mosquito, larvae, land use pattern, irrigation.

INTRODUCTION

The landscape of the western Thar desert of Rajasthan has changed considerably in recent decades as a result of a series of changes such as erratic rainfall, temperature variability, the continuous water supply through the Indira Gandhi (IG) Canal network, land use patterns, anthropogenic factors and population pressure. In consequence, there have been large shifts of flora and fauna in this desert part of Rajasthan (TYAGI & SINGH 1991, SINGH 2008, 2010, IDRIS et al. 2009).

The Thar desert of western Rajasthan was once considered an unstable zone for the breeding of mosquito vectors, so that the incidence of diseases like malaria and dengue was only occasional (AKHTAR & MCMICHAEL 1996, BATRA et al. 1999, TYAGI & YADAV 2001). In the recent past, however, as a result of changes in land use patterns, the now

ample water supply and climatic changes, this arid zone has become a permanent home to diseases such as malaria and dengue (BAEZA et al. 2011).

During the recent past several species of mosquitoes have established themselves in this part of the desert, spreading vector-borne disease. They are mainly *Anopheles stephensi* LISTON and *An. culicifacies* GILES for malaria, *Aedes aegypti* LIN. and *Ae. albopictus* SKUSE for dengue, and recently *Culex tritaeniorhynchus* GILES, a vector for Japanese encephalitis, which invaded the area after canal irrigation and the initiation of rice cultivation in the desert districts of Hanumangarh and Ganganagar (TYAGI & SINGH 1991, TYAGI & CHAUDHARY 1997). In addition to these, some other secondary vector and non-vector species are also found in association with major vectors viz. *Anopheles annularis* CELLIA, *An. subpictus* GRASSI, *An. pulcherrimus, An. minimus* THEOBALD, *An. fluvitalis* JAMES, *Ae. vittatus* BIGOT, *Culex pseudovishnui* COLLESS, *Cx. malayi* LEICESTER, *Cx. gelidus* THEOBALD, and *Cx. quinquefasciatus* SAY in this region (SINGH et al. 1991).

Culex (*Lutzia*) *fuscanus* is restricted to the old world. It is distributed all over India up to the east of the Aravalli Mountains, but was absent from western Rajasthan to Iran and Tehran (WRBU website 2012); *Culex* (*Lutzia*) *fuscanus* is a common mosquito, sharing the breeding sites of the common vector species *Culex, Aedes* and *Anopheles*, including humid and sub-humid areas in India. The present communication is a first report of the occurrence of this *Culex* species in western desert districts, where it is a successful and stable breeder.

Acknowledgements

The authors are grateful to the Director, Desert Medicine Research Centre, Jodhpur, for providing vector biology laboratory facilities, and to the Technical Staff of the Laboratory of Vector Biology of DMRC for their assistance in this work.

METHODS

Study area

The present study was conducted in Jodhpur (26° 00' to 27° 37' N and 72° 55' to 73° 52' E), one of the major desert districts of Rajasthan (Fig. 1), and is also considered the doorway to the Great Indian Desert, the Thar. Regular observations were conducted in the city of Jodhpur and its peri-urban and rural habitats. Mosquitoes were collected from 21 localities in Jodhpur. Adult mosquitoes were collected using a suction tube from different resting sites – cattle sheds, human dwellings, gardens and other man-made structures. Immatures were collected from peri-domestic containers like cemented tanks, fountains, ponds, ditches, discarded tyres, tanks (underground tanks) and other breeding habitats.

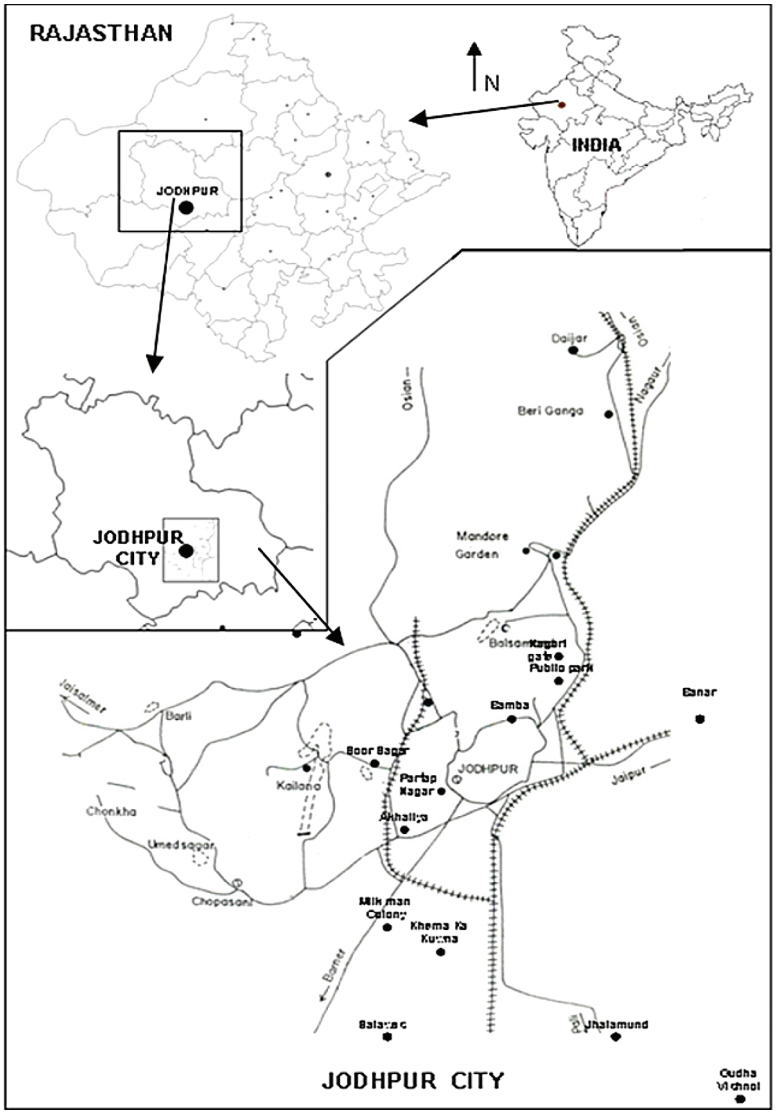

Fig. 1. *Culex* (*Lutzia*) *fuscanus* – sampling sites in Jodhpur.

Field and laboratory investigations

Entomological surveys for the collection of adults and larvae were conducted regularly throughout the year from 2010 to 2012. The larvae were collected from domestic and peri-domestic water storage tanks, ponds and ditches along with the larvae of other vector species. The predacious larvae were then separated from the others in enamel trays and reared to adult emergence following the standard methods described by GERBERG (1970).

Preliminary identification in the field was done by visually examining the robust predatory larvae during collection; species identification was confirmed in the laboratory, after the larvae had been reared to adults, using the keys by CHRISTOPHERS (1933), BARRAUD (1934), BELKIN (1962), REUBEN et al. (1994) and RATTANARITHIKUL et al. (2005).

The percentage occurrence of species was calculated on the basis of the number of times the presence of larvae was recorded out of the total number of visits made to a particular locality during the study.

RESULTS

The presence of *Culex* (*Lutzia*) *fuscanus* was recorded in the Jaisalmer, Bikaner, Barmer and Jodhpur districts of western Rajasthan (Table 1).

Table 1. Breeding records of *Culex* (*Lutzia*) *fuscanus* in the districts of Rajasthan.

Locality/ District	Stage collected	Habitat	Associated species
Ramdeora village/ Jaisalmer	Larvae	Inner city, in a cemented tank for water storage during construction	*Cx. quinqefaciatus*, *An. subpictus*
Rani village/ Barmer	Larvae	Cement tank near public hand pump	*An. stephensi*, *An. subpictus*
Khara village/ Bikaner	Larvae	In a cemented tank for cattle	*An. subpictus*, *Cx. quinqefaciatus*
City and periphery/ Jodhpur	Larvae & adults	Cemented tanks and fountains	*An. stephensi*, *Cx. quinqefaciatus*, *Ae. aegypti*, *An. culicifacies*, *An. subpictus*, *Ae. vittatus*, *Ae. albopictus*

Culex (*Lutzia*) *fuscanus* larvae were collected from 7 localities, i.e. Jhalamund, Nagauri Gate, Salawas, Mandore, Nehru park, Khema ka kunwa and Jalori Gate, along with larvae of nine other mosquito species.

Culex (*Lutzia*) *fuscanus* is a larger than the mosquitoes of *Anopheles, Aedes* and *Culex* sp. Its larvae are robust and heavily built with chewing and cutting type mouthparts; they

share a niche with *Aedes*, *Anopheles* and *Culex* species. The predatory larvae were collected mainly from cemented tanks (90%) and fountains (10%). The breeding containers from which larvae of *Culex* (*Lutzia*) *fuscanus* were collected mostly stood in the shade of large trees like *Ficus religiosa* (Peepal), *Azadirachta indica* (Neem) and *Prosopis juliflora* (Kikar) or in a shady place near trees.

The breeding habitats of the predatory mosquito were in clean water of pH 6.5 to 7.0 and temperature 18-34°C and contained some decaying leaf debris from the trees.

The breeding of this predacious mosquito was observed in these locations throughout the year except in the three months from April to June, which may be correlated with the high temperature and low rainfall during these months, when most water bodies and containers practically dry out. This reduces breeding in the containers and also the density of prey and predatory mosquitoes (Fig. 2).

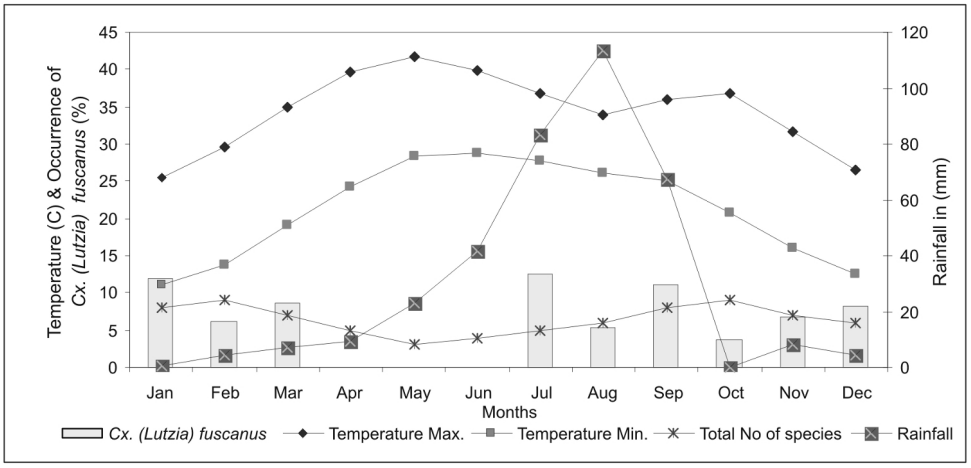

Fig. 2. Monthly distribution of *Culex* (*Lutzia*) *fuscanus* compared with rainfall and temperature.

This year-long investigation revealed that *Culex* (*Lutzia*) *fuscanus* appeared in stagnant water from late July with the onset of the rains in Jodhpur.

During this period, the climatic conditions become favourable for the breeding of almost all mosquito species, which increased the overall density of the prey population.

Although searches for adults of *Culex* (*Lutzia*) *fuscanus* during April – June were carried out, they were unsuccessful.

During the study 178 entomological surveys were carried out in 21 localities selected for the periodic recording of mosquito breeding in Jodhpur; the larvae of *Culex* (*Lutzia*)

fuscanus were recorded only 19 times (5.6%). *Anopheles stephensi* was found to be the most abundant species (28.5%) followed by *Culex quinquefasciatus* (21.4%) and *Aedes aegypti* (15.4%); the least frequent species was *An. pulcherrimus* (0.6%). All three abundant species, i.e. *An. stephensi*, *Ae. aegypti* and *Cx. quinquefasciatus*, were also found to occur in the drier months from April to June, when other species of mosquitoes were not detected (Table 2).

Table 2. Monthly percentage occurrence of mosquito species collected from various outdoor locations in Jodhpur district.

Months	**Relative occurrence of different species (%)**										**Frequency of visits**	**No. of species**
	An. stephensi	*An. culicifacies*	*An. subpictus*	*An. pulcherrimus*	*An. annularis*	*Aedes aegypti*	*Ae. vittatus*	*Ae. albopictus*	*Cx. quinquefasciatus*	*Cx.* (*Lutzia*) *fuscanus*		
January	28.0	12.0	4.0	0.0	8.0	12.0	8.0	0.0	16.0	12.0	**13.0**	**8**
February	30.3	6.1	0.0	3.0	3.0	6.1	12.1	3.0	30.3	6.1	**17.0**	**9**
March	34.8	4.3	0.0	4.3	0.0	21.7	4.3	4.3	17.4	8.7	**11.0**	**7**
April	38.5	11.5	3.8	0.0	0.0	11.5	0.0	0.0	34.6	0.0	**19.0**	**5**
May	61.1	0.0	0.0	0.0	0.0	16.7	0.0	0.0	22.2	0.0	**16.0**	**3**
June	46.2	0.0	7.7	0.0	0.0	23.1	0.0	0.0	23.1	0.0	**16.0**	**4**
July	25	0.0	25	0.0	0.0	12.5	12.5	0.0	12.5	12.5	**10.0**	**5**
August	28.9	7.9	15.8	0.0	0.0	18.4	5.3	0.0	18.4	5.3	**19.0**	**6**
September	16.7	5.6	27.8	0.0	5.6	16.7	5.6	0.0	11.1	11.1	**10.0**	**8**
October	17.3	6.2	16	0.0	6.2	17.3	12.3	1.2	19.8	3.7	**26.0**	**9**
November	16.7	6.7	16.7	0.0	0.0	13.3	16.7	0.0	23.3	6.7	**12.0**	**7**
December	37.5	8.3	0.0	0.0	4.2	16.7	4.2	0.0	20.8	8.3	**9.0**	**6**
Total	**28.5**	**6.5**	**10.1**	**0.6**	**3.0**	**15.4**	**8.0**	**0.9**	**21.4**	**5.6**	**178**	**10**

The occurrence of *Culex* (*Lutzia*) *fuscanus* peaked during January (12.0%) and dropped to a minimum during April – June. Following the onset of the rains, with the increase in

the breeding of prey mosquito larvae, the density of predacious larvae was also found to have increased (Fig. 2).

In laboratory conditions adults of *Culex* (*Lutzia*) *fuscanus* were observed to survive up to 46 days (females – average 11) and 18 days (males – average 5) at an ambient temperature of 27± 2 ^{o}C, RH 60-70%, after feeding on 20% glucose.

DISCUSSION

The present study reveals that sizeable breeding populations of *Culex* (*Lutzia*) *fuscanus* have established themselves in various locations of Jodhpur city as well as in other desert districts. Monthly monitoring of breeding locations showed that the population of *Culex* (*Lutzia*) *fuscanus* appears to follow a pattern with the occurrence of other prey mosquito species.

This study further showed that containers like peri-domestic cemented tanks (used by cattle for drinking) and garden fountains are the key containers in which predatory and other mosquito species breed. The population density of predacious larvae is correlated with the prey population density: the abundance of *Culex* (*Lutzia*) *fuscanus* larvae was found to be directly proportional to the abundance of the local prey species.

In the past, the sparse human population and adverse climatic conditions did not support the stable breeding of mosquitoes.

The change in the human population, the availability of water and the increase in the number of plantations in the environment have contributed to the stability of mosquito breeding in the desert. The stable breeding of vector mosquito populations may well have attracted the predacious mosquito species of thickets, i.e. *Culex* (*Lutzia*) *fuscanus*, to invade the desert and to establish itself successfully. Some of the studies conducted by HALPERN et al. (2005) on prey and predator species suggests that the stability of this predatory mosquito species in an ecosystem depends on the constant presence of a prey population.

The monthly follow-up studies also suggest that the population of predatory species starts to increase in July when there is an increase in the density of prey species viz. *Anopheles*, *Aedes* and *Culex* spp. in the outdoor breeding containers. During the hot and drier months (April to June), when the population of prey larvae also falls, no larvae of *Culex* (*Lutzia*) *fuscanus* were found.

A study of the bionomics of this species suggests that adults can survive up to 45 days (IKESHOJI 1966), and our laboratory finding have confirmed that it has an average life of 47 days. This duration of an adult's life may crucially enable it to escape the hot summer, when larval containers dry up. The major collection sites were situated near gardens with

lush green vegetation, which may provide shelter for the adults of this species until the favourable breeding season arrives. Several locations near the breeding sites were searched for adults of *Culex* (*Lutzia*) *fuscanus* during the summer months from April to June, but none were collected during this period. The adult form of this predatory mosquito is zoophilic and bites birds like pigeons late at night; this nocturnal behaviour resembles that of other mosquito species except *Aedes* sp. It can escape from the adverse daytime conditions during hot summers. The lifespan and feeding behaviour are appropriate for a mosquito in the harsh climate of Jodhpur.

Studies of changes in the environment have shown that several species of animals and birds have invaded the desert (SINGH 2008, 2010): *Culex* (*Lutzia*) *fuscanus* is one of those that has recently invaded and become acclimatized in the desert. It may be speculated that the invasion pathway of this species in this part of desert may be routed through the north-eastern canal irrigated area. The latest report on the occurrence of this species is available from Punjab and Uttar Pradesh (SINGH & PRAKASH 2008).

The addition of predators to ecological communities may increase variability in system dynamics (HALPERN et al. 2005). The establishment of a predatory mosquito breeding in desert conditions signifies that the mosquito population on which *Culex* (*Lutzia*) *fuscanus* larvae feed upon is stable in the habitats in which it was found breeding.

CONCLUSIONS

The changing environmental conditions of the desert are attracting several species from mesic environments to take up residence in the desert. This altered profile has favoured the incidence of vector-borne diseases (Rajasthan state reports). The change in climatic conditions and land use pattern with an excess water supply may have increased the vector density with respect to cases of vector borne diseases in certain canal-irrigated regions of western Rajasthan. However, the introduction of this predatory species may prove to be favourable as a natural bio-control agent against the vector breeding populations, provided the successful breeding of this species is managed. This may confer an added advantage on restricted habitats where chemical control is impossible either because of their inaccessibility or on culturally-protected water containers or tanks for cattle drinking. It may be an efficient biological vector control tool and could support the National Vector Control programme. These observations warrant a detailed study of the predatory potential of this species against individual vector species of Malaria Dengue/DHF, Chikungunya or Japanese encephalitis.

REFERENCES

AKHTAR R., MCMICHAEL A.J. 1996. Rainfall and malaria outbreaks in western Rajasthan. Lancet **348**: 1457-1458.

BAEZA A., BOUMA M.J., DOBSON A.P., DHIMAN R., SRIVASTAVA H.C., PASCUAL M. 2011. Climate forcing and desert malaria: the effect of irrigation. Malaria Journal **10**: 190.

BARRAUD P.J. 1934. The fauna of British India: Diptera. Vol. V. Taylor & Francis, London.

BATRA C.P., MITTAL P.K., ADAK T., SHARMA V.P. 1999 Malaria investigations in District Jodhpur Rajasthan, during the summer season. Indian Journal of Malariology **36**: 75-80.

BELKIN J.N. 1962. The mosquitoes of the South Pacific (Diptera, Culicidae). Vol. 1. University of California Press.

CHRISTOPHERS S.R. 1933. The fauna of British India: Diptera. Vol. IV. Taylor & Francis, London.

GERBERG E.J. 1970. Manual for mosquito rearing and experimental techniques. Bulletin 5. The Journal of American Mosquito Control Association.

HALPERN B .S, BORER E.T., SEABLOOM E.W., SHURIN J.B. 2005. Predator effects on herbivore and plant stability. Ecology Letters **8**: 189-194.

IDRIS M., SINGH P., JOHARI S. 2009. Impact assessment of the Indira Gandhi Canal on the avifauna of the Thar Desert. [In:] SIVAPERUMAN C., BAQRI Q.H., RAMASWAMY G., NASEEMA M. (eds). Faunal ecology and conservation of the Great Indian Desert. Springer Berlin Heidelberg, pp.: 119-135.

IKESHOJI T. 1966. Bionomics of *Culex* (*Lutzia*) *fuscanus*. The Japanese Journal of Experimental Medicine **36**: 321-334.

Mosquito Identification Resources. Walter Reed Biosystematics Unit. https://www.wrbu.si.edu/ accessed on 15.12.2012.

RATTANARITHIKUL R., HARBACH R.E., HARRISON B.A., PANTHUSIRI P., JONES J.W., COLEMAN R.E. 2005. Illustrated keys to the mosquitoes of Thailand. II. Genera *Culex* and *Lutzia*. The Southeast Asian Journal of Tropical Medicine and Public Health. **36**: 1-97.

Rajasthan state report assessed from official website of State Health Department. http://mohfw.nic.in/NRHM/Documents/High_Focus_Reports/Rajasthan_Report.pdf., accessed on 10.01.2013.

REUBEN R., TEWARI S.C., HIRIYAN J., AKIYAMA J. 1994. Illustrated keys to species of *Culex* associated with Japanese encephalitis in Southeast Asia (Diptera: Culicidae). Mosquito Systematics.

SINGH G., PRAKASH S. 2008. A new species of *Lutzia* (Diptera: Culicidae) comparable *Halifaxii* THEOBALD 1903 in a Semi-Arid Zone of India. [In:] TYAGI B.K. (ed.). Vector-borne diseases epidemiology and control. Scientific Publisher, pp.: 195-204.

SINGH H. 2008. Changing avian diversity of Jodhpur, Western Rajasthan. [In:] SIVAPERUMAN C., BAQRI Q.H., RAMASWAMY G., NASEEMA M. (eds). Faunal ecology and conservation of the Great Indian Desert. Springer Berlin Heidelberg, pp.: 99-112.

SINGH H. 2010. Invasion of garden species in the Thar Desert. [In:] Impact of climate change on biodiversity and challenges in the Thar Desert. Golden Jubilee of Desert Regional Centre, Zoological Survey of India, pp.: 277-288.

SINGH K.V., JOSHI,V., BANSAL S.K. 1991. Studies on mosquito vector species in indoor habitats of desert and non-desert regions of Rajasthan. Journals of Communicable Diseases **23**: 263-269.

TYAGI B.K., CHAUDHARY R.C. 1997. Outbreak of falciparum malaria in the Thar Desert (India), with particular emphasis on physiographic changes brought about by extensive canalization and their impact on vector density and dissemination. Journal of Arid Environments **36**: 541-555.

TYAGI B.K., SINGH K.V. 1991. Anopheline mosquitoes of Sri Ganganagar district (Rajasthan) transmitting malarial parasites. Journal of Applied Zoological Researches **2**: 85-91.

TYAGI B.K., YADAV S.P. 2001. Bionomics of malaria vectors in two physiographically different areas of the epidemic-prone Thar Desert, north-western Rajasthan (India). Journal of Arid Environments **47**: 161 172.

Received: February 21, 2013
Accepted: March 3, 2013