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Update on the Dispersal of *Aedes albopictus* in Mexico: 1988–2021

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The Asian tiger mosquito *Aedes albopictus* (Skuse) is one of the most important mosquito species in public health due to the variety of disease-causing viruses that this species can transmit. In Mexico, *Ae. albopictus* was reported for the first time in 1990 in the state of Tamaulipas, bordering to the state of Texas (USA). Since then, *Ae. albopictus* has been reported in 15 Mexican states. Currently, this species is present in all tropical and subtropical regions of the country and its presence is common in the states of the Gulf of Mexico and Chiapas. In the present study, the presence of *Ae. albopictus* is reported in six additional states: Colima, Guanajuato, Jalisco, Puebla, Oaxaca, and Querétaro. The rapid dispersal of *Ae. albopictus* in Mexico represents a risk to public health, and the surveillance of this species in regions where it has not yet been reported is essential as part of Mexican entomological surveillance programs.

Keywords: ***Aedes albopictus*, distribution, update, Mexico, new records**

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INTRODUCTION

The Asian tiger mosquito *Aedes albopictus* (Skuse) is a threat to human health because it is a vector of virus-causing diseases such as dengue, chikungunya, and Zika and a potential vector of more than 20 other pathogens (1). In Mexico, *Ae. albopictus* has been found naturally infected with the virus of dengue (2), Zika (3), chikungunya (4), and the dog heartworm *Dirofilaria immitis* (Leidy) (5). The presence of *Ae. albopictus* in Mexico was first detected during a mosquito survey conducted in March 1988, where immature stages of this species were collected from a discarded tire in Matamoros, Tamaulipas, bordering with Texas state (6). In September 1993, during a mosquito survey conducted in Coahuila state, immature stages of *Ae. albopictus* from different artificial containers were collected on the bordering cities of Ciudad Acuña and Piedras Negras (7). In 1997, immature stages of *Ae. albopictus* were collected from artificial containers in Allende city, Nuevo Leon state, confirming the spreading and establishment of this species in northeastern Mexico (8). In the same year, during a mosquito survey in eight localities of Veracruz state, *Ae. albopictus* was collected from ovitraps displayed in Veracruz, this state being the first tropical state located in the Gulf of Mexico where the species was detected (9). On September 2002, females of *Ae. albopictus* were collected biting humans and immature stages were collected from a variety of artificial containers in Chiapas, bordering with Guatemala, with Chiapas being the first tropical state located on the Pacific coast where *Ae. albopictus* was detected (10). On July and October 2009, immature stages of *Ae. albopictus* were collected from a variety of artificial containers in Morelos state, being

the first inland state where the species was collected (11). On September 2011, immature stages of *Ae. albopictus* were collected from flower vases in a cemetery of Cancun, Quintana Roo, which was the first state within the Yucatan Peninsula where *Ae. albopictus* was collected (12). In April 2012, *Ae. albopictus* was collected in Chapulhuacan, Hidalgo state. One year later, immature stages of this species were collected in the counties of Huahutla and Jaltocan, and the presence of *Ae. albopictus* was confirmed in Hidalgo (13). In November 2012 and September–October 2013, during mosquito surveys in tropical areas of San Luis Potosi state, immature stages of *Ae. albopictus* were collected from a variety of artificial and natural containers in diverse locations around Aquismon county (14). In January 2014, *Ae. albopictus* was collected from ovitraps in Culiacán, Sinaloa. Some larvae were reared to adults and the ribosomal second internal transcribed spacer (ITS2) was amplified by polymerase chain reaction (PCR) for identity confirmation (15). In July and October 2015, immature stages of *Ae. albopictus* were collected from several kinds of artificial and natural containers in Tabasco state, while adult females were collected while they were approaching to humans in October and November 2016 (16). In June 2017, ovitraps were placed in tropical areas of Tizimin, Yucatan, and adult mosquitoes were collected in the same area using BioDiVector (BDV) tent traps. Specimens collected from ovitraps and the BDV tent trap included *Ae. albopictus* (16). In September 2017, immature stages were collected from discarded tires and flower vases in Malinalco, Mexico state, and six larvae of *Ae. albopictus* were identified from these collections (17). In 2018, ovitraps were placed in Mexico City and collected eggs were placed in larval trays for rearing to adults and a single adult female of *Ae. albopictus* was detected (18). The presence of *Ae. albopictus* in Mexico City was confirmed by Dávalos-Becerril etal. (19). In November 2018, mosquitoes were collected using backpack aspirators in Ometepec and Tecoanapa counties in Guerrero state. Collected mosquitoes were transported to the Entomological and Bioassay Research Unit of Guerrero and the presence of *Ae. albopictus* was detected (20). From January 2019 to February 2020, ovitraps were placed in Campeche state. A total of 226 larvae from ovitraps placed in Campeche, Escárcega, Hecelchakán, Tenabo, and Calkini counties were positive for *Ae. albopictus* (21). With the intention of knowing the current distribution of *Ae. albopictus* in Mexico, the published historical mosquito Mexican records available in the literature deposited in the library of the Institute of Epidemiological Diagnosis and Reference (INDRE) were reviewed, as well as the records of recent collections from the INDRE were examined.

MATERIALS AND METHODS

Mosquito surveys were conducted in Mexico by personnel from the National Center for Preventive and Disease Control (CENAPRECE) from each state according to national regulation laws for vector-borne diseases control (22), which includes a national program (for all states) for mosquito collection, which is a continuous program but subject to regulatory changes; for this reason, collections are constant but irregular. Immature and adult stages of mosquitoes were collected according to the continuous and irregular mosquito collection national program during both dry and rainy seasons in diverse counties and regions of the states where the presence of *Ae. albopictus* had not been detected, which were as follows: Aguascalientes, Baja California, Baja California Sur, Chihuahua, Colima, Durango, Guanajuato, Jalisco, Michoacán, Nayarit, Oaxaca, Puebla, Querétaro, Sonora, Tlaxcala, and Zacatecas. Immature stages were collected from any water body where mosquito larvae were detected during surveys. Larval habitats were classified as artificial containers (discarded tires, flower vases, plastic buckets) and natural habitats (tree holes, rock holes, bromeliad axils, bamboo internodes). A portion of immature specimens were preserved alive in plastic cups with the same water from the original habitat and labeled, while the rest were killed with hot water (80°C) and preserved in ethanol (96%). Adult mosquitoes were collected using the Centers for Disease Control (CDC) light traps, aspirated intra- and peri-domiciliary in houses using mechanical aspirators, and approaching to the collector personnel with biting intention, mosquitoes were killed using lethal chambers, preserved in glass vials, and labeled. All the collected specimens were sent to the INDRE laboratory for rearing (in case of alive larvae), mounting, and identification. Immature stages were mounted in microscope slides using euparal as mounting medium, while adult mosquitoes were mounted using insect pins. All specimens were deposited in the "Collection of Arthropods of Medical Importance" (CAIM). The work of Darsie and Ward (23)—"Identification and geographical distribution of the mosquitoes of North America, North of Mexico"—was used as basis for the identification. Historical and recent collection records of the presence of *Ae. albopictus* in Mexico were consulted to determine the known distribution of this species. The reports where *Ae. albopictus* were detected for the first time in each state are mentioned in the section of references.

RESULTS

The presence of *Ae. albopictus* was detected in 34 counties of the six states sampled (**Figure 1**): Colima, Guanajuato, Jalisco, Querétaro, Oaxaca, and Puebla (**Table 1**). In Puebla, *Ae. albopictus* was collected in eight counties (Acateno, Tenampulco, Izucar de Matamoros, Cuetzalan, Venustiano Carranza, Jolalpan, Chicontla, and San Jose Acateno); in Querétaro, the species was collected in six counties (Cadereyta, Arroyo Seco, Pinal de Amoles, Landa de Matamoros, Jalpan de Serra, and Peñamiller); in Oaxaca, in 14 counties (Cosolapa, Loma Bonita, San Juan Cotzocon, Matías Romero, San Juan Guichicovi, San Juan Mazatlán, Barrio de la Soledad, Juchitan de Zaragoza, San Pedro Teutila, San Juan Bautista Tlacoatzintepec, San Andrés Teotilapam, Santa María Petapa, Santa María Colotepec, and San Carlos Yautepec); in Guanajuato, five

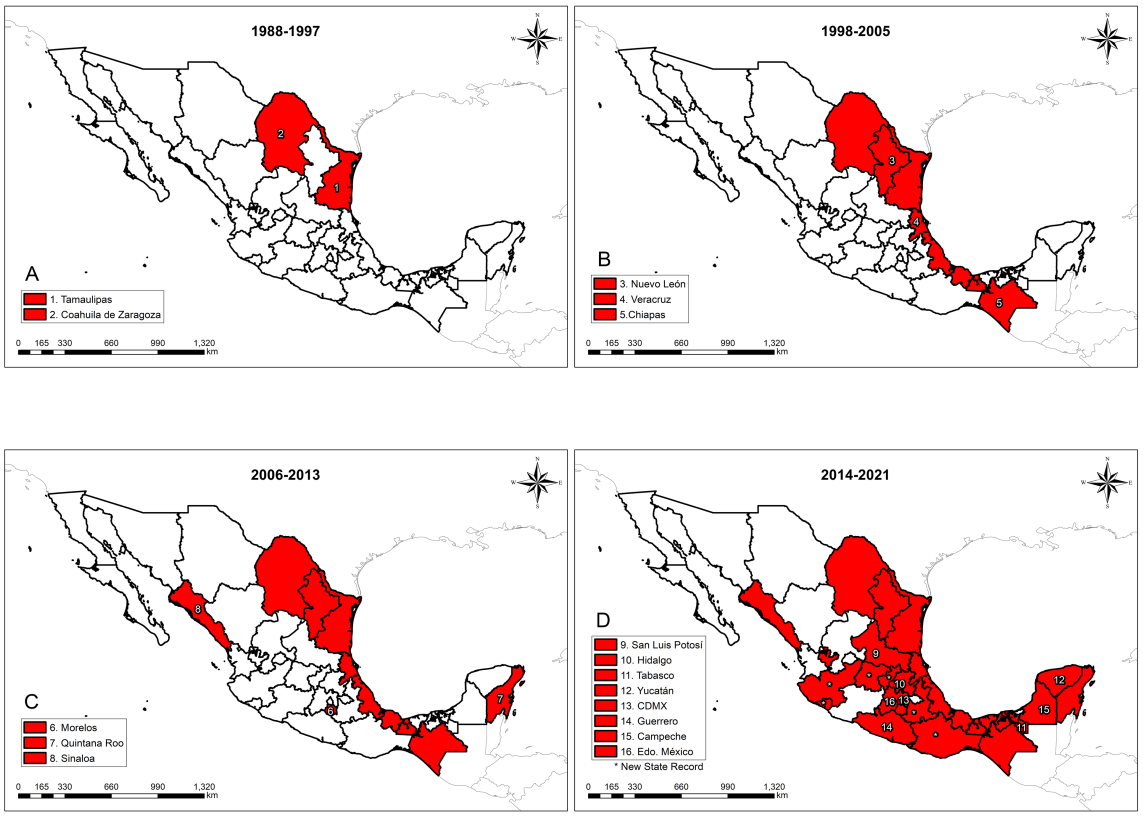

FIGURE 1 | Dispersal of *Aedes albopictus* in Mexico. **(A)** Tamaulipas and Coahuila; **(B)** Nuevo Leon, Veracruz, and Chiapas; **(C)** Morelos, Quintana Roo, and Sinaloa; **(D)** San Luis Potosi, Hidalgo, Tabasco, Yucatan, Mexico City, Guerrero, Campeche, Mexico State. New records: Puebla, Querétaro, Oaxaca, Guanajuato, Colima, and Jalisco.

counties were positive for *Ae. albopictus* (Atarjea, Xichú, Victoria, Allende, Santa Catarina), while in Colima and Jalisco, the species was collected in one single county, respectively (Manzanillo and Tonalá) (**Figure 2**). The most common habitat for immature stages of *Ae. albopictus* in the states where the species was collected was artificial containers, which included discarded tires, plastic containers, flower vases, and water tanks ($n = 30$), while in natural containers such as bamboo internodes, tree holes, and coconut shells, the number of species was fewer ($n = 4$).

DISCUSSION

The Asian tiger mosquito *Ae. albopictus* was originally described by Skuse in 1894 from three adult females collected in Calcutta, India (24). Originally, this species was mainly distributed in the Oriental Region, Oceania, Japan, and China (25). In August 1985, *Ae. albopictus* was first detected in the New World in Houston, Texas (USA) by personnel from the Harris County Mosquito Control District (26), and this was the beginning of a rapid dispersal in many regions of the world. Currently, *Ae. albopictus* is present in all continents except Antarctica (27), and this species encompasses 21 countries of the Americas (28), including bordering countries in the southern of Mexico: Belize (29) and Guatemala (30). In Mexico, the spread of *Ae. albopictus* has been accelerated throughout the country. Since *Ae. albopictus* was found for the first time in Mexico, the species has had a rapid dispersal throughout the country. Currently, the species occurs in 22 states: Campeche, Chiapas, Coahuila, Colima, Guanajuato, Guerrero, Hidalgo, Jalisco, Mexico City, Mexico State, Morelos, Nuevo Leon, Oaxaca, Puebla, Querétaro, Quintana Roo, San Luis Potosi, Sinaloa, Tabasco, Tamaulipas, Yucatan, and Veracruz, with Colima, Guanajuato, Jalisco, Oaxaca, Puebla, and Querétaro being the new state records for Mexico. The Mexican states where *Ae. albopictus* remains absent are Aguascalientes, Chihuahua, Baja California, Baja California Sur, Durango, Michoacán, Nayarit, Sonora, Tlaxcala, and Zacatecas (**Figure 1**). *Aedes albopictus* invaded Mexico through the international border with the USA from the recently established populations in Texas, and the species quickly established in the humid and subtropical regions of northeastern Mexico (Tamaulipas, Nuevo Leon, and Coahuila) (6). Although most of northeastern Mexico includes typically arid and semiarid regions, the species found favorable environmental conditions for its establishment such as tropical–subtropical humid climate, abundant vegetation in perennial

TABLE 1 | New mosquito records of the occurrence of *Aedes albopictus* in Mexico.

State	County	Coordinate, elevation (m.a.s.l.)	Date of collection	Habitat
Puebla	Acateno	20°7′49″N–97°12′43″W, 140	03/29/2010	Artificial container
Puebla	Tenampulco	20°10′11″N–97°24′26″W, 210	03/29/2010	Bamboo internode
Puebla	Izucar de Matamoros	18°35′59″N–98°28′56″W, 1,265	02/23/2016	Artificial container
Puebla	Cuetzalan	20°0′45″N–97°31′13″W, 1,032	03/23/2016	Discarded tire
Puebla	Venustiano Carranza	20°30′18″N–97°39′58″W, 132	04/21/2016	Artificial container
Puebla	Jolalpan	18°19′15″N–98°50′49″W, 855	04/21/2016	Artificial container
Puebla	Chicontla	20°14′36″N–97°49′55″W, 320	04/21/2016	Flower vase
Puebla	San Jose Acateno	20°7′48″N–97°12′32″W, 143	04/21/2016	Artificial container
Querétaro	Cadereyta	20°54′56″N–99°46′1″W, 1,560	02/28/2011	Artificial container
Querétaro	Arroyo Seco	21°30′19″N–99°43′56″W, 620	11/29/2011	Artificial container
Querétaro	Pinal de Amoles	21°9′3″N–99°13′41″W, 1,100	08/21/2012	Artificial container
Querétaro	Landa de Matamoros	21°16′8″N–99°14′49″W, 1,140	08/30/2012	Artificial container
Querétaro	Jalpan de Serra	21°12′28″N–99°28′20″W, 758	01/18/2012	Artificial container
Querétaro	Peñamiller	21°3′22″N–99°48′13″W, 1,324	12/27/2016	Artificial container
Oaxaca	Cosoloapa	18°36′0″N–96°39′42″W, 190	11/07/2011	Discarded tire
Oaxaca	Loma Bonita	18°7′15″N–95°58′30″W, 20	11/07/2011	Tree hole
Oaxaca	San Juan Cotzocon	17°26′34″N–95°19′45″W, 80	05/02/2012	Bamboo internode
Oaxaca	Matías Romero	17°13′33″N–95°3′10″W, 80	05/02/2012	Flower vase
Oaxaca	San Juan Guichicovi	16°59′35″N–95°2′14″W, 80	05/31/2012	Flower vase
Oaxaca	San Juan Mazatlán	17°20′33″N–95°19′7″W, 50	06/27/2012	Flower vase
Oaxaca	Barrio de la Soledad	16°48′4″N–95°6′3″W, 264	06/21/2012	Plastic bucket
Oaxaca	Juchitán de Zaragoza	16°27′35″N–95°0′8″W, 26	11/07/2012	Metal can
Oaxaca	San Pedro Teutila	17°58′25″N–96°42′10″W, 1,158	12/03/2012	Coconut shell
Oaxaca	San Juan Bautista Tlacoatzintepec	17°51′36″N–96°35′2″W, 558	12/03/2012	Artificial container
Oaxaca	San Andrés Teotilapam	17°57′15″N–96°39′23″W, 1,522	03/12/2014	Water tank
Oaxaca	Santa María Petapa	16°49′16″N–95°7′13″W, 246	06/05/2014	Animal drink tank
Oaxaca	Santa María Colotepec	15°53′53″N–96°56′13″W, 54	10/06/2014	Animal drink tank
Oaxaca	San Carlos Yautepec	16°29′43″N–96°6′24″W, 884	01/09/2015	Discarded tire
Guanajuato	Atarjea	21°16′5″N–99°43′6″W, 1,230	09/30/2014	Water tank
Guanajuato	Xichú	21°17′52″N–100°3′23″W, 1,338	10/28/2014	Artificial container
Guanjuato	Victoria	21°12′49″N–100°12′49″W, 1,750	07/01/2015	Artificial container
Guanajuato	Allende	20°53′56″N–100°45′55″W, 1,901	07/29/2015	Artificial container
Guanjuato	Santa Catarina	21°8′26″N–100°4′2″W, 1,587	06/05/2018	Water tank
Colima	Manzanillo	19°7′47″N–104°21′15″W, 0	10/24/2017	Flower vase
Jalisco	Tonalá	20°39′23″N–103°16′1″W, 1,555	06/15/2014	Discarded tire

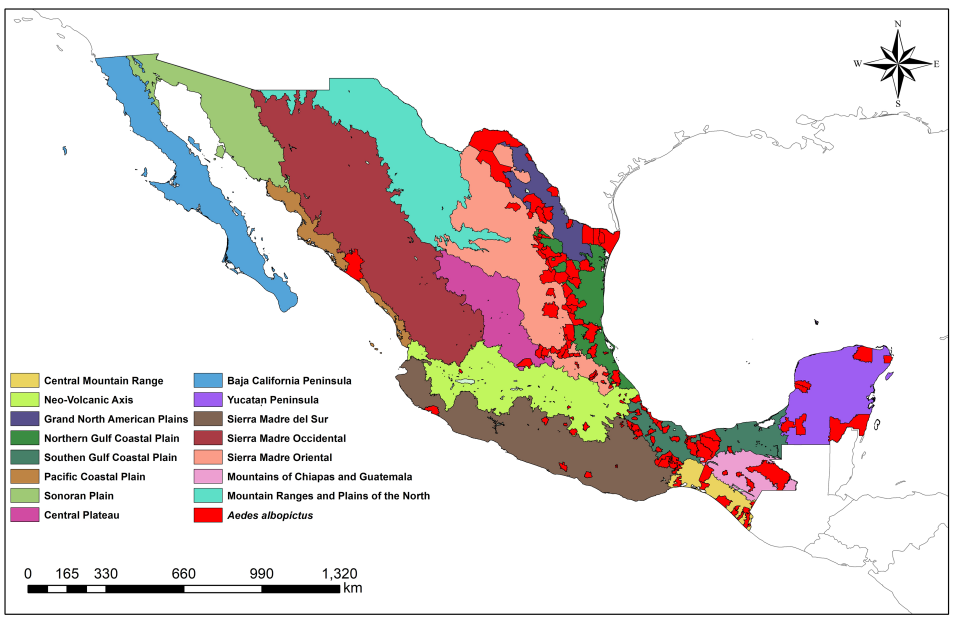

FIGURE 2 | Distribution of *Aedes albopictus* by physiographic region in Mexico.

forests, and constant rainfall derived from tropical storms originating in the Gulf of Mexico. The most important regions where the species spread to the southeastern were the mountain system of the Sierra Madre Oriental (to the east) and the Northern Gulf Coastal Plain; through these regions, *Ae. albopictus* reached new regions at the tropical–southern such as the Southern Gulf Coastal Plain (Veracruz, Hidalgo, Querétaro, San Luis Potosi, Puebla, and Tabasco) and, a few years later, the Yucatan Peninsula (Campeche, Yucatan, and Quintana Roo). However, arid and semiarid regions of the northeastern and middle of the country were partially invaded given the adverse environmental conditions for the establishment of the species such as dry climate and presence of mountain systems with high elevations. These regions include the Grand North America Plains, the Neo-Volcanic Axis, and the Central Plateau (Morelos, Mexico City, Mexico State, and Guanajuato); for this reason, the *Ae. albopictus* populations are fewer than in other regions and the species is not well established in these states and regions (**Figure 2**). Nevertheless, it is well known that *Ae. albopictus* is capable of dispersing through human activities (31, 32). Immature stages (eggs, larvae, and pupae) of *Ae. albopictus* can be transported from one region to another in rainwater accumulated in used tires, which apparently are the primary breeding site in North America and the most likely means of its introduction to the United States (33). The spread of *Ae. albopictus* has been linked to global shipping routes and road networks, but much remains unknown about the human role in the dispersal mechanism. However, this species can be commonly transported also by cars and other motor vehicles (1). After 10 years of the first detection in Tamaulipas, *Ae. albopictus* had a natural dispersion throughout conserved regions between northern Coahuila, Nuevo Leon, and Tamaulipas, reaching the northern–middle area of Veracruz, where the species had its southernmost distributional rank. The early detection of *Ae. albopictus* in Tapachula, Chiapas, in 2002 was surprising because the environmental conditions between Tamaulipas and Veracruz favored the rapid expansion of the species; however, between the Southern Gulf Coastal Plain in Veracruz state and the Central Mountain Range, in southern Chiapas, there is a mountain system with high elevation that includes temperate mountain ranges where the natural dispersal of *Ae. albopictus* would be much slower. It is possible that the presence of *Ae. albopictus* in the coastal region of Chiapas was due to a second invasion of the species in Mexico, probably from Guatemala or eggs and/or larvae dispersing in discarded tires or flower vases from northern Mexico, where the species was already established. From coastal Chiapas, *Ae. albopictus* spread through the Central Mountain Range and the Sierra Madre del Sur reaching states in the Pacific coast such as Oaxaca and Guerrero, where the species was recently detected whose presence was still sporadic with low populations. There are two possible natural routes of dispersion of the species to the western limit of the Neo-Volcanic Axis in the states of Jalisco and Colima: a) well-established populations of *Ae. albopictus* from the Central Mountain Range that spreads into the Sierra Madre del Sur throughout the conserved areas near the Pacific Coast; if this is true, the species currently occurs in the forest and/or coastal areas of Michoacán; and b) not well-established populations of the species that spreads from the Sierra Madre Oriental throughout the Neo-Volcanic Axis. This hypothesis is less likely because the presence in the volcano and mountain system includes temperate forest with elevations that exceed the 1,000 m above the sea level, where the dispersal of *Ae. albopictus* would be much slower. Currently, *Ae. albopictus* occurs in 11 of the 15 physiographical regions of Mexico (34) in both the Nearctic and the Neotropical biogeographical zones. In the Nearctic zone, the species occurs in the Central Plateau, Grand North America Plains, Neo-Volcanic Axis, Northern Gulf Coastal Plain, Pacific Coastal Plain, and Sierra Madre Oriental, while in the Neotropical zone, *Ae. albopictus* occurs in the Central Mountain Range, Sierra Madre del Sur, Mountains of Chiapas and Guatemala, Southern Gulf Coastal Plain, and the Yucatan Peninsula. Nearctic zones where the species has not been recorded are the Baja California Peninsula, Mountain Ranges and Plains of the North, Sierra Madre Occidental, and the Sonoran Plain (**Figure 2**). Because of its medical importance, the surveillance of *Ae. albopictus* is recommended in other regions of Mexico, especially in regions where the species has not been collected.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

AUTHOR CONTRIBUTIONS

AO-M and HH-J: contribution to the study conception and design and analysis of data. CP-R, JO-A and JAS: material preparation and morphological identification of specimens. FD-M and FC-M: funding acquisition. AO-M, CP-R, JO-A, JAS, FD-M, FC-M, and HH-J: drafting the manuscript or revising it critically for important intellectual content. All authors contributed to the article and approved the submitted version.

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REFERENCES

1. Ertija R, Palmer JRB, Roiz D, Sanpera–Calbet I, Bartumeus F. Direct Evidence of Adult *Aedes Albopictus* Dispersal by Car. *Sci Rep* (2017) 7:14399. doi: 10.1038/s41598-017-12652-5
2. Ibáñez-Bernal S, Briseño B, Mutebi JP, Argot E, Rodríguez G, Martínez–Campos C, et al. First Record in America of *Aedes Albopictus* Naturally Infected With Dengue Virus During the 1995 Outbreak at Reynosa, Mexico. *Med Vet Entomol* (1997) 11(4):305–9. doi: 10.11/j.1365–2915.1997.tb00413.x
3. Huerta H, González–Roldán JF, Sánchez–Tejeda G, Correa–Morales F, Romero–Contreras FE, Cárdenas–Flores R, et al. Detection of Zika Virus in *Aedes Albopictus* From Mexico. *Trans R Soc* (2017) 111(7):238–331. doi: 10.1093/trstmh/trx056
4. Correa–Morales F, González–Acosta C, Mejía–Zúñiga D, Huerta H, Pérez–Rentería C, Vazquez–Pichardo M, et al. Surveillance for Zika in Mexico: Naturally Infected Mosquitoes in Urban and Semi-Urban Areas. *Pathog Glob Health* (2019) 113(600):1–6. doi: 10.1080/20477724.2019.1706291
5. Alvarado–Torres H, Viveros–Santos V, Torres–Monzón JA, López–Ordóñez T, Torres–Chablé OM, Casas–Martínez M. Detección De *Dirofilaria Immitis* (Spirurida: Onchocercidae) En La Comunidad De Mosquitos (Diptera: Culicidae) De Cementerios De La Region Soconusco, Sur De México. *Entomol Mex* (2019) 6:490–6.
6. Francy DB, Moore CG, Eliason DA. Past, Present and Future of *Aedes Albopictus* in the United States. *J Am Mosq Control Assoc* (1990) 6:127–32.
7. Ibáñez–Bernal S, Martínez–Campos C. *Aedes Albopictus* in Mexico. *J Am Mosq Control Assoc* (1994) 10(2):231–2.
8. Orta–Pesina H, Mercado–Hernández R, Valdez–Rodríguez MA. *Aedes Albopictus* in Allende City, Nuevo Leon, Mexico. *J Am Mosq Control Assoc* (2001) 17(4):260–1.
9. Flisser A, Velasco–Villa A, Martínez–Campos C, González–Domínguez F, Briseño–García B, García–Suarez R, et al. Infectius Diseases in Mexico. A Survey From 1995–2000. *Arch Med Res* (2002) 33:343–50. doi: 10.1016/S0188-4409(02)00381-8
10. Casas–Martínez M, Torres–Estrada JL. First Evidence of *Aedes Albopictus* (Skuse) in Southern Chiapas, Mexico. *Emerg Infect Dis* (2003) 9:606–7. doi: 10.3201/eid0905.020678
11. Villegas–Trejo A, Manrique–Saide P, Che–Mendoza A, Cruz–Canto W, González–Fernández M, González–Acosta C, et al. First Report of *Aedes Albopictus* and Other Mosquito Species in Morelos, Mexico. *J Am Mosq Control Assoc* (2010) 26(3):321–3. doi: 10.2987/10-6014.1
12. Salomón–Grajales J, Lugo–Moguel GV, Tinal–Gordillo VR, de la Cruz–Velázquez J, Beaty BJ, Eisen L, et al. *Aedes Albopictus* Mosquitoes, Yucatan Peninsula, Mexico. *Emerg Infect Dis* (2012) 18(3):525–7. doi: 10.3201/eid1803.111626
13. Ortega–Morales AI, Cueto–Medina SM, Siller–Rodríguez QK. First Record of the Asian Tiger Mosquito *Aedes Albopictus* in Hidalgo State, Mexico. *J Am Mosq Control Assoc* (2016) 32(3):234–6. doi: 10.2987/16-6576.1
14. Ortega–Morales AI, Siller–Rodríguez QK. First Record of *Aedes Albopictus* (Diptera: Culicidae) in San Luis Potosi, Mexico. *J Vector Ecol* (2016) 41 (2):314–5. doi: 10.1111/jvec.12229
15. Torres–Avendaño JI, Castillo–Ureta H, Torres–Montoya EH, Meza–Carrillo E, Lopez–Mendoza RL, Vazquez–Martinez MG, et al. First Record of *Aedes Albopictus* in Sinaloa, Mexico. *J Am Mosq Control Assoc* (2015) 31(2):164–6. doi: 10.2987/14-6461R
16. Ortega–Morales AI, Bond G, Méndez–López R, Garza–Hernández JA, Hernández–Triana LM, Casas–Martínez M. First Record of Invasive Mosquito *Aedes Albopictus* in Tabasco and Yucatan, Mexico. *J Am Mosq Control Assoc* (2018) 34(2):120–3. doi: 10.2987/18-6736.1
17. Adeniran AA, Hernández–Triana LM, Ortega–Morales AI, Garza–Hernández JA, de la Cruz–Ramos J, Chan–Chable RJ, et al. Identification of Mosquitoes (Diptera: Culicidae) From Mexico State, Mexico Using Morphology and *COI* DNA Barcoding. *Acta Trop* (2021) 213:1–16. doi: 10.1016/j.actatropica.2020.105730
18. Ortega–Morales AI, Moreno–García M, González–Acosta C, Correa–Morales F. Mosquito Surveillance in Mexico: The Use of Ovitraps for *Aedes Aegypti*, *Ae. Albopictus*, and non–Target Species. *Fla Entomol* (2018) 101(4):623–6.
19. Dávalos–Becerril E, Correa–Morales F, González–Acosta C, Santos–Luna R, Peralta–Rodríguez J, Pérez–Rentería C, et al. Urban and Semi–Urban Mosquitoes of Mexico City: A Risk for Endemic Mosquito–Borne Disease Transmission. *PloS One* (2019) 14(3):1–19. doi: 10.1371/journal.pone.0212987
20. González–Acosta C, Correa–Morales F, Canche–Aguilar I, Silva–Domíbguez R, Salgado–Alonzo MC, Muñóz–Urias R, et al. First Report of *Aedes Albopictus* in Guerreo State, Mexico. *J Am Mosq Control Assoc* (2019) 35 (4):285–7. doi: 10.2987/19-6829.1
21. Hernández–Rodríguez JL, Pérez–Pacheco R, Vásquez–López A, Mejenes–Hernández MC, Granados–Echegoyen CA, Arcos–Cordova IR, et al. Asian Tiger Mosquito in Yucatan Peninsula: First Record of *Aedes* (*Stegomyia*) *Albopictus* (Diptera: Culicidae) in Campeche, Mexico. *J Med Entomol* (2020) 20:1–3. doi: 10.1093/jme/tjaa133
22. SEGOB. Secretaría de Gobernación. *Norma Oficial Mexicana NOM–032–SSA2–2014 Para La Vigilancia Epidemiológica, Promoción, Prevención Y Control De Las Enfermedades Transmitidas Por Vectores*. Mexico: Diario Oficial de la Federación (2015).
23. Darsie RF, Ward RF. *Identification and Geographical Distribution of the Mosquitoes of North America, North of Mexico*. Gainesville, Florida: University Press of Florida (2005).
24. Skuse FA. The Banded Mosquito of Bengal. *Indian Mus Notes* (1895) 3(5):20.
25. Becker N, Petric D, Zgomba M, Boase C, Dahl C, Madon M, et al. *Mosquitoes and Their Control. 2nd ed*. Heidelberg, Germany: Springer (2010).
26. Sprenger D, Wuithiranyagool T. The Discovery of *Aedes Albopictus* in Harris County, Texas. *J Am Mosq Control Assoc* (1986) 2:217–9.
27. Kreamer MUG, Sinka ME, Duda KA, Mylne A, Shearer FM, Brady OJ, et al. The Global Compendium of *Aedes Aegypti* and *Ae. Albopictus* Occurrence. *Sci Data* (2015) 2:1–8. doi: 10.1038/sdata.2015.35
28. García–Rejon JE, Navarro JC, Cigarroa–Toledo N, Baak–Baak CM. An Updated Review of the Invasive *Aedes Albopictus* in the Americas; Geographical Distribution, Host Feeding Patterns, Arbovirus Infection, and the Potential for Vertical Transmission of Dengue Virus. *Insects* (2021) 12:1–13. doi: 10.3390/insects12110967
29. Ortega–Morales AI, Mis–Ávila P, Doínguez–Galera M, Canul–Amaro G, Esparza–Aguilar J, Carlos–Azueta J, et al. First Record of *Stegomyia Albopicta* [*Aedes Albopictus*] in Belize. *Southwest Entomol* (2010) 35 (2):197–8. doi: 10.3958/059.035.0208
30. Ogata K, López–Samayoa A. Discovery of *Aedes Albopictus* in Guatemala. *J Am Mosq Control Assoc* (1996) 12(3):503–6.
31. Moore CG, Mitchell CJ. *Aedes Albopictus* in the United States: Ten–Year Presence and Public Health Implications. *Emerg Infect Dis* (1997) 3:329–34. doi: 10.3201/eid0303.970309
32. Roche B, Léger L, L´Ambert G, Lacour G, Foussadier R, Besnard G, et al. The Spread of *Aedes Albopictus* in Metropolitan France: Contribution of Environmental Drivers and Human Activities and Predictions for a Near Future. *PloS One* (2015) 10(5):e0125600. doi: 10.1371/journal.pone.0125600
33. Hawley WA, Reiter P, Copeland RS, Pumpuni CB, Criag GB. *Aedes Albopictus* in North America: Probable Introduction in Used Tires From Northern Asia. *Science* (1987) 236(4805):1114–6. doi: 10.1126/science.3576225
34. Instituto Nacional de Estadistica y Geografía. *Regiones Fisiográficas* (2021). Available at: https://www.inegi.org.mx/temas/fisiografia (Accessed March 15, 2021).

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