



# The Distribution of Cuban Brown Anoles, *Anolis sagrei* (Squamata: Dactyloidae), in Mexico, with New Records and Comments on Ecological Interactions

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**Abstract.**—The Cuban Brown Anole (*Anolis sagrei*) is native to the Bahamas, the Cuba Archipelago, and Little Cayman, but is now among the world's most widely distributed invasive lizards. In Mexico, the species has been reported from the states of Campeche, Chiapas, Jalisco, Quintana Roo, Tabasco, Tamaulipas, Veracruz, and Yucatán. However, no complete compendium exists summarizing the locality-level distribution of *A. sagrei* in Mexico. Herein we provide an exhaustive compilation of vouchered Mexican specimens based on museum records and the literature. Supplementing this review are reports of five new localities for *A. sagrei* in Veracruz and Tabasco. We conclude with brief comments on the potential ecological effects of this species in Mexico.

The Cuban Brown Anole (*Anolis sagrei*) is native to the Bahamas, Cuba, and Little Cayman (Powell and Henderson 2012). Widely introduced, it has become established on a number of Caribbean islands (Powell et al. 2011), Central America, including Mexico (Lee 1996; McCranie and Köhler 2015; Batista et al. 2019), the United States (Kraus 2009), Ecuador (Amador et al. 2017), Brazil (Oliveira et al. 2018), Singapore (Tan and Lim 2012), and Taiwan (Norval et al. 2002). Interestingly, Smith and Burger (1949) described a subspecies, *Anolis sagrei mayensis*, from Panloa Island, Campeche, Mexico, implying that Mexican populations are not necessarily exotic (Yáñez-Arenas et al. 2016). However, González-Sánchez et al. (2017), in the most recent comprehensive treatment of the herpetofauna of the Yucatán Peninsula (comprising all or part of the Mexican states of Campeche, Quintana Roo, Tabasco, and Yucatán), considered *A. sagrei* a non-native species to this region. We tentatively concur.

In Mexico, *Anolis sagrei* has been reported from the states of Campeche, Chiapas, Jalisco, Quintana Roo, Tabasco, Tamaulipas, Veracruz, and Yucatán (Lee 1996; Álvarez-Romero et al. 2008; Terán-Juárez et al. 2015; Toscano-Flores and Calzada-Arciniega 2015; Venerozo-Tlazalo et al. 2017; Pazos-Nava et al. 2019). In Veracruz, populations are known from the municipalities of Los Tuxtlas (González-Soriano et al. 1997), Minatitlán (Mestizo-Rivera 2006;

Zamora-Abrego et al. 2006), Alvarado (Toscano-Flores and Calzada-Arciniega 2015), Córdoba (Venerozo-Tlazalo et al. 2017), and Banderilla (MZFC 5479-1). In Tabasco, *A. sagrei* populations have been reported near the coast, 30 km north of Villahermosa (USNM 192544), and the municipalities of Cárdenas (Sánchez 2013), and Huimanguillo (Sánchez 2015). Herein we document additional populations of *A. sagrei* in both Veracruz and Tabasco and provide a comprehensive compendium of vouchered *A. sagrei* localities for Mexico.

We built a database of records of *Anolis sagrei* in Mexico in the Global Biodiversity Information Facility (<https://www.gbif.org>), VertNet (<http://www.vertnet.org/index.html>), and in the published literature (Table 1). We excluded some records under circumstances proposed by Soto-Huerta and Clause (2017): (1) the existing locality data were ambiguous, available only at the municipality level; (2) an irreconcilable contradiction existed between the locality's written description and global positioning system coordinates; (3) the locality referenced a place name absent from existing maps and lacked global positioning system coordinates; or (4) the location was within two kilometers of one or more other locations, in which case we generated a single point. This database includes five newly documented locations for *A. sagrei* in the states of Veracruz and Tabasco (Fig. 1), for which we deposited digital photographic vouchers at the Natural History

**Table 1.** Vouchered localities for Cuban Brown Anoles (*Anolis sagrei*) in Mexico based on a review of museum collections and pertinent literature. CM = Carnegie Museum of Natural History; CNAR = Colección Nacional de Anfibios y Reptiles; ECNB = colecciones de la Escuela Nacional de Ciencias Biológicas; ECO-CH-H = Museo de Zoología, El Colegio de la Frontera Sur, Unidad Chetumal; ECO-SC-H = Colección Herpetológica del Sureste de México; IHNE-CZRHE = Instituto de Historia Natural y Ecología; KU = University of Kansas Biodiversity Institute; LACM = Natural History Museum of Los Angeles County; LSUMZ = Louisiana State University Museum of Natural Science; MCZ R = Reptile Collection, Museum of Comparative Zoology, Harvard University; MCZ = Museum of Comparative Zoology, Harvard University; MZFC = Museo de Zoología de la Facultad de Ciencias, UNAM; OMNH = Sam Noble Oklahoma Museum of Natural History; UCM = University of Colorado Museum of Natural History; UF = Florida Museum of Natural History; UIMNH = Collection of Herpetology, University of Illinois; UMMZ = Collection of Herpetology, University of Michigan; UTEP = Collection of Herpetology, University of Texas-El Paso; USNM = National Museum of Natural History, Smithsonian Institution.

| State (Municipality)               | Locality                                    | Voucher/Reference                          |
|------------------------------------|---|--|
| Campeche (Campeche)                | Campeche                                    | UCM 18427                                  |
| Campeche (Campeche)                | Ciudad del Carmen                           | KU 157205                                  |
| Campeche (Campeche)                | Ciudad del Carmen                           | UCM 20663                                  |
| Campeche (Carmen)                  | Isla Aguada                                 | CNAR 3482                                  |
| Campeche (Carmen)                  | Panlao                                      | UIMN H4170                                 |
| Campeche (Calakmul)                | KM20, Dos Naciones, Mancolona               | Colston et al. 2015                        |
| Campeche (————)                    | Los Petenes, heading to Yultán              | IHNE-CZRHE 536                             |
| Campeche (Carmen)                  | Encarnación                                 | USNM 137211                                |
| Chiapas (Ocozocoautla de Espinosa) | Ocozocoautla-Mal Paso, km 43 of the road    | IHNE-CZRHE 1342                            |
| Chiapas (Tecpan)                   | Nueva Alianza                               | ECO-SC-H 91                                |
| Chiapas (Ocozocoautla de Espinosa) | El Cielito, 1 km al W                       | ECO-SC-H 104                               |
| Chiapas (Ocozocoautla de Espinosa) | El Aguajito, 1 km W                         | ECO-SC-H 40                                |
| Jalisco (Puerto Vallarta)          | Cuale River Island                          | Pazos-Nava et al. 2019                     |
| Tabasco (————)                     | 30 mi N of Villahermosa                     | USNM 192544                                |
| Tabasco (Cárdenas)                 | Garden of 0.5 ha of a house in a rural area | Sánchez, 2013                              |
| Tabasco (Huimanguillo)             | Campus Tabasco, Colegio de Postgraduados    | Sánchez, 2015                              |
| Tabasco (Jalapa)                   | Rancho El Tiloncho)                         | This study                                 |
| Tabasco (Jalapa)                   | Rancho Santa Lucía)                         | This study                                 |
| Tamaulipas (Altamira)              | Altamira City                               | Terán-Juárez et al. 2015                   |
| Tamaulipas (Madero)                | Madero City                                 | Terán-Juárez et al. 2015                   |
| Veracruz (Boca del Río)            | Las Vegas colony                            | This study                                 |
| Veracruz (Yanga)                   | 2.5 km W of Yanga                           | This study                                 |
| Veracruz (Alvarado)                | Los Aguacates colony                        | This study                                 |
| Veracruz (Córdoba)                 | Córdoba                                     | Venerozo-Tlazalo et al. 2017               |
| Veracruz (Banderilla)              | Esquilón, between Banderillas and Jilotepec | MZFC 5479-1                                |
| Veracruz (Los Tuxtlas)             | Catemaco                                    | González-Soriano et al. 1997               |
| Veracruz (Minatitlán)              | ca. 1 km N of Minatitlán                    | Zamora-Abrego et al. 2006                  |
| Veracruz (Alvarado)                | Mandinga                                    | Toscano-Flores and Calzada-Arciniega 2015) |
| Yucatán (San Felipe)               | Near Gulf of Mexico, mouth of Río Lagartos  | UF 27737                                   |
| Yucatán (Progreso)                 | Progreso, grounds of Hotel Cocoteros        | OMNH 33369                                 |
| Yucatán (Progreso)                 | ————  | OMNH 33371                                 |
| Yucatán (Río Lagartos)             | 2 km S, 5.5 km W Las Coloradas              | ECNB 14591                                 |
| Yucatán (Río Lagartos)             | Río Lagartos                                | KU 157211                                  |
| Yucatán (Dzilam Bravo)             | Dzilam Bravo                                | KU 157215                                  |

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| State (Municipality)                  | Locality                                      | Voucher/Reference           |
|---------------------------------------|---|-----------------------------|
| Yucatán (Celestun)                    | Celestún Village                              | ECO-CH-H 1708               |
| Yucatán (Celestun)                    | Celestun                                      | KU 157227                   |
| Yucatán (Tizimín)                     | El Cuyo                                       | ECNB 14600                  |
| Yucatán (Merida)                      | Merida  | UCM 18424                   |
| Yucatán (Chichen itza)                | Chichen Itza, Thompson's Cenote               | UCM 28657                   |
| Yucatán (Tinum)                       | Pisté   | UCM 45597                   |
| Yucatán (————)                        | Isla Pérez                                    | MZFC28487                   |
| Yucatán (Ticul)                       | Ticul   | MZFC 6192-1                 |
| Yucatán (Calakmul)                    | Xpujil  | Calderón et al. 2003        |
| Yucatán (Valladolid)                  | Valladolid                                    | KU 298652                   |
| Quintana Roo (Cozumel)                | Cozumel Island, E side of Punto Morena        | UF 122710                   |
| Quintana Roo (Othón P. Blanco)        | Ciudad Chetumal                               | CM 45279                    |
| Quintana Roo (Cozumel)                | San Miguel, Casa Candela Room 5               | CM 55814                    |
| Quintana Roo (Isla Mujeres)           | Isla Mujeres, N end                           | KU 70115                    |
| Quintana Roo (Othón P. Blanco)        | Xcalak  | KU 74872                    |
| Quintana Roo (Cozumel)                | Isla Cozumel, 8 km NE San Miguel              | KU 248756                   |
| Quintana Roo (Cozumel)                | Isla Cozumel, 15 km S San Miguel              | LACM 127400                 |
| Quintana Roo (Cozumel)                | Xpalbarco                                     | MCZ R-149562                |
| Quintana Roo (Isla Mujeres)           | Isla Contoy                                   | UCM 21401                   |
| Quintana Roo (Solidaridad)            | Solidaridad                                   | MZFC 16577-1                |
| Quintana Roo (Cancún)                 | Puerto Juárez                                 | MCZ R-67410                 |
| Quintana Roo (Bacalar)                | Lake Bacalar                                  | LSUMZ 33349                 |
| Quintana Roo (Othón P. Blanco)        | Calderitas                                    | Badillo-Saldaña et al. 2016 |
| Quintana Roo (Othón P. Blanco)        | Banco Chinchorro                              | Charruau et al. 2015        |
| Quintana Roo (Felipe Carrillo Puerto) | Ejido X-Hazil S and annexes                   | ECO-CH-H 2803               |
| Quintana Roo (Othón P. Blanco)        | Ejido Caobas, in the village                  | ECO-CH-H 2585               |
| Quintana Roo (Felipe Carrillo Puerto) | Petcacab Village                              | ECO-CH- H 2661              |
| Quintana Roo (Felipe Carrillo Puerto) | Felipe Carrillo Puerto, RBSK, Petén en Playón | ECO-CH- H 1811              |
| Quintana Roo (Othón P. Blanco)        | Chetumal center                               | ECO-CH-H 1263               |
| Quintana Roo (Felipe Carrillo Puerto) | Vigía Chico                                   | ECO-CH-H 0022               |
| Quintana Roo (Isla Mujeres)           | Isla Cayo Norte Mayor                         | MZFC 28473                  |
| Quintana Roo (Isla Mujeres)           | Isla Cayo                                     | ECO-CH-H2794                |
| Quintana Roo (Benito Juárez)          | Benito Juárez Zona Centro                     | CNAR-4068                   |
| Quintana Roo (Puerto Morelos)         | Puerto Morelos                                | CNAR-4104                   |
| Quintana Roo (Felipe Carrillo Puerto) | Bahia De La Ascención                         | UMMZ 78584                  |
| Quintana Roo (Cozumel)                | Near San Miguel, along beach                  | UTEP-H-7488                 |
| Quintana Roo (Benito Juárez)          | 3 mi E Esmeralda, 0.25 mi S Lake Chichankanab | LACM-114031                 |

Museum of Los Angeles County (LACM PC). We identified *A. sagrei* based on three diagnostic characters: laterally compressed tail, orange to red dewlap with a yellow margin, and enlarged post-anal scales (Köhler 2008).

Although Pazos-Nava et al. (2019) recently provided a database of *Anolis sagrei* localities in Mexico, they overlooked

some records available on the VertNet platform and other records reported in the literature (e.g., Terán-Juárez et al. 2015). Our map and list include those missing records, and we also distilled the records to individual localities, making it easier to enumerate and visualize the site-specific Mexican distribution of the species. Based on our review, Mexican popu-





**Fig. 1.** Records of Cuban Brown Anoles (*Anolis sagrei*) in Mexico.



**Fig. 2.** An adult male Cuban Brown Anole (*Anolis sagrei*) from Alvarado, Veracruz (LACM PC 2469). Photograph by Axel Fuentes-Moreno.

lations have been reported in 69 localities in 36 municipalities in eight states (Tables 1 and 2, Fig. 1), including five new localities based on our own recent fieldwork.

At around 0930 h on 2 January 2011, we observed several *Anolis sagrei* (Fig. 2) in a small 50-m<sup>2</sup> private garden in an urbanized area of Colonia los Aguacates in Alvarado, Municipality of Alvarado, Veracruz (18°46'38.9"N, 95°46'08.4"W; WGS 84; elev. 30 m asl). On 2 October 2019, we re-surveyed the population in this same garden, recording four adults (a male and three females) and five young. We found the lizards among ornamental plants, on



**Fig. 3.** An adult male Cuban Brown Anole (*Anolis sagrei*) from Yanga, Veracruz (LACM PC 2466). Photograph by Víctor Vásquez-Cruz.





**Fig. 4.** An adult male Cuban Brown Anole (*Anolis sagrei*) from Rancho el Tiloncho, Tabasco (LACM PC 2467). Photograph by Luis Canseco-Márquez.

dead plant matter, on the ground, and on the walls of the garden. We also have since observed *A. sagrei* in other gardens in the city, possibly indicating multiple independent introductions. The Colonia los Aguacates record is 42 km SE of the nearest previously known locality in the town of Mandinga, Municipality of Alvarado (Toscano-Flores and Calzada-Arciniega 2015).

At 1516 h on 23 May 2017, we observed many Cuban Brown Anoles in and around a greenhouse in an industrial area on the outskirts of the town of Yanga, Municipality of Yanga, Veracruz (18°50'10.78"N, 96°48'25.27"W; WGS 84; elev. 540 m asl). We recorded seven males, nine females, and 10 juveniles (Fig. 3). The lizards were thermoregulating on the plastic greenhouse cover, on nearby rocks and tree trunks, and moving about among the *Anthurium* sp. plants in the greenhouse. This record is the second from west-central Veracruz and is 13.4 km SE of the nearest previously known locality in the city of Córdoba, Municipality of Córdoba (Venerozo-Tlazalo et al. 2017).



**Fig. 5.** An adult male Cuban Brown Anole (*Anolis sagrei*) from Rancho Santa Lucia, Tabasco (LACM PC 2468). Photograph by Luis Canseco-Márquez.

At around 1600 h on 14 December 2018, we observed a male *Anolis sagrei* inside a house in the Las Vegas Colony (19°08'18.6"N, 96°07'52.7"W; WGS 84; elev. 8 m asl) in the city of Boca del Río, Municipality of Boca del Río, Veracruz. Subsequently, on 18 August 2019, we observed a juvenile *A. sagrei* in the yard of the same house, and on 4 October 2019 we encountered two *A. sagrei* in the yard, an adult male thermoregulating on a fence (Fig. 4) and a juvenile eating a spider (Lycosidae). This record is 13 km N of the nearest previously known locality in the town of Mandinga, Municipality of Alvarado (Toscano-Flores and Calzada-Arciniega 2015).

At around 1000 h on 3 November 2017, we observed an adult *A. sagrei* thermoregulating at the base of a stump (Fig. 5) at Rancho Santa Lucia, Municipality of Jalapa, Tabasco (17°44'39.0"N, 92°49'46.0"W; WGS 84; elev. 14 m asl). Subsequently, at around 1500 h, we observed an adult male (Fig. 6) at Rancho El Tiloncho, Municipality of Jalapa, Tabasco (17°42'19.0"N, 92°51'52.0"W; WGS 84; elev. 14 m asl). We observed no other lizards at these sites, and both localities are characterized by a high degree of disturbance with areas destined for palm cultivation. These records are the southernmost in Tabasco. Respectively, they are 64 and 62 km SE of the nearest previously known locality in the Municipality of Huimanguillo (Sánchez 2015).

Several types of ecological interaction have been reported between introduced *A. sagrei* and native species, including commensalism (Delaney et al. 2014a), competition (Delaney et al. 2014b), predator-prey (Simpson et al. 2019), and interspecific mating (Thawley et al. 2019). In the Yanga locality of Veracruz, we observed several Rose-bellied Lizards (*Sceloporus variabilis*), a species native to Mexico, and we speculate that the introduced *A. sagrei* at this site could act both as a direct predator and competitor to *S. variabilis*, similar to reports of agonistic interactions with Silky Anoles (*Anolis sericeus*) and Teapen Rose-bellied Lizards (*Sceloporus teapensis*) elsewhere in Mexico (Schüttler and Karez 2008; Yáñez-Arenas et al. 2016). The potential colonization and spread of *A. sagrei* in this area could also lead to negative interactions with nearby populations of Greater Scaly Anoles (*A. tropidonotus*) and *A. sericeus*,





Fig. 6. An adult male Cuban Brown Anole (*Anolis sagrei*) from Boca del Rio, Veracruz (LACM PC 2471). Photograph by Axel Fuentes-Moreno.

**Table 2.** Number of municipalities and localities inhabited by *Anolis sagrei* in Mexico.

| State        | Municipalities | Localities |
|--------------|----------------|------------|
| Campeche     | 3              | 7          |
| Chiapas      | 2              | 5          |
| Jalisco      | 1              | 1          |
| Quintana Roo | 8              | 27         |
| Tabasco      | 3              | 5          |
| Tamaulipas   | 2              | 2          |
| Veracruz     | 7              | 8          |
| Yucatán      | 10             | 15         |

which we documented in patches of vegetation within 2 km of the current *A. sagrei* population. Such interactions could even lead to eventual extirpation of native lizards. Notably, *Anolis sericeus* was previously found in the urban garden where we first documented *A. sagrei* in the town of Alvarado, Veracruz, but we have observed none following the colonization of this garden by *A. sagrei*. The ecological effects of the spread of *A. sagrei* may not, however, be entirely deleterious to native herpetofauna. For instance, we documented an *A. sagrei* being consumed by the native Atlantic Central American Milksnake (*Lampropeltis polyzona*) (V. Vásquez-Cruz, unpubl. data) at the Yanga locality.

The largest number of *Anolis sagrei* records in Mexico occurs in the states of Campeche, Quintana Roo, and Yucatan (70% of nationwide records; Table 2), and in the last 20 years the species has spread across the Gulf of Mexico into the states of Tabasco and Veracruz, mostly in urban areas. We identify

two phenomena involved in this spread: (1) incidental introduction of *A. sagrei* via product importation or other human-mediated pathways; and (2) progressive natural colonization radiating outward from single introduction points, for example the records in Boca del Rio, Mandinga, and Alvarado in Veracruz and Rancho El Tiloncio and Rancho Santa Lucia in Tabasco. Studying the geographical origins and population status of *A. sagrei* in these locations is necessary to evaluate the speed of colonization and its impact on the native Mexican species.

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