Vector Hazard Report: Puerto Rico

Dengue, Chikungunya, Yellow Fever & Zika Virus Mosquito Vectors

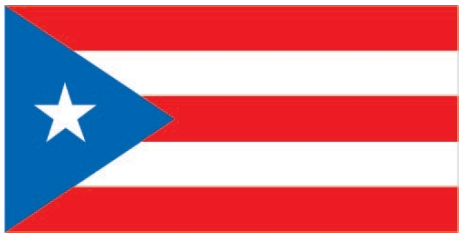
WRAIR
Walter Reed Army Institute of Research

WRBU

Walter Reed Biosystematics Unit

Last updated by David Pecor April 2021

Table of Contents:



Overview

Additional Resources

Vector Species Profiles:

- *Aedes aegypti*
- *Aedes albopictus*
- *Aedes mediovittatus*
- *Aedes vittatus*

Common Diagnostic Characters

Habitat Suitability

Dengue Transmission Map

Chikungunya Transmission Map

Zika Transmission Map

Arboviruses of Puerto Rico

References

Overview:

For the most up-to-date information about vector species, please visit the Walter Reed Biosystematics Unit Website.

The primary mosquito vector of dengue, chikungunya, yellow fever and Zika viruses on the island of Puerto Rico is *Aedes aegypti* (Linnaeus, 1762). However, *Aedes albopictus* (Skuse, 1894) and *Aedes mediovittatus* (Coquillett, 1906) have played significant roles in past outbreaks. Further complicating the issue is the recent detection of *Aedes vittatus* (Bigot, 1861) in the Caribbean. This vector species may be already be present or may become established on the island in the near future. This report summarizes the biology, distribution and identification resources associated with these important vector species. Also included are maps of recently reported local disease transmission and links to additional resources such as guidance on surveillance and counter measures.

Historically, arbovirus outbreaks reported from Puerto Rico have an increased number of cases in the late summer and fall (August to September), which are the hottest and wettest months of the year in Puerto Rico. There have been outbreaks of dengue fever in Puerto Rico since 1963 and it continues to be endemic to the island today. The largest reported outbreak occurred in 2010 with over 25,000 locally acquired cases reported to the Centers for Disease Control and Prevention.

The spread of vector species such as *Aedes aegypti*, *Ae*. *albopictus* and *Ae*. *vittatus* around the world in the past 50 years is well documented and facilitated by a unique life trait: their eggs can survive desiccation. This trait allows eggs laid by these species to travel undetected in receptacles like used tires, or lucky bamboo plants, which are distributed throughout the world. When these receptacles are wetted (e.g. by rain, watering), the larva emerge and grow to adults in their new environment. In temperate or tropical environments conditions are highly suitable for populations to quickly become established.

Compounding this problem is that these mosquito species are capable of ovarian viral transmission – meaning that if the mother is infected with a virus, she can potentially pass it on to her offspring through her eggs. Each female mosquito lays 100-120 eggs, every 4-5 days (c.4-8 times in her life time of 1-3 months), and if she is infected, all her offspring emerge ready to infect the first person they bite. Reducing the exposure of infected people to mosquitoes requires the widespread availability of rapid diagnostic tests, effective treatment and most importantly, containment of the patients. Given that there is currently no vaccine or effective treatment for Zika virus, reducing the opportunity for mosquitoes to bite infected people is critical in slowing the continued spread of the disease.

Back to Table of Contents

Resources: Vector Borne Disease Threats in Puerto Rico

CIA Factbook: Puerto Rico

CDC Travelers Overview

CDC National & State Maps (Disease and vector surveillance reported to CDC)

CDC: Zika Virus and Complications

Global Aedes Insecticide Resistance Map (IRMapper)

Video Library:

Dengue and Chikungunya in Our Backyard: Preventing Aedes Mosquito-Borne Diseases

Zika Virus Prevention: Summary for General Public in Puerto Rico

Hunting for mosquitoes in Puerto Rico

Vector Surveillance and Control Resources:

Armed Forces Pest Management Board (AFPMB) Technical Guide # 47 Aedes Mosquito Vector Control

Armed Forces Pest Management Board (AFPMB) Technical Guide # 14 Personal Protective Gear & Equipment for Pest Management Personnel

Armed Forces Pest Management Board (AFPMB) Technical Guide # 48 Pest and Vector Surveillance

Environmental Protection Agency Mosquito Control: Controlling Mosquitoes at the Larval Stage

Fight the Bite for Protection from Malaria: Guidelines for DEET Insect Repellent Use

CDC: Guidelines for Aedes aegypti and Aedes albopictus Surveillance and Insecticide Resistance Testing in the United States

Back to Table of Contents

Aedes (*Stegomyia*) *aegypti* (Linnaeus, 1762)

Aedes aegypti (F) Habitus, photo credit: WRBU

Aedes aegypti (F) Thorax, dorsal (scutum), photo credit: WRBU

For diagnostic morphology, identification keys, exemplar DNA sequences, a full list of associated pathogens and detailed bionomics visit the WRBU Species Page

Aedes aegypti are found in close association with humans, making them an extremely efficient vector of many arboviruses. Larvae are found in common water-collecting containers around homes such as buckets, tires, flower pots and refuse. Human socioeconomic factors play a role in *Ae*. *aegypti* abundance. Studies have demonstrated that communities of lower socioeconomic status support higher populations of *Ae*. *aegypti*, as well as other important vector species. In Puerto Rico, recent *Ae*. *aegypti* population surges have been associated with large numbers of abandoned houses that were the result of mass evacuations during Hurricane's Maria & Irma (2017) and Dorian (2019). Productivity of individual larval sites is influenced chiefly by the availability of water and organic material for food. Females are day-time biters and not active at night. Pyrethroid resistant populations of *Ae*. *aegypti* have been detected in Puerto Rico. It has been demonstrated that these resistant populations require significantly higher concentrations of pyrethroids to reduce attack rates. Adult *Ae*. *aegypti* are easily distinguishable from other mosquito species by their striking black and white coloration and distinctive lyre-shaped white scale pattern on the scutum.

Back to Table of Contents

Aedes (*Stegomyia*) *albopictus* (Skuse, 1895)

Aedes albopictus (F) Habitus, photo credit: WRBU

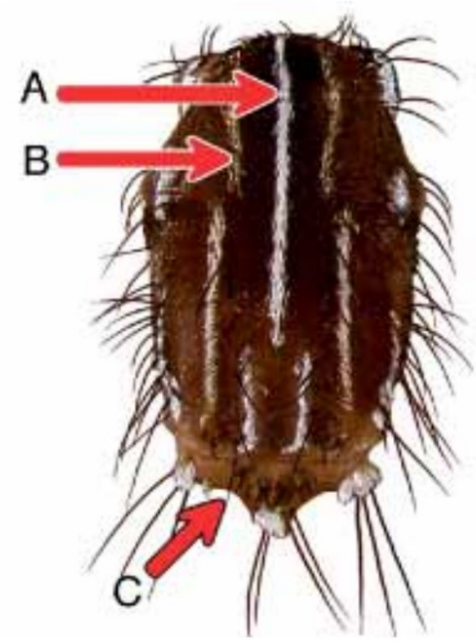
Aedes albopictus (F) Thorax, dorsal (scutum), photo credit: WRBU

For diagnostic morphology, identification keys, exemplar DNA sequences, a full list of associated pathogens and detailed bionomics visit the WRBU Species Page

Aedes albopictus are less abundant in urban areas as compared to *Ae*. *aegypti*, but pose a significant threat in peri-urban and rural environments. This species will readily feed on humans or animal hosts and is capable of transmitting a number of arboviruses to humans. Females feed during the daytime and generally require more bloodmeals than *Ae*. *aegypti* to produce eggs, increasing the risk of disease transmission. *Aedes albopictus* has very quickly established a global distribution due to its ability to dry its eggs for long-periods of time. Eggs can be laid in human containers but also potted plants and tires. The eggs can stay dry for months while these items travel to different parts of the world and hatch quickly after exposed to water again. *Ae*. *albopictus* is also more tolerant to lower temperatures and may outcompete *Ae*. *aegypti* in some areas. Both these species have played dominant roles in all major vector-borne disease outbreaks in Puerto Rico in the last 20 years. *Aedes albopictus* has a similar white/ silver and black pattern but can be distinguished from *Ae*. *aegypti* by a narrow median-longitudinal white stripe on the scutum.

Back to Table of Contents

Aedes (*Gymnometopa*) *mediovittatus* (Coquillett, 1906)

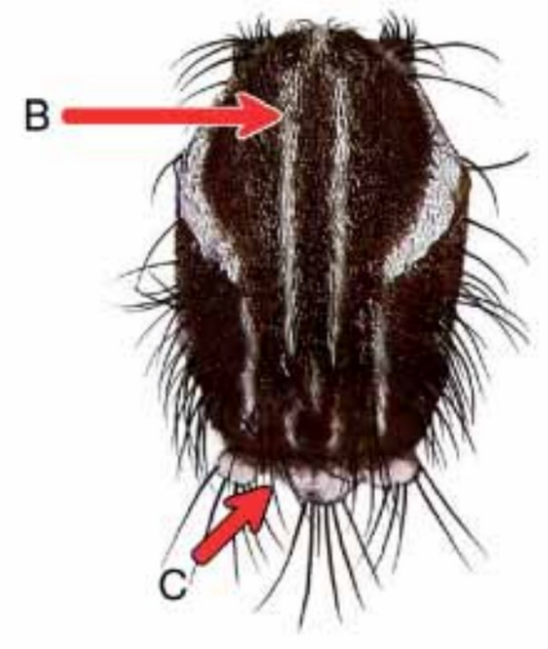


Aedes mediovittatus (Scutum: female)

A. Silver/ white median stripe

B. B. Two silver/ white longitudinal dorsocentral stripes

C. scutellum without broad flat white scales on all lobes



Aedes aegypti (Scutum: female)

B. Two silver/ white median stripes

C. scutellum with broad flat white scales on all lobes

From: Rueda, L. M. (2004). Pictorial keys for the identification of mosquitoes (Diptera: Culicidae) associated with dengue virus transmission. Walter Reed Army Institute of Research Washington DC Department Of Entomology.

For diagnostic morphology, identification keys, exemplar DNA sequences, a full list of associated pathogens and detailed bionomics visit the WRBU Species Page

Aedes mediovittatus has long been known as a maintenance vector of dengue virus in Puerto Rico. It is capable of transovarial infection of its offspring to maintain dengue virus (DENV-1) in rural populations during interepidemic periods. Although it has been demonstrated that *Ae*. *mediovittatus* is a poor vector of dengue to humans as compared to *Ae*. *aegypti*, its role in maintaining the virus in nature means it must also be considered when developing plans to reduce dengue infection risk. Females will feed on humans but also target a variety of other mammals as well as birds. This species is mostly found in rural, forested areas but has been detected in urban and peri-urban environments. Larval sites are generally natural and not associated with humans. *Aedes mediovittatus* is also white/ silver and black colored but can be distinguished from *Ae*. *aegypti* and *Ae*. *albopictus* by using two characters: 1. Scutum: A silver/ white median stripe and two longitudinal stripes. 2. Hindtibia: White patch of scales about 1/3 distance from base.

Back to Table of Contents

Aedes (*Fredwardsius*) *vittatus* (Bigot, 1861)

Aedes vittatus (F) Habitus, photo credit: WRBU

Aedes vittatus (F) Thorax, dorsal (scutum), photo credit: WRBU

For diagnostic morphology, identification keys, exemplar DNA sequences, a full list of associated pathogens and detailed bionomics visit the WRBU Species Page

Aedes vittatus has not been detected in Puerto Rico at the time of writing, however there is a high likelihood this vector may already be established or may soon be. For more information about this important vector including its initial detection by U.S. military entomologists view the WRBU Spotlight Report: *Aedes vittatus* – first incursion into the New World. This species can easily be recognized by the scale pattern on the scutum of 6 white/ silver spots.

Like *Ae*. *aegypti* and *Ae*. *albopictus*, *Ae*. *vittatus* is an effective vector of the top four *Aedes* fever viruses – chikungunya, dengue, yellow fever and zika viruses. In Jaipur district (India), 20% of Ae. vittatus larvae test showed evidence of vertically transmitted DEN virus, higher than *Ae*. *albopictus* (18.7%) and Ae. aegypti (13.3%) from the same sites (Angel & Joshi, 2008). *Aedes vittatus* is involved in the sylvatic transmission cycle of yellow fever to monkeys; YFV is also passes transovarially in *Ae*. *vittatus*.

Back to Table of Contents

Common Diagnostic Characters

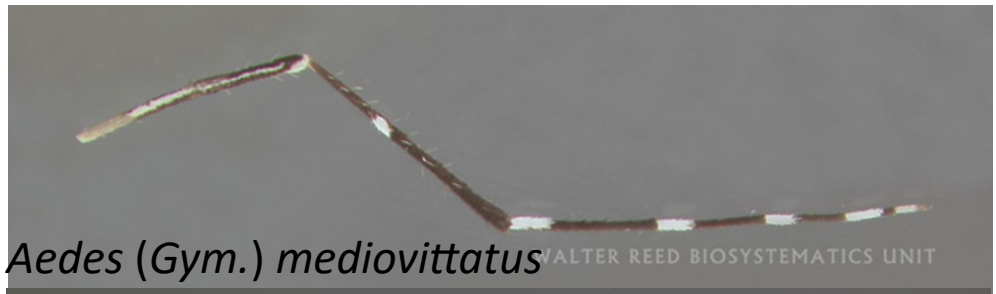
Scutum:

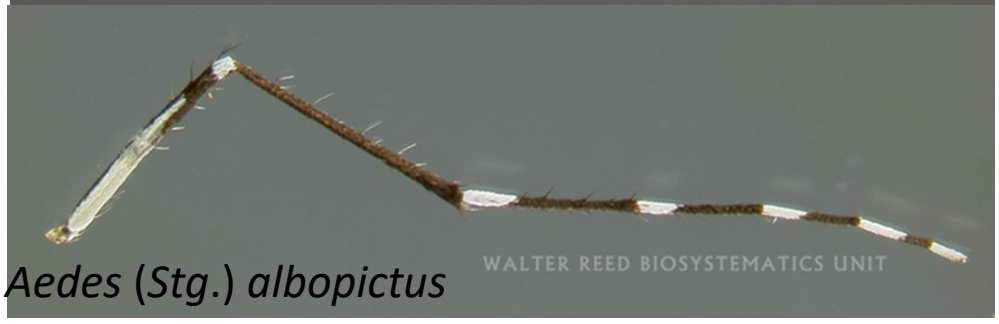
Aedes (*Stg.*) *aegypti*

Aedes (*Stg.*) *albopictus*

Aedes (*Fre.*) *vittatus*

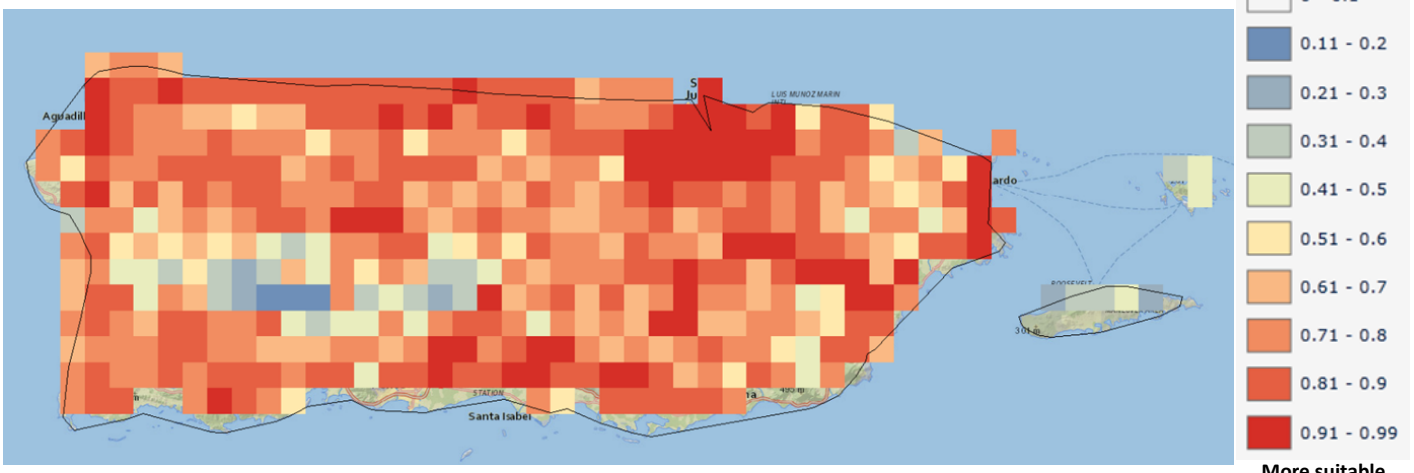
Hindleg:



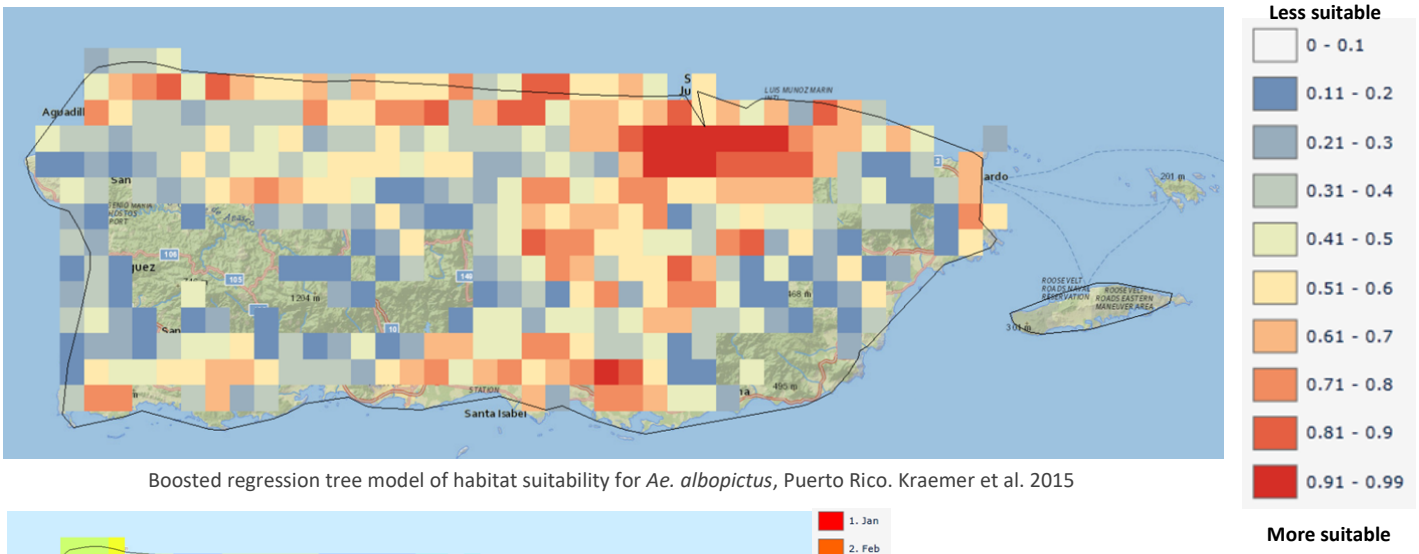


Back to Table of Contents

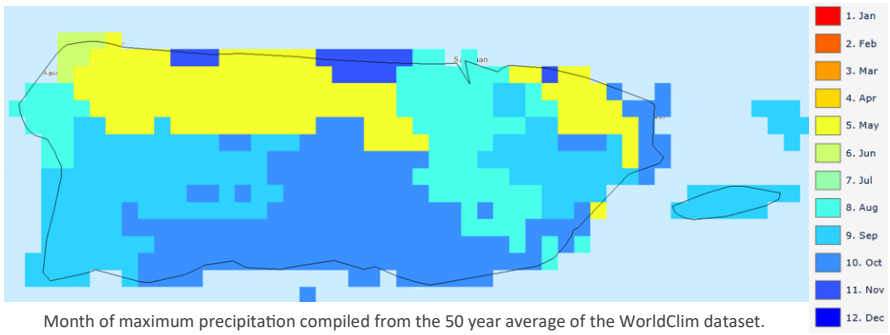
Habitat Suitability *Aedes aegypti* and *Ae. albopictus*



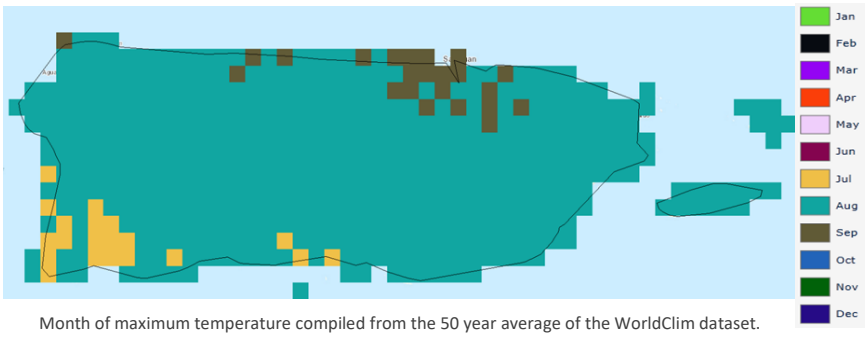
Boosted regression tree model of habitat suitability for *Ae. aegypti*, Puerto Rico. Kraemer et al. 2015



Boosted regression tree model of habitat suitability for *Ae. albopictus*, Puerto Rico. Kraemer et al. 2015



Month of maximum precipitation compiled from the 50 year average of the WorldClim dataset.



Month of maximum temperature compiled from the 50 year average of the WorldClim dataset.

For more detailed surveillance data and additional habitat suitability models, visit

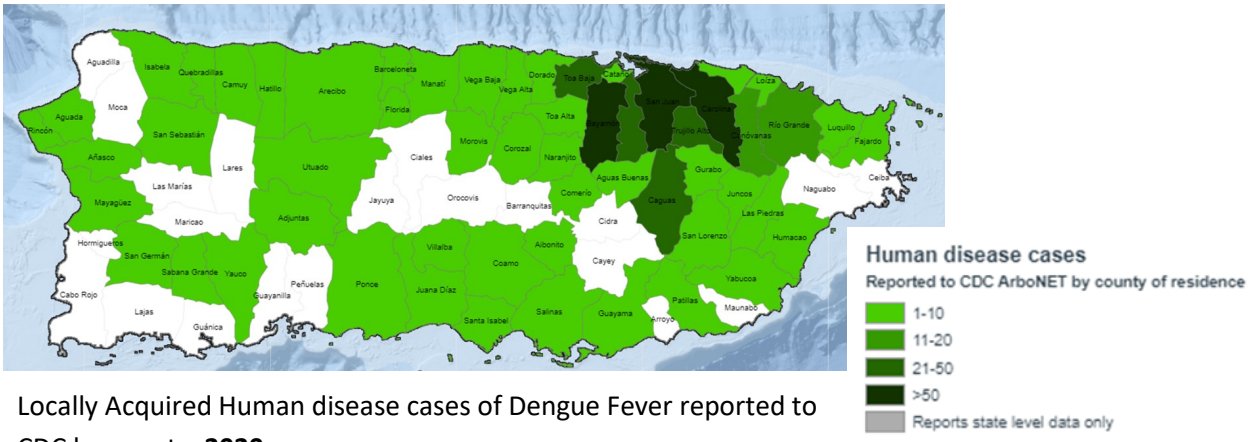
VectorMap.si.edu

Back to Table of Contents

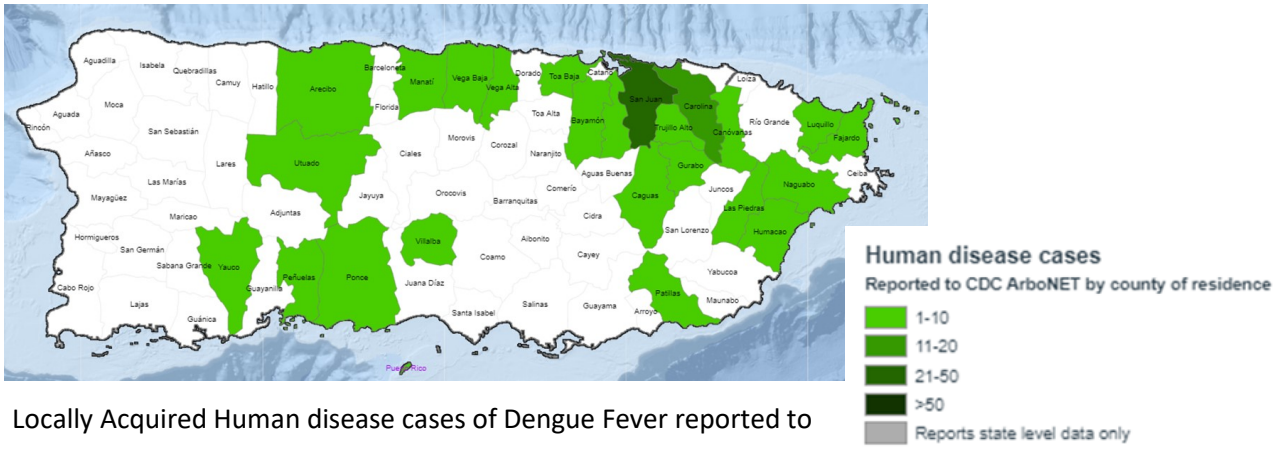
Dengue Virus Transmission Maps (CDC)

From CDC Disease Maps: [National & State Maps (including county-level data) from 2003 to present]

Locally Acquired Human disease cases of Dengue Fever reported to CDC by county, **2021** (last updated April 2021)



Locally Acquired Human disease cases of Dengue Fever reported to CDC by county, **2020**

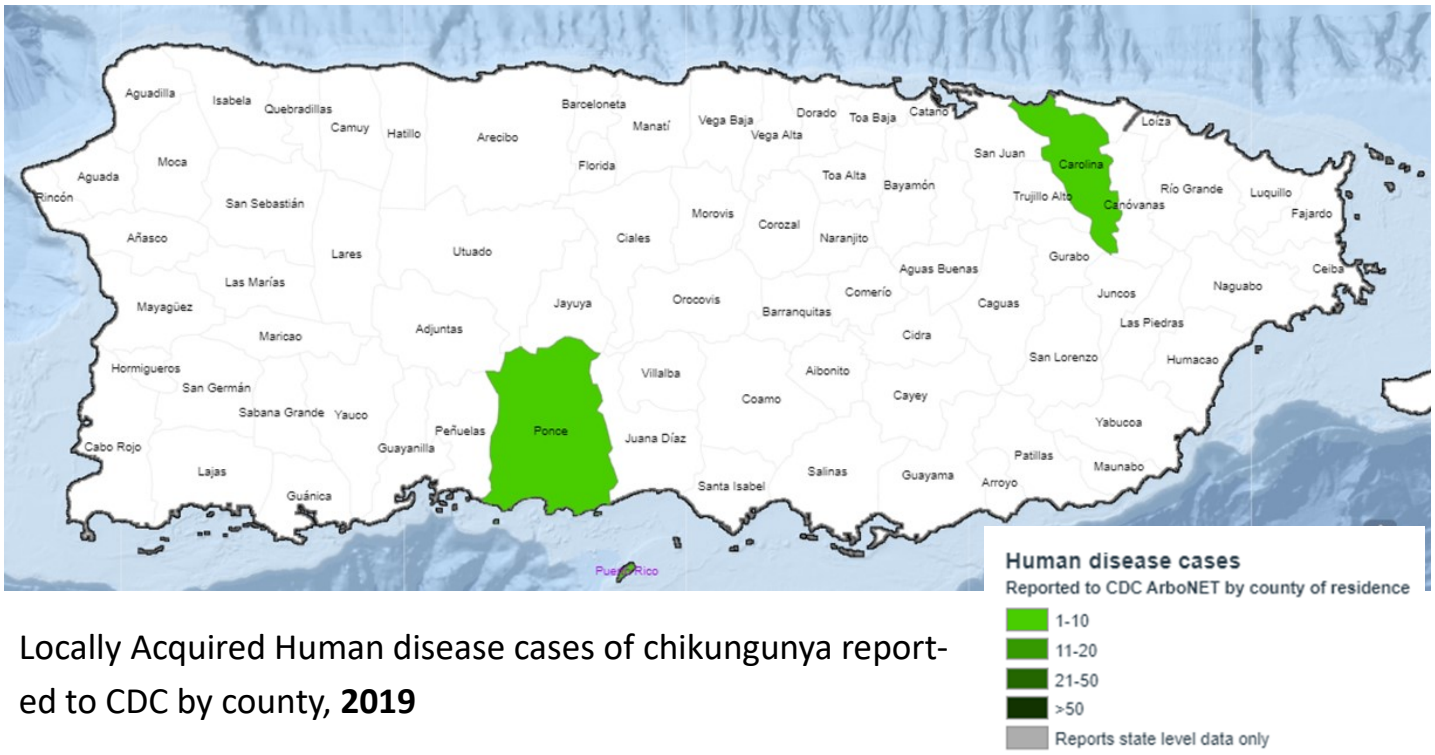


Locally Acquired Human disease cases of Dengue Fever reported to CDC by county, **2019**

[Back to Table of Contents]

Chikungunya Virus Transmission Map (CDC)

From CDC Disease Maps: [National & State Maps (including county-level data) from 2003 to present]

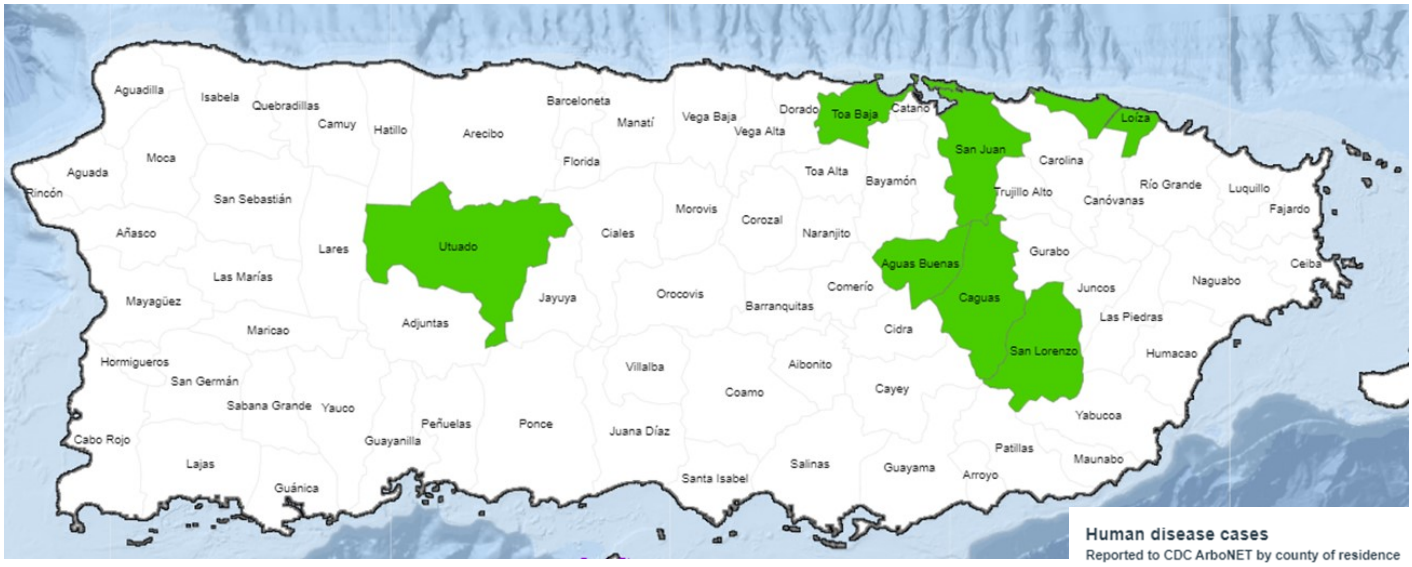


Locally Acquired Human disease cases of chikungunya reported to CDC by county, **2019**

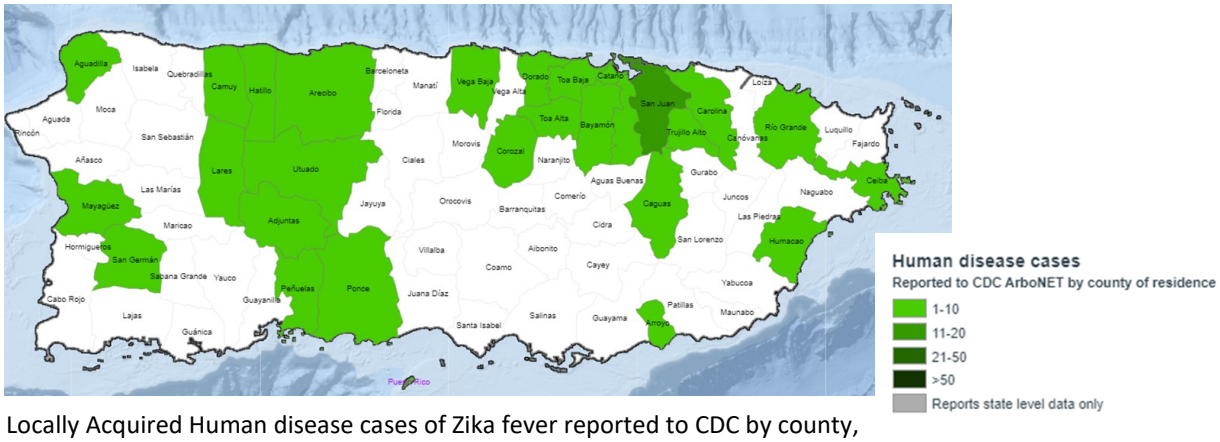
[Back to Table of Contents]

Zika Virus Transmission Map (CDC)

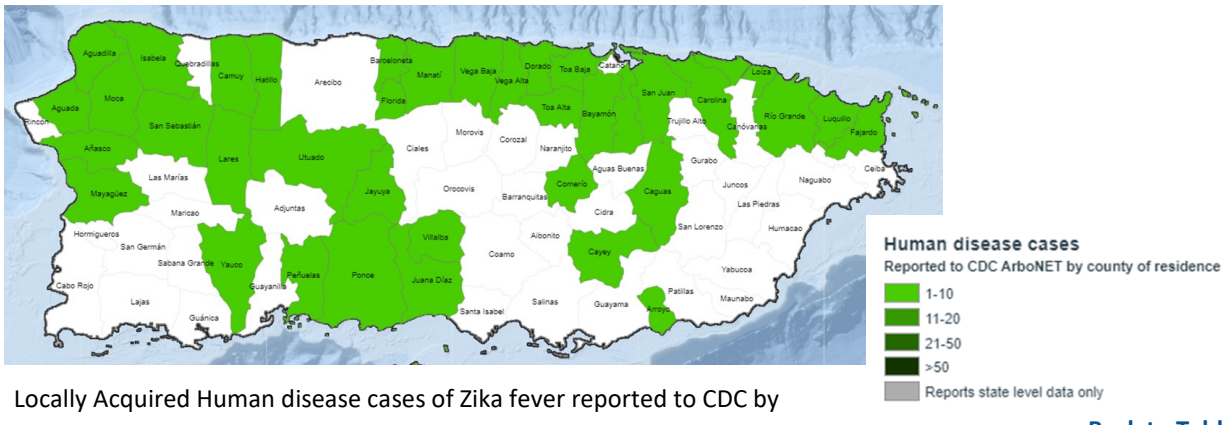
From CDC Disease Maps: [National & State Maps (including county-level data) from 2003 to present]



Locally Acquired Human disease cases of Zika fever reported to CDC by county, **2021** (last updated 21 Apr 2021)



Locally Acquired Human disease cases of Zika fever reported to CDC by county, **2020**



Locally Acquired Human disease cases of Zika fever reported to CDC by county, **2019**

Back to Table of Contents

Arboviruses associated with Aedes mosquitoes reported from Puerto Rico:

Virus	Abbreviation	Virus	Abbreviation
Apeu virus	APEUV	Melao virus	MELV
Banzi virus	BANV	Mucambo virus	MUCV
Barmah Forest virus	BFV	Murray Valley encephalitis virus	MVEV
Bunyamwera virus	BUNV	Murutucu virus	MURV
Bussuquara virus	BSQV	Nyando virus	NDOV
Bwamba virus	BWAV	O'nyong'nyong virus	ONNV
California encephalitis virus	CEV	Oriboca virus	ORIV
Caraparu virus	CARV	Oropouche virus	OROV
Catu virus	CATUV	Ossa virus	OSSAV
Chagres virus	CHGV	Restan virus	RESV
Chikungunya virus	CHIKV	Rift Valley Fever virus	RVFV
Cotia virus	COTV	Ross River virus	RRV
Calovo virus	CVOV	St. Louis encephalitis virus	SLEV
Dengue virus	DENV	Sepik virus	SEPV
Eastern equine encephalitis virus	EEEV	Semliki Forest virus	SFV
Everglades virus	EVEV	Shuni virus	SHUV
Ganjam virus	GANV	Sindbis virus	SINV
Germiston virus	GERV	Spondweni virus	SPOV
Guama virus	GAMV	Tahyna virus	TAHV
Guaroa virus	GROV	Tataguine virus	TATV
Ilesha virus	ILEV	Tensaw virus	TENV
Ilheus virus	ILHV	Venezuelan equine encephalitis virus	VEEV
Inkoo virus	INKV	Western equine encephalitis virus	WEEV
Itaqui virus	ITQV	West Nile virus	WNV
Japanese encephalitis virus	JBEV	Wesselsbron virus	WSLV
Kunjin virus	KUNV	Wyeomyia virus	WYOV
La Crosse virus	LACV	Wyeomyia virus	WYOV
Madrid virus	MADV	Yellow fever virus	YFV
Marituba virus	MTBV	Zika virus	ZIKAV
Mayaro virus	MAYV		

Back to Table of Contents

References

Agramonte, N. M., Bloomquist, J. R., & Bernier, U. R. (2017). Pyrethroid resistance alters the blood-feeding behavior in Puerto Rican *Aedes aegypti* mosquitoes exposed to treated fabric. *PLoS neglected tropical diseases*, *11*(9), e0005954. DOI: https://doi.org/10.1371/journal.pntd.0005954

Alarcón-Elbal, P. M., Rodríguez-Sosa, M. A., Newman, B. C., & Sutton, W. B. (2020). The First Record of *Aedes vittatus* (Diptera: Culicidae) in the Dominican Republic: Public Health Implications of a Potential Invasive Mosquito Species in the Americas. *Journal of Medical Entomology*, *57*(6), 2016-2021. DOI: https://doi.org/10.1093/jme/tjaa128

Barrera, R., Acevedo, V., & Amador, M. (2020). Role of Abandoned and Vacant Houses on *Aedes aegypti* Productivity. *The American Journal of Tropical Medicine and Hygiene*, 104(1), 145-150. DOI: https://doi.org/10.4269/ajtmh.20-0829

Barrera, R., Amador, M., & Clark, G. G. (2006). Ecological factors influencing *Aedes aegypti* (Diptera: Culicidae) productivity in artificial containers in Salinas, Puerto Rico. *Journal of Medical Entomology*, *43*(3), 484-492. DOI: https://doi.org/10.1093/jmedent/43.3.484

Barrera, R., Amador, M., & Clark, G. G. (2006). Use of the pupal survey technique for measuring *Aedes aegypti* (Diptera: Culicidae) productivity in Puerto Rico. *The American Journal of Tropical Medicine and Hygiene*, 74(2), 290-302. DOI: https://doi.org/10.4269/ajtmh.2006.74.290

Barrera, R., Amador, M., & MacKay, A. J. (2011). Population dynamics of *Aedes aegypti* and dengue as influenced by weather and human behavior in San Juan, Puerto Rico. *PLoS Neglected Tropical Diseases*, *5*(12), e1378. DOI: https://doi.org/10.1371/journal.pntd.0001378

Barrera, R., Amador, M., Ruiz-Valcárcel, J., & Acevedo, V. (2020). Factors Modulating Captures of Gravid *Aedes aegypti* Females. *Journal of the American Mosquito Control Association*, *36*(2), 66-73. DOI: https://doi.org/10.2987/20-6931.1

Barrera, R., Felix, G., Acevedo, V., Amador, M., Rodriguez, D., Rivera, L., ... & Hemme, R. R. (2019). Impacts of hurricanes Irma and Maria on *Aedes aegypti* populations, aquatic habitats, and mosquito infections with dengue, Chikungunya, and Zika viruses in Puerto Rico. *The American Journal of Tropical Medicine and Hygiene*, 100(6), 1413-1420. DOI: https://doi.org/10.4269/ajtmh.19-0015

Cheong, W. H. (1967). Preferred *Aedes aegypti* larval habitats in urban areas. *Bulletin of the World Health Organization*, *36* (4), 586.

Estep, A. S., Sanscrainte, N. D., Waits, C. M., Louton, J. E., & Becnel, J. J. (2017). Resistance status and resistance mechanisms in a strain of *Aedes aegypti* (Diptera: Culicidae) from Puerto Rico. *Journal of Medical Entomology*, 54(6), 1643-1648. DOI: https://doi.org/10.1093/jme/tjx143

Freier, J. E., & Rosen, L. (1988). Vertical transmission of dengue viruses by *Aedes mediovittatus*. *The American Journal of Tropical Medicine and Hygiene*. *39*(2), 218-222. DOI: https://doi.org/10.4269/ajtmh.1988.39.218

Gubler, D. J., Novak, R. J., Vergne, E., Colon, N. A., Velez, M., & Fowler, J. (1985). *Aedes* (*Gymnometopa*) *mediovittatus* (Diptera: Culicidae), a potential maintenance vector of dengue viruses in Puerto Rico. *Journal of Medical Entomology*, *22* (5), 469-475. DOI: https://doi.org/10.1093/jmedent/22.5.469

Kraemer, M. U., Sinka, M. E., Duda, K. A., Mylne, A. Q., Shearer, F. M., Barker, C. M., ... & Hay, S. I. (2015). The global distribution of the arbovirus vectors *Aedes aegypti* and *Ae*. *albopictus*. *elife*, *4*, e08347. DOI: https://doi.org/10.7554/eLife.08347

Little, E., Barrera, R., Seto, K. C., & Diuk-Wasser, M. (2011). Co-occurrence patterns of the dengue vector *Aedes aegypti* and *Aedes mediovitattus*, a dengue competent mosquito in Puerto Rico. *Ecohealth*, *8*(3), 365-375. DOI: https://doi.org/10.1007/s10393-011-0708-8

References

Lozano-Fuentes, S., Kenney, J. L., Varnado, W., Byrd, B. D., Burkhalter, K. L., & Savage, H. M. (2019). Susceptibility and vectorial capacity of American *Aedes albopictus* and *Aedes aegypti* (Diptera: Culicidae) to American Zika virus strains. *Journal of Medical Entomology*, *56*(1), 233-240. DOI: https://doi.org/10.1093/jme/tjy114

Lwande, O. W., Obanda, V., Lindström, A., Ahlm, C., Evander, M., Näslund, J., & Bucht, G. (2020). Globe-trotting *Aedes aegypti* and *Aedes albopictus*: risk factors for arbovirus pandemics. *Vector-Borne and Zoonotic Diseases*, *20*(2), 71-81. DOI: https://doi.org/10.1089/vbz.2019.2486

Pagac, B. B., Spring, A. R., Stawicki, J. R., Dinh, T. L., Lura, T., Kavanaugh, M. D., ... & Linton, Y. M. (2021). Incursion and establishment of the Old World arbovirus vector *Aedes* (*Fredwardsius*) *vittatus* (Bigot, 1861) in the Americas. *Acta Tropica*, *213*, 105739. DOI: https://doi.org/10.1016/j.actatropica.2020.105739

Poole-Smith, B. K., Hemme, R. R., Delorey, M., Felix, G., Gonzalez, A. L., Amador, M., ... & Barrera, R. (2015). Comparison of vector competence of *Aedes mediovittatus* and *Aedes aegypti* for dengue virus: implications for dengue control in the Caribbean. *PLoS Neglected Tropical Diseases*, 9(2), e0003462. DOI: https://doi.org/10.1371/journal.pntd.0003462

Scavo, N. A., Barrera, R., Reyes-Torres, L. J., & Yee, D. A. (2021). Lower socioeconomic status neighborhoods in Puerto Rico have more diverse mosquito communities and higher *Aedes aegypti* abundance. *Journal of Urban Ecology*, 7(1), juab009. DOI: https://doi.org/10.1093/jue/juab009

Scott, T. W., Amerasinghe, P. H., Morrison, A. C., Lorenz, L. H., Clark, G. G., Strickman, D., ... & Edman, J. D. (2000). Longitudinal studies of *Aedes aegypti* (Diptera: Culicidae) in Thailand and Puerto Rico: blood feeding frequency. *Journal of Medical Entomology*, *37*(1), 89-101. DOI: https://doi.org/10.1603/0022-2585-37.1.89

Sharp, T. M., Hunsperger, E., Santiago, G. A., Muñoz-Jordan, J. L., Santiago, L. M., Rivera, A., ... & Tomashek, K. M. (2013). Virus-specific differences in rates of disease during the 2010 Dengue epidemic in Puerto Rico. *PLoS Neglected Tropical Diseases*, *7*(4), e2159. DOI: https://doi.org/10.1371/journal.pntd.0002159

Sharp, T. M., Roth, N. M., Torres, J., Ryff, K. R., Rodríguez, N. M. P., Mercado, C., ... & García, B. R. (2014). Chikungunya cases identified through passive surveillance and household investigations—Puerto Rico, May 5–August 12, 2014. *MMWR. Morbidity and Mortality Weekly Report*, *63*(48), 1121. Link: https://pubmed.ncbi.nlm.nih.gov/25474032/?dopt=Abstract

Smartt, C. T., Shin, D., & Alto, B. W. (2017). Dengue serotype-specific immune response in *Aedes aegypti* and *Aedes albopictus*. *Memórias do Instituto Oswaldo Cruz*, *112*(12), 829-837. DOI: https://doi.org/10.1590/0074-02760170182

Sudeep, A. B., & Shil, P. (2017). *Aedes vittatus* (Bigot) mosquito: An emerging threat to public health. *Journal of Vector Borne Diseases*, *54*(4), 295. DOI: https://doi.org/10.4103/0972-9062.225833

Zimler, R. A., Yee, D. A., & Alto, B. W. (2021). Transmission Potential of Zika Virus by *Aedes aegypti* (Diptera: Culicidae) and *Ae*. *mediovittatus* (Diptera: Culicidae) Populations From Puerto Rico. *Journal of Medical Entomology*. DOI: https://doi.org/10.1093/jme/tjaa286