

Larval habitat of *Ochlerotatus albifasciatus* (Diptera: Culicidae) in the southern edge of the Americas, Tierra del Fuego Island

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ABSTRACT

The information about ecological topics of mosquitoes at the southernmost tip of South America is fragmentary and scarce. The present study evaluates lentic freshwater habitat located in the surroundings of main roads of the Argentine sector of Tierra del Fuego as larval habitat of *Ochlerotatus albifasciatus*, also analyzes the relationships between their presence and several environmental variables: water turbidity, percentage of gramineans, percentage of macrophytes, presence of crustacean cyanobacteria, and filamentous chlorophytes. Mosquito immatures were collected with dip nets. A generalized linear model (GLM) with negative binomial error distribution was used to determine the effects of different variables of the water bodies on abundance of *Oc. albifasciatus* in the larval habitats. Collections were made in 45 lentic freshwater bodies. Preimaginal stages were found in 17.70% of the studied habitats. *Oc. albifasciatus* was the only culicid registered. The GLM explained 93.17% of the variability, and showed a negative relationship between the abundances of *Oc. albifasciatus* and water turbidity, and a positive relationship with percentage of gramineans. The gramineans would improve food supply, because the plants are providing suitable substrate for different types of microbiota, a layer of leaves would protect eggs from extreme temperatures, and could help the

larvae to hide from potential predators. The negative association between abundance of this species with water turbidity could be related to the presence of vegetation that favors retaining the substrate, reducing water turbidity.

Keywords: *Ochlerotatus*; Mosquitoes; Larval Habitat; Patagonia; South America

1. INTRODUCTION

Knowledge of the mosquito larval habitat and the habitat conditions favouring the presence of immature mosquitoes is essential to understanding the ecology of culicid populations, particularly for species acting as vectors of important human and animal diseases [1].

At the southernmost tip of South America, the information about ecological topics on mosquitoes is fragmentary and scarce. In Patagonia, Chubut Province (45°35'S, 69°05'W), Burroni *et al.* [2] found *Ochlerotatus albifasciatus* and *Culex eduardoi* in a study on wetlands in agroecosystems (Burroni *et al.* [3]), and an update of the distribution of the species in Patagonia Argentina shows that its northern provinces registered between 6 and 14 species, whereas the southernmost continental province of Patagonia (Santa Cruz) has only 5 species [4]. In particular, in the Tierra del Fuego Island (Argentina), Bachmann and Bejarano [5] reported adults of *Oc. albifasciatus* (Macquart 1838) in Ushuaia City and Lapataia Bay documenting the irritating effects of their bites on humans due to the high abundance of

mosquitoes at this high latitude. In addition, adults of this species were reported by Marinone [6] from Kosobo Lake, located 74 km to the northeast of Ushuaia. This persistent biter that causes considerable discomfort both to humans [7] and to cattle [8], has sanitary importance since it has been recognized as a competent vector of the western equine encephalitis virus [9-12]: the east equine encephalitis virus and the Valle Cache virus [13]; and of *Dirofilaria immitis*, the etiological agent of canine filariasis [9,14].

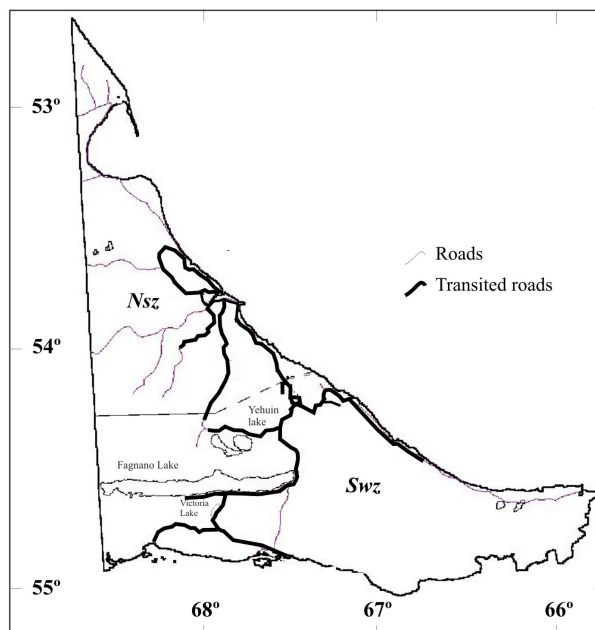
Information about the larval habitat of culicids is not available for the Tierra del Fuego Island, and ref. [4] has recently pointed out the lack of information about bio-nomics of mosquitoes in this region. This study was aimed at evaluating lentic freshwater habitat located in the surroundings of the main roads of the Grand Island of Tierra del Fuego (Argentina) as potential larval habitat for *Oc. albifasciatus*, and analyzing the relationships between the abundance of their immature stages and several key environmental variables.

2. MATERIALS AND METHODS

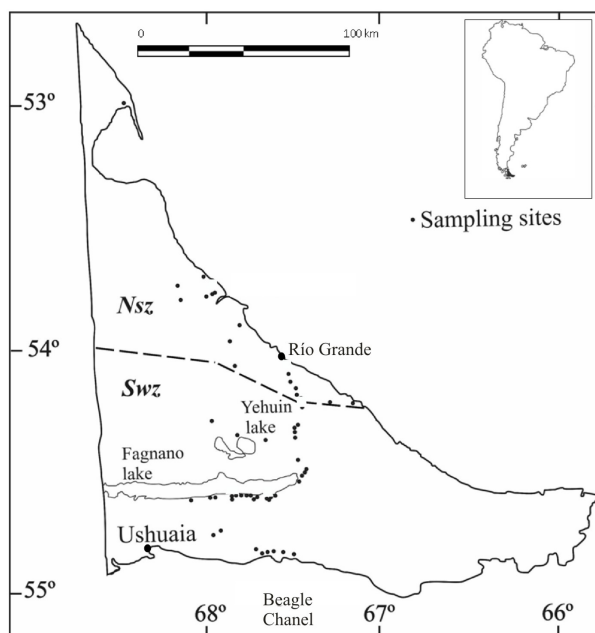
2.1. Study Area

This study was carried out in the Grand Island of Tierra del Fuego (Argentine sector) (52°33' - 55°00'S, 65°46' - 68°41'W), from 8 to 14 January 2002. The climate of this island is cold-temperate with a mean annual temperature between 4°C and 6°C [15] and a mean annual precipitation between 300 and 500 mm. The island is characterized by little temperature fluctuations due to the maritime influence, precipitations all year round, high cloudiness, no frost-free period, and strong westerly and southwesterly winds [16].

Because of its severe weather and harsh relief, Tierra del Fuego has experienced a relatively low level of anthropogenic impact [17]. The 48,100 km² of the island are populated by 126,190 inhabitants who settled there during the last decades (<http://economia.tierradelfuego.gov.ar>). The region corresponds to the Fueguinian District of the Patagonian phytogeographic Province belonging to the Neotropical Region [18]. Two distinct landscape areas can be distinguished in the island: 1) an open steppe with large plains, isolated hills and plateaus covered with gramineous plants to the north, and 2) woodlands to the south (**Figure 1(a)**). The northern steppe zone characterized by an annual mean temperature between 5°C and 6°C, accumulated annual precipitations of 300 - 400 mm, and persistent strong westerly winds. The southern woodlands zone is partially sheltered from the winds by the presence of the southernmost continental heights of the Andes mountain range, having annual precipitations of 500 mm and annual mean temperatures of 4°C [19].



(a)



(b)

Figure 1. a) Main routes and roads in the Argentine sector of Grand Island of Tierra del Fuego. Those that were transited in search of freshwater water bodies are indicated in thick line. The dashed line indicates the approximate limit between the northern steppe (NsZ) and the southern woodland (Swz) zones; b) Location of the freshwater water bodies surveyed of the Grand Island of Tierra del Fuego, on January 2002.

2.2. Sample Collection

About 1000 km of the main routes and roads of the island were traveled to sample lentic freshwater bodies located in their surroundings (**Figure 1(a)**). Mosquito

immatures were collected with 350 μm -mesh dip nets with square frames. The nets were swept sideways and turned back along the same path to collect dislodged organisms [20]. Three persons sampled for 20 - 30 min in the open water, littoral areas and along the bottom, in each water body <1 m deep, and only in the littoral zone in wetlands >1 m deep, so that the sample size was proportional to the surface area of each environment. The material was fixed *in situ* in 80% ethanol.

The following environmental variables were recorded at each habitat: a) water turbidity (on a scale from 0 (transparent) to 1 (very turbid) (estimated visually within a 20-cm diameter by 15-cm deep white container), b) percentage of gramineans, c) percentage of macrophytes, d) presence of macroscopic algae crustaceous cyanobacteria, and e) presence of filamentous chlorophyceans. The percentage of gramineans and macrophytes was computed with the cover abundance scale for vegetation of Braun-Blanquet [21].

Immature mosquitoes were identified to the species level [22]. Same larvae and pupae were reared to adult emergence to confirm the species collected. The abbreviation of mosquito genera follows Reinert [23]. The material is held in the larval collection of N. E. Burroni (Laboratory of Grupo de Estudio de Mosquitos, Buenos Aires University, Argentina).

2.3. Data Analysis

A generalized linear model (GLM) [24] analysis with negative binomial error distribution and log link function was used to determine the effects of different variables of the water bodies on abundance of *Oc. albifasciatus* in the larval habitats. Statistical analyses were carried out using R software, Version 2.15.1 (R Development Core Team 2011). The water turbidity, the percentage of gramineans and macrophytes were treated as quantitative variables, and the crustaceous cyanobacterias, filamentous chlorophyceans presence, were treated as factors.

3. RESULTS

Collections were made in 45 lentic freshwater water bodies (**Figure 1(b)**). *Oc. albifasciatus* was the only species of culicid registered. Preimaginal stages of this species were found in 17.7% of the habitats, but it was only found in one type of water body, the roadside pools. This water body type was the more abundance (**Table 1**). The number of each type of environment sampled was approximately proportional to its relative abundance in the area.

A total of 365 immatures were accounted, and all specimens of culicids were found in the southern woodland zone of the island.

The generalized linear model (GLM) performed between the abundance of *Oc. albifasciatus* and environmental variables of larval habitats explained 93.17% of the variability.

This analysis of GLM showed a negative relationship between the abundances of *Oc. albifasciatus* and water turbidity, and a positive relationship with percentage of gramineans (**Table 2**).

4. DISCUSSION

In agreement with former reports of adult culicids for Tierra de Fuego [5,6], the only species detected in our study was *Oc. albifasciatus*, which was widely distributed in southern South America. This species has been reported from southern Brazil, Bolivia, Paraguay, Uruguay, Chile, continental Argentina—excepting the arid Provinces of San Luis and San Juan—[25,26], and Tierra del Fuego, which is the southern limit of its distribution. So far, the works on the larval habitats of *Oc. albifasciatus* have been carried out in temperate zones [e.g. 27-30], therefore, this study represents the first one dealing with larval habitat characteristics of this species in the austral extreme of the Americas.

The insular condition of Tierra del Fuego with its very low temperatures year round and the pervasive strong

Table 1. Number, origin and presence of *Oc. albifasciatus* of water body type sampled in Argentine sector of Grand Island of Tierra del Fuego.

Water body type	N	Origin of the water body	<i>Oc. albifasciatus</i>
Roadside pools	24	Made by road construction	P
Quarry pools	3	Dug to provide stone for road construction	A
Floodplain pools	6	Caused by stream or river overflow	A
Peatland ponds	3	Located in <i>Sphagnum</i> sp. peatlands	A
Beaver ponds	4	Water body modeling by these animals	A
Large ponds	5	Natural	A

Presence = P; Absence = A.

Table 2. Generalized linear model coefficients, standar error (SE) and Z values of these coefficients performed to studied the effects of environmental variables of larval habitat on *Oc. albifasciatus* abundance. Theta: 1.054 (Std. Err = 0.574).

Coefficients	Estimate	SE	Z value	
Intercept	-6.059	1.602	-3.782	***
Gramineans percentage	0.183	0.033	5.517	***
Water turbidity	-2.881	1.222	-2.358	*

Significance codes: ***p < 0.0001; *p < 0.01.

winds—specially in northern steppe zone—would preclude the dispersal and colonization of *Oc. albifasciatus*. This would coincide with the lack of records in the northern steppe zone of the island.

In the present study, the vegetation was the predictor of *Oc. albifasciatus*. The abundance of immatures of this species was positively associated to gramineans. Many authors have reported that the presence of immatures of certain mosquito species is related to the presence of vegetation [e.g. 31-33]. Indirectly, the vegetation improves food supply, because the plants are providing suitable substrate for different types of microbiota [34]. Organic detritus is consumed by bacteria and fungi [35] as well as diverse macroinvertebrates including larval mosquitoes [36]. Field studies showed that a layer of leaves protected eggs of *Oc. albifasciatus* from extreme temperatures [37]. The grass, here, could play this function too. In addition, this organic detritus may alter the aquatic chemistry in water bodies, potentially influencing the attractiveness of these habitats to ovipositing female mosquitoes [38]. On the other hand, the presence of vegetation like grass could help the larvae to hide from potential predators by providing them shelter [39,40]. Therefore, the association of *Oc. albifasciatus* abundance with gramineans could be related with these aspects. In Argentina, this species was positively associated with grass in temporary pools in Buenos Aires City [27]. The macrophytes can also provide refuge and food for mosquitoes immature, however, these plants are more representative of habitats of more permanency of water. *Oc. albifasciatus* is a floodwater mosquito, because the females lay their eggs on the wet soil of habitats subject to cycles of drought and flood [7]. This would explain the lack of association between the abundance of this mosquito and macrophytes.

The negative association between abundance of immatures of mosquitoes with water turbidity found in this study could be related to the presence of vegetation that favors retaining the substrate, reducing the dissolved solids in the water column, and thus reducing water turbidity.

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