New record and larval habitats of *Culex eduardoi* (Diptera: Culicidae) in an irrigated area of Patagonia, Chubut Province, Argentina

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The object of the present work was to identify the larval habitats of Culex eduardoi *and to determine the microenvironmental conditions related to their presence in different artificial freshwater environments (temporary, semi-permanent, irrigation ditches, and drainage ditches) in tillable areas of Chubut Province, Argentina. This report represents the first record of* Cx. eduardoi *from this Province and extends its range to latitude 45°S. Immature stages of* Cx. eduardoi *were found in 8 out of 109 (7.3 %) freshwater habitats and were significantly more prevalent in semi-permanent water bodies. Positive sites had significantly larger surface areas and more vegetation cover than negative sites.*

Key words: aquatic vegetation - larval habitats - Culicidae - *Culex eduardoi* - Patagonia

Human-caused environmental disturbances may alter the population dynamics of some mosquito species (Barrera et al. 1979) or create suitable conditions for their proliferation (Gomes 1986, Lopes & Lozovei 1995, Robert et al. 1998). Many studies conducted in different world regions have shown a link between availability of mosquito larval habitats and anthropogenic activities in tillable areas (Forattini et al. 1993, Robert et al. 1998, Herrel et al. 2001). Artificial irrigation systems in both rural and urban arid regions may create freshwater environments that are suitable for mosquito immatures. Irrigation systems implemented in Sarmiento village, Chubut Province (Patagonia, Argentina) provide an example for this study. Only two species of mosquito, *Culex pipiens* and *Ochlerotatus albifasciatus*, are known to occur in Chubut Province (Mitchell & Darsie 1985), and the present study reports the first finding of *Culex eduardoi*. Studies on ecology of Culicidae from Patagonia are scarce and, in particular, no information is available on environmental characteristics of larval habitats.

The characterization of mosquito larval habitats based on biological, physical, and chemical features is important for understanding the complex interactions among immatures and the biotic and abiotic components of their aquatic environment (Laird 1988). In addition, the knowledge of both their aquatic habitats and the factors that constrain the ecological distribution of mosquitoes is of potential epidemiological interest (Forattini 1965), because many mosquito species have been incriminated in the transmission of important human and animal diseases.

The object of the present work was, therefore, to identify larval habitats of *Cx. eduardoi* and to determine characteristics related to their presence in Chubut Province, Argentina.

The village of Sarmiento (45º35'S - 69º05'W) is located on the floodplain of the Senguer River, in the center of the Patagonian plateau, Chubut Province, Argentina. The landscape is dominated by steppe (Cabrera 1971) and the temperate climate is dry and cold (Paruelo et al. 1999). In January 2003 air temperature was varied in the range 12.6°C to 24.8ºC (mean temperature 18.5ºC) and accumulated precipitation was 0.87 mm (NOAA). There are a few lentic freshwater environments, which are fed by rainfall and melting ice during summer.

The main economic activities of the village are agriculture and cattle raising, and the productivity of farmlands has been improved after the implementation of an irrigation system fed by the Senguer River. It consists of a network of irrigation and drainage ditches, and the volume of water delivered to each farm is controlled by opening and closing the ditches. At the time of the study, about 12,606 ha (comprising 22% of the total village area) were irrigated by this method. The artificial flood regime takes place from mid-spring to mid-autumn, and farmlands are irrigated more than twice during this period due to water loss by evaporation.

Different artificial freshwater environments in the urban and rural areas of Sarmiento were surveyed in the austral summer from January 9-24, 2003. Aquatic environments were classified into the following four major categories: temporary water bodies, semi-permanent water bodies, irrigation ditches, and drainage ditches. The water surface area, the depth, and the percent of vegetation covering were estimated for each freshwater habi-

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tat. The surface area was estimated by measuring the area of a rectangle containing the water body, multiplied by the percentage of this geometric shape covered by water. The percent of vegetation covering the water surface was estimated visually.

The following physical and chemical variables of the water were also recorded: water turbidity, pH (measured with a digital pH meter pHep-Hanna), dissolved oxygen (measured with a digital oximeter Lutron CD-4303), salinity (measured with a portable refractometer VISTA A366ATC), and temperature (measured with a digital thermometer TFA). Turbidity was estimated by placing 5 l of water sample in a white container (20 cm diameter by 15 cm deep), and classified in three levels: 1 = turbid, 0.5 = semitransparent, and 0 = clear water. Turbid samples were those where the white container background could not be seen.

To collect immatures, one sample was taken from each environment with a 350 µm mesh hand-net. Each sample was composed for a numbers of dips. The number of dips was proportional to the surface area of each habitat. Each dip measured 1 m, with 0.5 dips for surfaces from 0.1 to 1 m^2 and 18 for surfaces higher than 1000 m^2 (Fontanarrosa et al. 2004). In all cases, the material collected was fixed in situ with 80% ethanol. Preimaginal mosquitoes were identified with an appropriate key (Darsie 1985). The other species detected was *Oc. albifasciatus*, but this did not constitute part of this study.

The numbers of habitats positive for *Cx. eduardoi* in each aquatic environment category were compared with larva-negative sites by mean of test for independent proportions, whose value of the statistic may be referred to tables of chi squares (Fleiss 1981). Habitat characteristics of larva-positive and negative sites for *Cx. eduardoi* were compared using Mann-Whitney U-tests (Zar 1996).

Immature stages of *Cx. eduardoi* were found in 8 out of 109 (7.3%) freshwater environments (Table I).

Eight percent of the freshwater habitat contained *Cx. eduardoi* in the rural area, while no larva-positive sites were detected in the urban area. Higher prevalence in semi-permanent water bodies contributed to significantly different occupancy by this species of the four habitat types ($\chi^2_{(3)} = 45.31$, $p < 0.001$). Vegetation commonly found in these environments were rooted aquatic plants such as like bulrushes (*Schoenoplectus* sp.) and cattails (*Typha* sp.), and free-floating aquatic plants including water ferns (*Azolla* sp. and *Salvinia* sp.) and duckweeds (*Lemna* sp. and *Wolffiella* sp.).

TABLE I

Number of larva-positive sites respect to examined aquatic sites for each category in rural and urban areas, January 2003, village of Sarmiento, Chubut Province, Argentina

	Areas	
Freshwater environments	Rural	Urban
Temporary	1/69	0/6
Semi-permanent	6/10	0/0
Irrigation ditches	0/5	0/1
Drainage ditches	1/16	0/2
Total	8/100	0/9

Positive sites had a median area of approximately 4700 m^2, significantly more than negative sites ($U_{7,81} = 153.5$, $p < 0.05$), and a vegetation cover higher than 90% significantly more than negative sites ($U_{8,101} = 155$, $p < 0.01$). No statistically significant differences were found between positive and negative sites with respect to pH, dissolved oxygen, salinity, temperature, turbidity, and depth of the water column (Table II).

The present paper extends the geographic range of *Cx. eduardoi* to latitude 45ºS, its previously known southern distribution limit was at 34º55'S in Buenos Aires Province, Argentina (Mitchell & Darsie 1985). This is the first report of larval mosquito sites associated with anthropogenic activity in tillable areas of Southern Argentina. In Sarmiento, the number of freshwater habitats with stagnant or slow-moving water has been increased by the flood irrigation method, thus increasing the availability of larval sites for mosquitoes such as *Cx. eduardoi*.

The immature stages of *Cx. eduardoi* are found in a wide variety of freshwater environments in temperate and tropical regions, that include natural temporary (Casal & García 1968, Fischer et al. 2000, Oria et al. 2002), natural permanent and semi-permanent environments (Forattini et al. 1993, Lopes & Lozovei 1995, Oria et al. 2002), and different types of artificial containers (Lopes 1997).

Our results suggest that the water surface area and the percentage of aquatic vegetation cover may affect the selection of oviposition sites by *Cx. eduardoi*. The

TABLE II

Values of microenvironmental variables (median and interquartile range) in positive and negative sites for *Culex eduardoi*

	Positive sites			Negative sites		
Variables	N	Median	Q1 - Q3	N	Median	Q1 - Q3
pH	8	7.60	7.26 - 8.76	91	8.40	7.71 - 9.26
Dissolved oxygen (mg/l)	8	5.45	4.70 - 7.13	92	7.35	5.38 - 10.63
Salinity (‰)	8	8.00	2.00 - 9.00	91	8.00	3.00 - 9.00
Temperature (ºC)	8	20.53	19.08 - 21.11	94	19.93	17.60 - 23.64
Turbidity	8	0.25	0 - 0.50	97	0.00	0 - 0.50
Surface area (m^2) [a]	7	4674.00	1531.50 - 8000.00	81	273.00	39.04 - 1050.00
Depth (cm)	8	32.50	27.50 - 40.00	99	25.00	15.00 - 40.00
Vegetation cover (%) [b]	8	0.98	0.88 - 1.00	101	0.50	0.10. - 0.90

Significant differences by Mann-Whitney U test (*a*: $p < 0.05$, *b*: $p < 0.01$).

water surface area would be related directly with its degree of permanence, which in turn would favour vegetation cover. Vegetation cover is likely to provide shelter from the wind during oviposition, and food resources (Schneider & Frost 1996) and protection from predators of immatures (Laird 1988).

The ocurrence of immature stages of *Cx. eduardoi* throughout the year has been documented in Buenos Aires City, Argentina (Fischer et al. 2000) and in Southern Brazil (Lopes 1997). According to Lopes (1997), the presence of this species throughout the year may reflect an adaptive response to a wide range of thermal conditions. Thus, it may be reasonable to assume that the adaptive capacity of this species might account for its occurrence at latitudes as high as ~ 45ºS. Among the mosquito species present in southern South America, *Cx. eduardoi*, together with *Oc. albifasciatus* and *Cx. pipiens* (Mitchell & Darsie 1985), would appear to be the best adapted to cold and arid environmental conditions.

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