

Geographical limits of the Southeastern distribution of Aedes aegypti (Diptera, Culicidae) in Argentina

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Accepted Version

Diaz-Nieto, L. M., Macia, A., Perotti, A. and Beron, C. M. (2013) Geographical limits of the Southeastern distribution of *Aedes aegypti* (Diptera, Culicidae) in Argentina. PLoS Neglected Tropical Diseases, 7 (1). e1963. ISSN 1935-2735 doi: <https://doi.org/10.1371/journal.pntd.0001963> Available at <https://centaur.reading.ac.uk/29437/>

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To link to this article DOI: <http://dx.doi.org/10.1371/journal.pntd.0001963>

Publisher: Public Library of Science

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1 **Geographical limits of the Southeastern distribution of *Aedes aegypti* (Diptera,**
2 **Culicidae) in Argentina**

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4 **Leonardo M. Díaz-Nieto¹, Arnaldo Maciá², M. Alejandra Perotti³, Corina M.**
5 **Berón^{1*}**

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7 **1** Centro de Estudios de Biodiversidad y Biotecnología (CEBB-CIB-FIBA-Mar del
8 Plata) – CONICET, Mar del Plata, Argentina, **2** División Entomología, Facultad de
9 Ciencias Naturales y Museo de La Plata (UNLP), La Plata, Argentina, **3** School of
10 Biological Sciences, University of Reading, Reading, UK

11 * E-mail: cberon@fiba.org.ar

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14 **Background**

15 *Aedes aegypti* (Linnaeus) is a human-biting mosquito and the primary vector of
16 human dengue and yellow fever viruses; it is also considered the principal vector of
17 Chikungunya virus in Asia [1,2]. In particular, dengue and dengue hemorrhagic fever
18 constitute an important burden to humankind in terms of morbidity and mortality. About
19 3.6 billion people in the tropics, mainly in Asia, the Western Pacific region, the
20 Caribbean, as well as Central and South America, live under risk of infection with one
21 or more of the four dengue virus serotypes (DEN-1 to DEN-4), and recent reports
22 estimate over 230 million infections, over 2 million cases of the severe form of the
23 disease and 21,000 deaths [3].

24 It is believed that *A. aegypti* originally migrated from West Africa to the New
25 World beginning with the 15th century aboard slave ships, and after that yellow fever

26 appeared in the new world. Presumably the yellow fever virus was introduced by
27 travellers on these ships, especially African slaves. The adaptation of this insect to
28 survive in human environments was crucial for colonization and development in water
29 storage containers in the holds of sailing ships [4]. At present, *A. aegypti* lives in close
30 proximity to people, in urban areas, breeding in all types of domestic and peridomestic
31 collections of fresh water, including flower vases, water drums, tins, broken coconut
32 shells, old tyres and gutters. A major range of expansion of *Aedes* mosquitoes into these
33 urban areas is also attributable to the adaptation of the genera *Aedes* to breed in water-
34 holding automobile tyres [5].

35 *A. aegypti* is a tropical and subtropical species spanning a geographical
36 distribution from 35°N to 35°S. Its lower thermal threshold corresponds to 10°C
37 isotherms during the winter, and although it has been found up to 45°N, its presence in
38 colder regions is due to its ability to colonise new areas during the warm season [6]. In
39 South America, the historic direction of dispersal of *Aedes* mosquitoes has been towards
40 higher latitudes and from tropical to sub-tropical areas, in particular in the Southern
41 Cone. We propose, that the south eastern movement of *A. aegypti* might be related to
42 human migrations from rural areas to towns lacking in a proper housing policy and
43 essential services like water, and sewage disposal systems
44 (http://www.migraciones.gov.ar/pdf_varios/estadisticas/Patria_Grande.pdf) [7].

45 Between the 1950s, 1960s and most of the 1970s, in Central and South America
46 epidemic dengue was rare because *A. aegypti* had been eliminated from most of the
47 countries. The eradication program organized by the Pan American Health Organization
48 (PAHO) was discontinued in the early 1970s, and consequently the mosquito was
49 reintroduced in countries from which it had been eradicated [6,8]. In Argentina, the
50 earliest records of *A. aegypti* go back to the 1900s and are concurrent with the dengue-

51 like epidemic of 1916, which affected the coastal areas of the Uruguay River (31°44'S,
52 60°31'W) [9]. However, in 1986 re-infestation took place in the northern border with
53 Paraguay, deriving in its spread over wide areas of the country. Nowadays, the current
54 geographical distribution of *A. aegypti* in Argentina is wider than during its eradication
55 in 1967 [10,11]. Recently it has been demonstrated that the three *A. aegypti* main
56 haplogroups identified in Argentina would represent different colonization events,
57 probably from neighboring countries: Bolivia, Paraguay, and Brazil (Fig. 1A and B) [7].
58 Particularly, in Buenos Aires province, the most densely populated area of the country,
59 the records of high abundances of well-established populations of *A. aegypti* were taken
60 in La Plata (capital of the province) and in Buenos Aires (capital city of the country),
61 both located on the East coast, and the southernmost findings in Chascomús, from 132
62 Km from Buenos Aires city (35°33'S, 58°00'W, Fig 1) [10-15].

63 On the other hand, cases of dengue have increased in the last few years in
64 Argentina. From January to June 2012, 2,043 patients with symptoms were reported,
65 and 194 were confirmed with serotypes DEN-1, DEN-2 or DEN-3
66 (http://www.msal.gov.ar/dengue/images/stories/partes_dengue/parte74.pdf). In 2011
67 PAHO emitted an epidemiological alert due to the introduction of DEN-4 serotype in
68 the Americas (<http://new.paho.org>), being Brazil, Paraguay and Bolivia countries of
69 high risk of dengue infection, with 57,267 possible cases and 5 deaths (Brazil); 10,827
70 suspected cases, 30 victims (Paraguay) and 3,233 notified cases with 28 deaths
71 (Bolivia) (Fig 1B)
72 (http://www.msal.gov.ar/dengue/images/stories/partes_dengue/parte74.pdf).

73 In the USA, the dispersal of *Aedes albopictus* Skuse offered an opportunity to
74 understand the synanthropic behavior of *Aedes* mosquitoes. The mosquito was
75 introduced in 1985 in the continental territory through shipments of used tyres

76 containing eggs originated in Asia [16]. In subsequent years, the pattern of spread of
77 this container-dwelling species followed the main interstate highways [17], quickly
78 reaching and colonizing several new areas of the USA in a few years. We wondered
79 whether *A. aegypti* would present a similar behavior, and is making use of human
80 transportation [18]. For this, we investigated the occurrence of the mosquito in major
81 roads connecting densely populated cities with the Southeast of Argentina (Table 1).

82 One of the most important highways in Argentina is the Provincial Route N°2,
83 connecting Buenos Aires and La Plata cities with Mar del Plata city and the most visited
84 beaches of the country, principally in summer time, representing about two million
85 people commuting between those places (Fig 1C and Table 1)
86 (<http://www.indec.mecon.ar>). Route N°2 crosses the most prominent wetland areas of
87 the Pampas, and its construction has definitely reshaped the landscape, making available
88 new manmade wetlands, which offer shelter to an increasing diversity of flora and
89 fauna, including mosquitoes [19]. On this artery there are some small towns that offer
90 several travel services such as tyre-repair stations or “gomerías”, which store used
91 automobile and truck tyres for long periods of time, thus these tyres accumulate
92 rainwater (Fig 2 and 3A). Moreover, along this highway a lot of vehicles transport
93 goods from the north of the country to the coastal area without any sanitary control to
94 prevent insects exchange from one region to the other. The latest scientific
95 southernmost record of *A. aegypti* carried on in Buenos Aires province, was obtained in
96 Chascomús a town located on Route N°2 [11]. Route N°2 takes the bulk of the traffic
97 and people in south-eastern direction. On the other hand, Route N°11, connecting
98 Buenos Aires and La Plata cities with the Atlantic coast, is a short motorway parallel to
99 the coastline and Route N°226 runs south-west and is mostly used by freight transport
100 (Fig 1C).

101 **Present distribution of *A. aegypti* in the most populated areas of the Buenos**
102 **Aires province**

103 In order to understand the status of the southern distribution of *A. aegypti*, we
104 sampled mosquito larvae and pupae during the rain period, in January and March 2011,
105 and only in March 2012 because rainfall levels were very low in January (Fig. 2). The
106 sampling stations were located in towns situated along Route N°2 and the other two
107 major arteries that connect Buenos Aires with the South. The sampling stations were
108 cemeteries, that are far from the towns and are shortly visited and “gomerías” located in
109 densely populated areas of each town, both at the edge of the roads (Fig. 3 and Table 2).
110 Larval specimens were collected and reared until fourth instar or adult stage to facilitate
111 identification using specific keys [13,20]. Voucher specimens, prepared from all
112 localities, were submitted to the local museum, Museo de Ciencias Naturales “Lorenzo
113 Scaglia” (Mar del Plata, Argentina).

114 Larvae of *A. aegypti* were found in March 2011 and 2012 in Chascomús,
115 agreeing with and confirming previous records [11,13]. Here we report the finding of *A.*
116 *aegypti* in the towns of Lezama, Castelli and Dolores for the first time. A population of
117 mosquitoes was found in Lezama in March 2011, 39.2 Km southeast of Chascomús,
118 being both localities separated by farmland and uniquely connected by Route N°2. As a
119 high number of larvae of all stages and pupae were found in multiple containers in this
120 locality, we feel confident that Lezama holds a natural, well-established population. In
121 March 2012, we found a higher number of larvae of all stages and pupae in the same
122 type of containers for a second time in Lezama; and for the first time in Castelli (27.7
123 Km south from Lezama) and Dolores (59.5 Km south from Lezama), stating Dolores
124 the southernmost limit of the species’ range within Argentina, now 98.7 Km south from

125 Chascomús (Fig 1C). In Routes N°11 and 226 *A. aegypti* was not found in any of the
126 water containers examined.

127 In the south of Argentina *A. aegypti* is very likely to be moving by passive
128 dispersal using the major highway connecting the North with the Southeast of the
129 country. It is noteworthy that this same behavior has been studied and documented in a
130 closely related species, *A. albopictus* in the USA. Previous observations on this
131 mosquito in North America are consistent with the hypothesis of mosquito migration
132 facilitated by anthropic action, presumably by transportation of scrapped tyres through
133 the interstate highway system [17]. In *A. aegypti*, egg resistance in absence of water, a
134 feature shared with *A. albopictus*, can lead to a similar way of transferring to new places
135 in order to breed. Therefore, passive dispersal of *Aedes* species using frequented
136 freeways should be considered at the time of designing new monitoring programs.

137 According to Shepherd *et al.* [21] dengue virus transmission follows two general
138 patterns: epidemic dengue and hyperendemic dengue. Epidemic dengue transmission
139 occurs when dengue virus is introduced into a region as an isolated event that involves a
140 single viral strain. If the number of vectors and susceptible hosts are sufficient,
141 explosive transmission can occur with an infection incidence of 25-50%. Hyperendemic
142 dengue transmission is characterized by the circulation of multiple viral serotypes in an
143 area with susceptible hosts and competent vector (with or without seasonal variation)
144 and appears to be a major risk for dengue hemorrhagic fever. Travelers to these areas
145 are more likely to be infected than travelers going to areas that experience only
146 epidemic transmission.

147 In South America, particularly in Buenos Aires Province, it is known that the
148 provincial Health Ministry has a program of surveillance of *A. aegypti*, which involves
149 mosquito larvae and eggs monitoring and their control. However, this surveillance does

150 not follow a regular pattern, being erratic in terms of time and each council or
151 municipality decides to carry it on or not. In addition, to obtain official data from
152 concrete actions is sometimes unlikely to find.

153 The new biogeographical record of Central and Southern Argentina, reported in
154 this article, is an important fact of the constant expansion of *A. aegypti* into new
155 southernmost areas. Together with the presence of the different dengue serotypes
156 indicate that the situation is far more dangerous than previously thought. Urgent and
157 responsible actions must be taken to control the Dengue vector and its further expansion
158 into new areas.

159

160 **Acknowledgments**

161 We especially thank Prof. Ana Tassi for critical revision of the manuscript.
162 LMDN is a PhD student at the National University of Mar del Plata, and recipient of the
163 ANPCyT doctoral scholarship (Argentina). AM is Research Assistant of Comisión de
164 Investigaciones Científicas (CIC), Argentina. CMB is a Research Fellow. This work is
165 part of LMDN's PhD thesis.

166

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224 **Legends to figures**

225

226 **Figure 1. *Aedes aegypti* and dengue fever in South America. (A)** Historical
227 distribution of *A. aegypti* in Argentina, indicating: 1916, first dengue-like
228 epidemic; 1986 re-infestation places and biogeographical records between
229 1991 and 1999, **(B)** Current geographic distribution of *A. aegypti* and regions
230 with risk of transmission of dengue in South America, **(C)** Studied area, showing
231 highways between Buenos Aires and Mar del Plata cities, sampling points and
232 distances between them. (A and B) adapted from Curto *et al.*, Vezzani and
233 Carbajo, [10,15] and <http://www.healthmap.org/dengue/index.php>.

234

235 **Figure 2. Weather conditions of the studied area, from July 2010 to June**
236 **2012.** On the left mean temperature in °C (T), on the right % of relative humidity
237 (RH) and total precipitation in mm (PP). <http://www.tutiempo.net/clima>. Arrows
238 indicate sampling times.

239

240 **Figure 3. Sampling places in Buenos Aires province: (A)** Tyre-repair
241 stations showing tyres with accumulated rainwater, **(B)** flowerpots at
242 cemeteries.

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Table 1. Information of cities connected by Route N° 2 in Buenos Aires Province
(<http://www.censo2010.indec.gov.ar/>).

City	Area km²	Population size	Number of households
Buenos Aires	2,681	12,801,365	3,147,638
Chascomús	3,452	38,477	18,277
Lezama	1,102	4,111	nd ^c
Castelli	2,063	8,206	3,448
Dolores	1,973	26,601	10,687
General Guido	2,814	2,814	1,508
Maipú	2,641	10,172	4,375
Mar del Plata	1,461	618,989	308,570
MdP, Summer time ^a	1,461	2,000,000	nd ^c

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^aMdP, Mar del Plata.

^cNo data

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Table 2. Sampling stations and species collected in cities along Route N° 2, in the Southeast of Argentina.

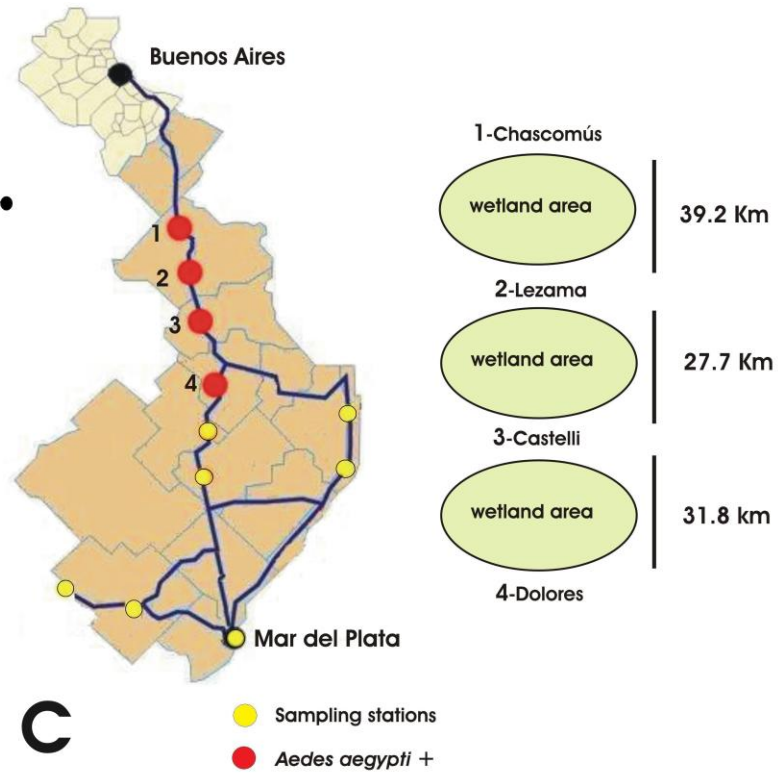
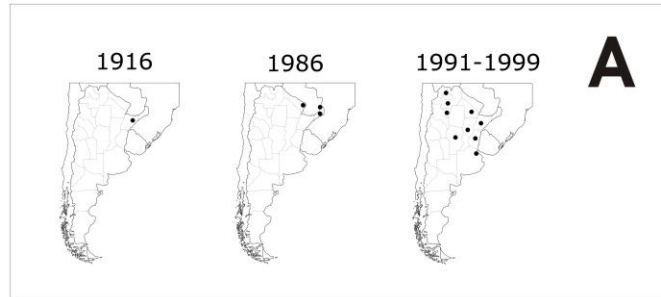
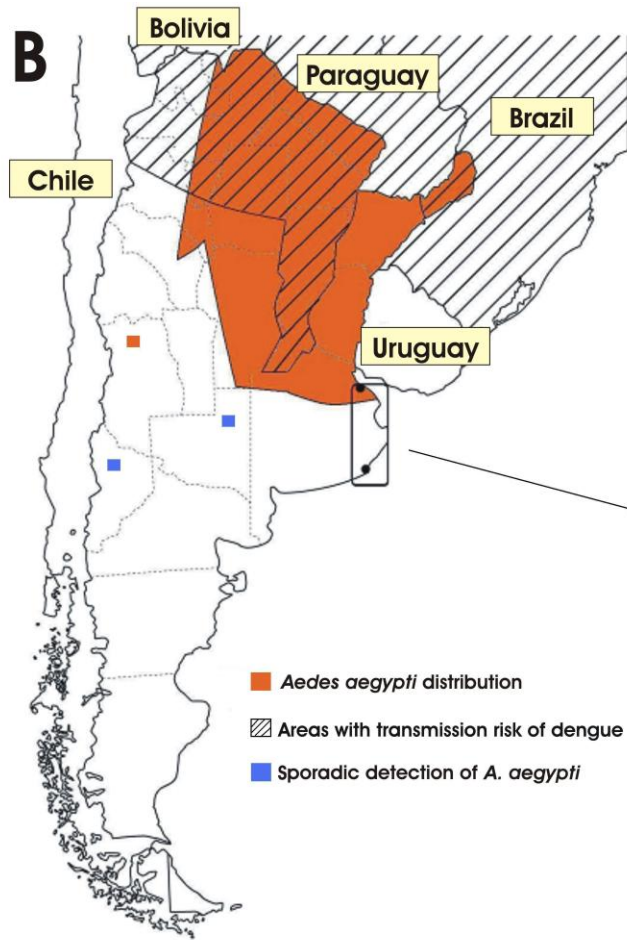
City	2011			2012			City	2012			City	2012		
	Flowerpots ^a	<i>Culex</i> sp.	<i>A. aegypti</i>	Tyre-repair stations ^b	<i>Culex</i> sp.	<i>A. aegypti</i>		Flowerpots ^a	<i>Culex</i> sp.	<i>A. aegypti</i>		Tyre-repair stations ^b	<i>Culex</i> sp.	<i>A. aegypti</i>
Chascomús	239 (12/0)	+	-	1 (1/1)	+	+	Chascomús	300 (8/2)	+	+	Chascomús	2 (2/2)	+	+
Lezama	200 (0/0)	-	-	3 (3/1)	+	+	Lezama	200 (5/0)	+	-	Lezama	3 (3/3)	+	+
Castelli	480 (0/0)	-	-	3 (3/0)	+	-	Castelli	200 (3/2)	+	+	Castelli	3 (3/3)	+	+
Dolores	730 (29/0)	+	-	2 (2/0)	+	-	Dolores	400 (12/1)	+	+	Dolores	2 (2/2)	+	+
Gral. Guido	280 (1/0)	+	-	2 (2/0)	+	-	Gral. Guido	300 (7/0)	+	-	Gral. Guido	3 (3/0)	+	-
Maipú	440 (5/0)	+	-	2 (2/0)	+	-	Maipú	nd ^c	nd ^c	nd ^c	Maipú	2 (1/0)	+	-
Mar del Plata	3,600 (~45/0)	+	-	10 (8/0)	+	-	Mar del Plata	3,600 (~45/0)	+	-	Mar del Plata	10 (8/0)	+	-

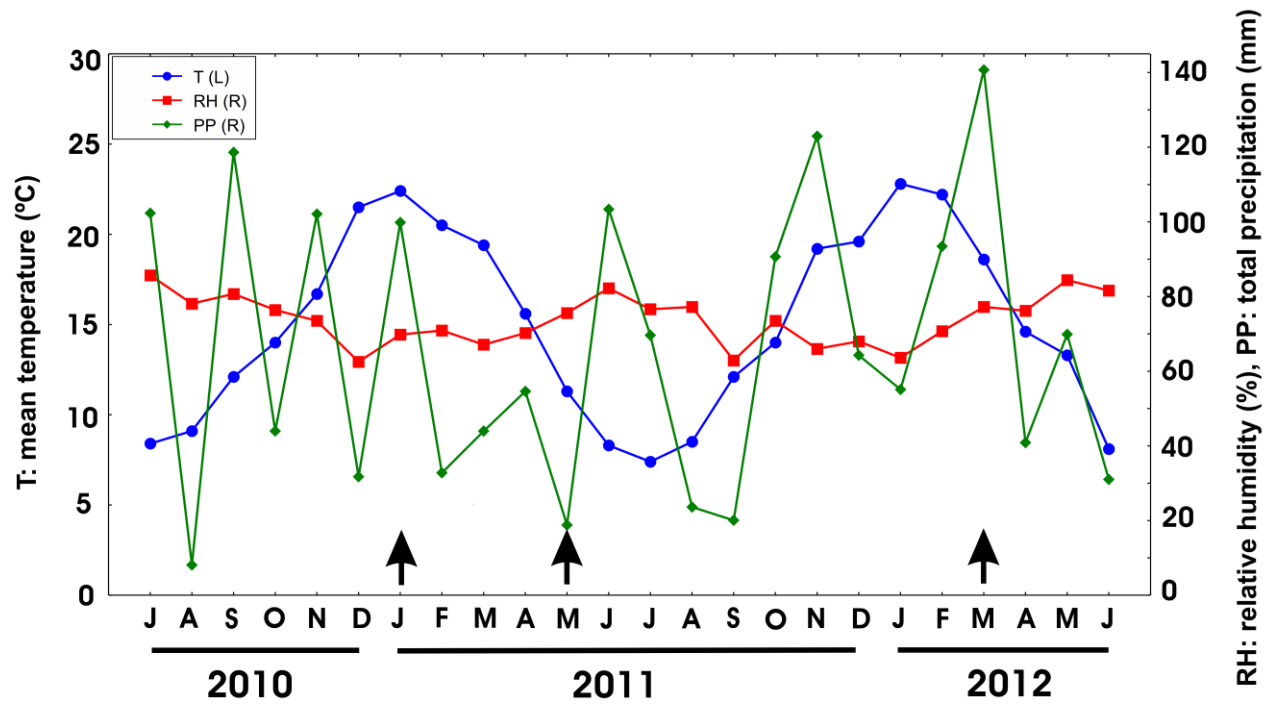
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^a Number of flowerpots sampled, in brackets positive ones for *Culex sp* and for *A. aegypti* respectively.

^b The number of *A. aegypti* was 500 larvae or more in each tyre-repair station, in brackets positive ones for *Culex sp* and for *A. aegypti* respectively.

^c No data





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