Revista Ibérica de Aracnología, nº **33** (31/12/2018): 113–116.
Grupo Ibérico de Aracnología (S.E.A.). ISSN: 1576 - 9518.

The invasive tropical tent-web spider, *Cyrtophora citricola* (Forskål, 1775) (Araneae: Araneidae) has reached Isla de la Juventud, Cuba

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Abstract: The tropical tent-web spider, *Cyrtophora citricola* (Forskål, 1775) (Araneidae), is an invasive alien species in the New World. It was first reported from the West Indies (on Hispaniola) in 2001 and from eastern Cuba in 2003. In 15 years it has colonised most of the Cuban archipelago, but the westernmost part had remained so far free from this species. Herein for the first time we report the occurrence of *C. citricola* at Isla de la Juventud, the second largest island of Cuba, and comment on the possible introduction pathway and potential impacts.
Key words: Araneae, Araneidae, alien species, ballooning, potential impact, range expansion, West Indies.

La araña parda del Mediterráneo, *Cyrtophora citricola* (Forskål, 1775) (Araneae: Araneidae) llega a la Isla de la Juventud, Cuba
Resumen: La araña parda del Mediterráneo, *Cyrtophora citricola* (Forskål, 1775) (Araneidae), es una especie exótica invasora en el Nuevo Mundo. En 2001 se reportó por primera vez en Las Antillas (de La Española) y en 2003 en la región oriental de Cuba. En 15 años ha colonizado la mayor parte del archipiélago cubano, pero la región más occidental hasta ahora había permanecido libre de esta especie. Aquí se reporta por primera vez la presencia de *C. citricola* en la Isla de la Juventud, la segunda mayor isla del archipiélago cubano y se comenta sobre la posible vía de introducción e impactos potenciales.
Palabras clave: Araneae, Araneidae, especie exótica, aeróstatos, impacto potencial, expansión de distribución, Las Antillas.

The tropical tent-web spider, *Cyrtophora citricola* (Forskål, 1775) (Araneidae), is native from the Mediterranean and Africa, but it has spread into several parts of the world (Rypstra, 1979; Levi, 1997; Teruel *et al*., 2014). It is a gregarious orbweaver that under favorable conditions (prey-rich habitats) may occur in large colonies of several hundred individuals of both sexes and different age-classes (Blanke, 1972; Lubin, 1974; Rypstra, 1979; Leborgne *et al*., 1998; Mestre & Lubin, 2011; Johannesen *et al*., 2012). The compound webs of this spider sometimes may be huge, covering the entire substrate selected (e.g., trees and shrubs foliage, electricity poles, fence posts) (Alayón *et al*., 2001; Sánchez-Ruiz & Teruel, 2006; Martín-Castejón & Sánchez-Ruiz, 2010; Teruel *et al*., 2014); Wheeler (1926) described colonies of over 90 m^2 and Sánchez-Ruiz & Teruel (2006) even recorded quasi-continuous webs extending tens of kilometers alongside roads. The silk is very strong and thus withstands a large amount of debris (dead leaves, flowers, fruits, twigs, egg-sacs, and prey carcasses) that accumulates on the webs, giving them a dusty appearance and making identification very easy (Sánchez-Ruiz & Teruel, 2006; Teruel *et al*., 2014; Alayón *et al*., 2017). There are multiple observations suggesting possible deleterious effects on the supporting plants when heavy populations of this spider have become established, including leaf loss, terminal twig dieback, and even plant death (Cárdenas-Murillo et al., 1997; Levi, 1997; Alayón *et al*., 2001, 2017; Alayón, 2003; Starr, 2005; Edwards, 2006). It has been speculated that the extensive web cover restricts the air circulation, causing a raise of the temperature, and that the numerous debris block the sunlight affecting the photosynthesis and causing desiccation of the leaves, young branches and fruits (Cárdenas-Murillo *et al*., 1997; Edwards, 2006).

In the West Indies *C. citricola* was first observed at Oviedo, Pedernales Province, Dominican Republic in 1999 (Alayón *et al*., 2001) and then it started to colonize the remaining islands very fast (Alayón, 2003; Armas, 2010; Starr & Sewlal, 2011; Teruel *et al*., 2014; Díaz-Alvarez *et al*., 2017). In Cuba the first web of this species was reported from the eastern region, in the banks of the Taco river, Baracoa, in 2003, and in only 15 years it has invaded most of the country (Alayón, 2003; Sánchez-Ruiz & Teruel, 2006; Sánchez-Ruiz, 2012; Barba-Díaz *et al*., 2014; Teruel *et al*. 2014; Díaz-Alvarez *et al*., 2017; Pérez-Silva & García-Lahera, 2017). However, the westernmost part of Cuba so far has remained free of this species. Herein for the first time we report the occurrence of *C. citricola* at Isla de la Juventud, the second largest island of the Cuban archipelago, and comment on the possible introduction pathway and potential impacts.

On 12 July 2018, we found a mature web (estimated volume 40 cm^3) of *C. citricola* on an isolated tree locally known as "*peralejo*" (*Byrsonima crassifolia* [L.] Kunth, 1822, Malpighiaceae; Fig. 1A, B) about three meters tall by a path 2.8 km southwest of La Victoria (21°42'01.9" N, 82°56'53.6" W; 20 m a.s.l.; datum WGS 84), in the western part of Isla de la Juventud Special Municipality, Cuba (Fig. 2). This location is about 150 km SSW of the nearest mainland record at Santiago de las Vegas, La Habana Province (Teruel *et al*., 2014). The western part of Isla de la Juventud is characterized by a humid, acidic, quartz sand plain (known as white sands) where the original vegetation is open pinewoods (Borhidi, 1991), but the place where we found *C. citricola* is heavily disturbed because of cattle raising and the predominant vegetation is secondary open savanna with isolated trees and shrubs (Fig. 1A). The web was about two meters above the ground (Fig. 1A) and contained a dark-brown adult female *C. citricola* (11.5 mm total length; Fig. 1C) and a string of six egg-sacs (four empty and two still containing eggs/hatchlings), which is typical of this species (Fig. 1D). In the morning of July 16th (four days after collection), the female had died and 431 spiderlings emerged from one of the egg-sacs in captivity (Fig. 3). The adult female, 10 spiderlings, and the egg-sacs (one still containing eggs) were deposited in the arachnological collection of the Instituto de Ecología y Sistemática (CZACC 3.4384), Havana, Cuba.

The main dispersal mechanism of *C. citricola* seems to be through ballooning during spiderlings phase, however, in Cuba this species has been commonly seen alongside roads following the electricity and/or telephone lines and fences (Sánchez-Ruiz & Teruel, 2006; Teruel *et al*., 2014), where it possibly also takes extra advantage of vehicles to disperse. We have been surveying Isla de la Juventud for nearly two years without additional sightings of *C. citricola*. This, joined to the poor development of the web we found



Fig. 1. Small tree (*Byrsonima crassifolia*, Malpighiaceae) where we found a web of *Cyrtophora citricola* (A – red circle – and B) in the western part of Isla de la Juventud, which contained an adult female (C) and several egg-sacs (D). Photographs by T.M. Rodríguez-Cabrera.

with a single adult spider, isolated in a semi-natural area away from major cities or towns, all suggest that this species arrived recently to this island, most likely by ballooning.

Based on an experience at Santiago de Cuba, Teruel *et al*. (2014) commented that adult females (presumably carrying fertilized eggs and/or sperm) are transported by the wind too. Size is one of the major restrictions to ballooning in spiders, but several studies demonstrate that relatively large spiders (up to 14 mm body length and over 100 mg) are able to balloon by using multiple strands (Dean & Sterling, 1985; Wickler & Seibt, 1986; Greenstone *et al*., 1987; Schneider *et al*., 2001; Oleszczuk & Karg, 2012; Cho *et al*., 2018). Adult females *C. citricola* average just over 10 mm body length and about 100 mg (Levi, 1997; Edwards, 2006; T. M. Rodríguez-Cabrera, pers. obs.), which falls within the size range reported for large ballooners. However, in an experimental study, Johannesen *et al*. (2012) observed that the propensity to disperse in *C. citricola* decreased with increasing age; pre-mating and adult females did not disperse (see also Edwards *et al*., 2003). Web-building requires great investment of energy and silk in *C. citricola* and as consequence web relocation in this species is costly (Lubin, 1974; Mestre & Lubin, 2011; Johannesen *et al*., 2012). Nonetheless, the frequent hurricanes in the Caribbean might have contributed to disperse the species (Teruel *et al*., 2014), including the much heavier adult females. Actually, between 8–9 September 2017 (about 10 months before our finding), the extremely powerful Category 5 hurricane "Irma" stroke most part of the Cuban archipelago with winds over 250 km/h (INSMET, 2017; Fonseca-Rivero *et al*., 2018), which might have favored dispersal of *C. citricola* from mainland Cuba to Isla de la Juventud.

An alternative possibility that does not exclude the ballooning hypothesis is parthenogenesis, which has been repeatedly reported or suggested for several spider genera such as *Theotima*, *Nephila, Dysdera, Triaeris,* and *Argiope* (e.g., Deeleman-Reinhold, 1986; Oh *et al*., 2000; Edwards *et al*., 2003; Korenko *et al*., 2009; Terhivou *et al*., 2011). Although males of *C. citricola* are well known (e.g., Levi, 1997; Johannesen *et al*., 2012; Teruel *et al*., 2014), an initial facultative parthenogenesis, whether or not involving manipulative endosymbiotic bacteria such as *Wolbachia* (e.g., Oh *et al*., 2000), would partially explain the success of this species in colonizing new areas. The important thing is that *C. citricola* has invaded several continents thousand kilometers away from its native range and a male and a female spiderlings being carried by the wind to a specific place on a remote island seems unlikely. In any case, additional studies are needed to test both the ballooning adult females and the parthenogenetic hypotheses.

The possible impact of this invasive alien spider on the native biota of Cuba is still unclear (Teruel *et al*., 2014; Alayón *et al*., 2017; Díaz-Alvarez *et al*., 2017), although there are some evidences indicating that even small passerine birds may be affected (Sánchez-Ruiz & Teruel, 2006). However, in any case we recommend to follow the precautionary principle, which states that the lack of absolute scientific certainty on the existence of damage to the environment should not be considered an impediment to adopt measures to diminish or eliminate it (e.g., Vera, 1994). The place where we found *C. citricola* is located between (and about 3 km from) two important protected areas: "Los Indios" Ecological Reserve and "La Cañada" Managed Resource Protected Area. These protected areas harbor a high number of local endemic and threatened species, particularly of vascular plants (Borhidi, 1994; González *et al*., 2016). The potential deleterious effects of this spider on the local flora and associated entomofauna (potential pollinators) deserve full attention. If our hypothesis about its recent arrival to Isla de la Juventud is correct, then the local wildlife conservation authorities might be still in time to take actions in order to control its establishment and rapid spread, as occurred in mainland Cuba and in other Caribbean islands. However, once established the control and management of *C. citricola* can become a challenging task. The introduction of a single female seems sufficient to establish a new population in a span of about a year (Teruel *et al*., 2014); a female *C. citricola* may lay up to 10 cocoons containing several hundred eggs each during its lifespan (Leborgne *et al*., 1998; Edwards, 2006; Johannesen *et al*., 2012; this paper). The closely related New Guinean tent-web species *C. moluccensis* (Doleschall, 1857) reaches maturity between two (males) and four months (females) (Berry, 1987), therefore, multiple generations may occur in a one-year period. The egg-sacs we found at Isla de la Juventud and the further emergence of spiderlings in captivity constitute irrefutable evidences of reproductive activity in this area. Moreover, four out of the six egg-sacs had already hatched in the field, which means that probably several hundred spiderlings are currently dispersing across that area and new colonies of *C. citricola* might appear in the near future.

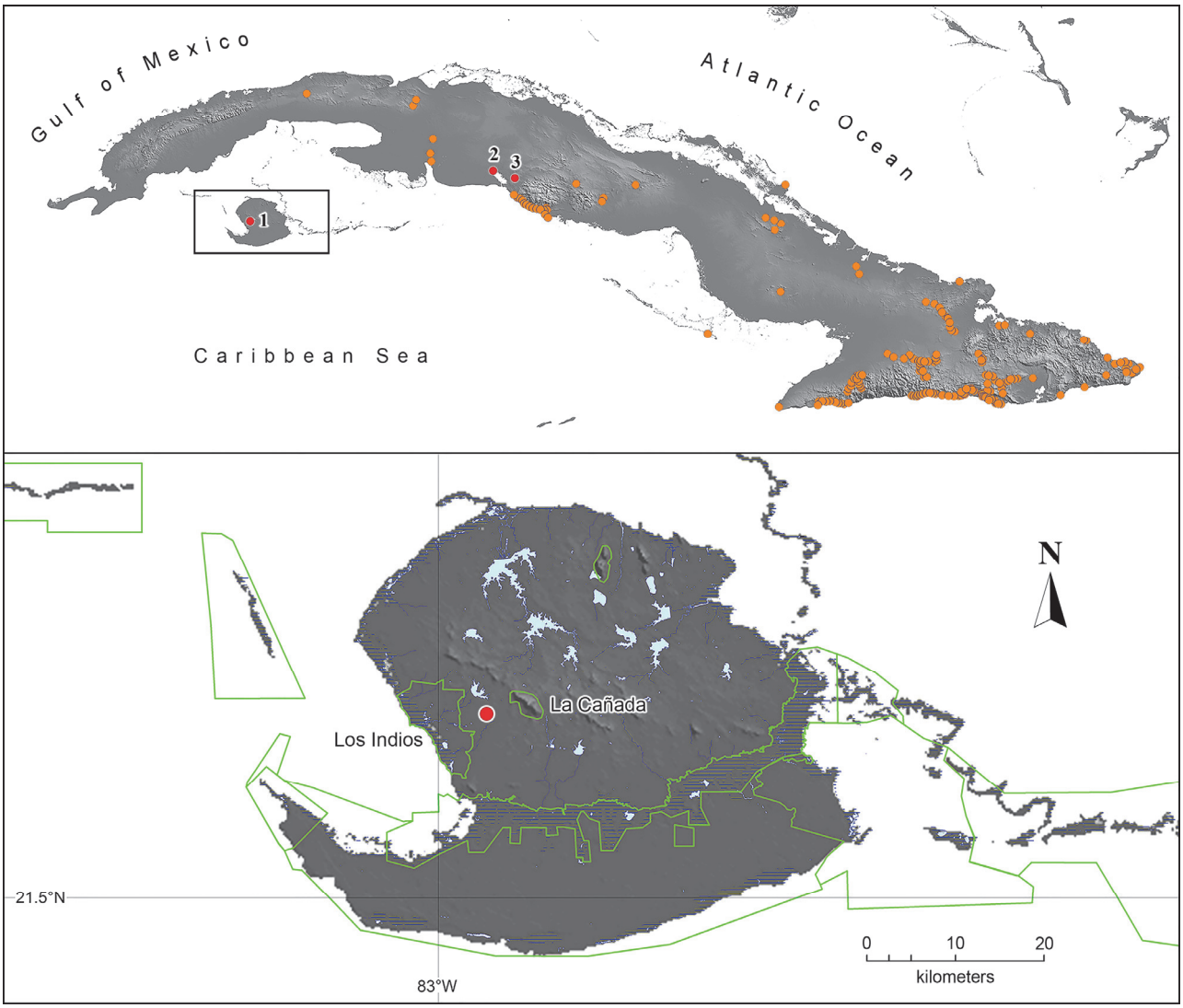


Fig. 2. Above: Map of Cuba depicting the distribution of *Cyrtophora citricola* in the archipelago: orange dots represent previous records (Alayón, 2003; Sánchez-Ruiz & Teruel, 2006; Sánchez-Ruiz, 2012; Barba-Díaz *et al*., 2014; Teruel *et al*. 2014; Díaz-Alvarez *et al*., 2017; Pérez-Silva & García-Lahera, 2017); red dots represent new records: 1) 2.8 km SW of La Victoria, Isla de la Juventud, 2) guardrails of the Damují river bridge, Cienfuegos (22°12'00.2" N, 80°32'51.8" W; 5 m a.s.l.; visual record), and 3) Jardín Botánico de Cienfuegos (22°07'36.7" N, 80°19'52.2" W; 75 m a.s.l.; visual record). Below: Map of Isla de la Juventud depicting the location (red dot) where we found *C. citricola* and the network of Protected Areas (green outlines), highlighting the two closest ones: "Los Indios" Ecological Reserve and "La Cañada" Managed Resource Protected Area. Horizontal blue dashes represent marshy areas.

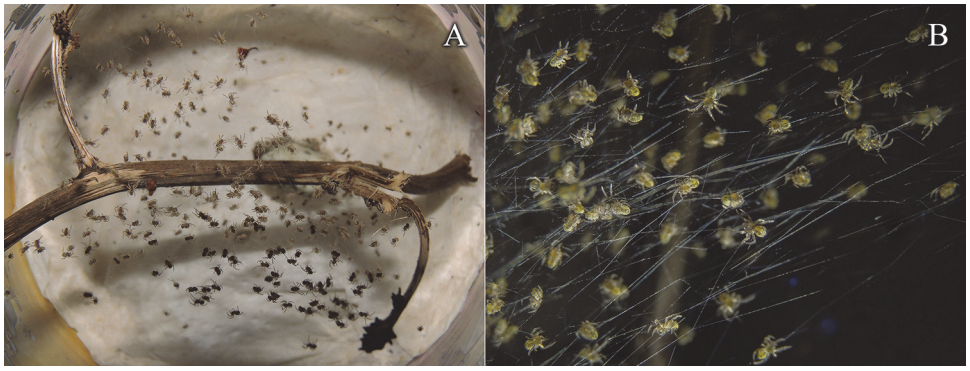


Fig. 3. Mass of over 400 spiderlings of *Cyrtophora citricola* that emerged from one of the egg-sacs collected at Isla de la Juventud (A) and close-up of the spiderlings (B). Photographs by T.M. Rodríguez-Cabrera.

Acknowledgements

We thank the staff from the Empresa Nacional para la Protección de la Flora y la Fauna at Isla de la Juventud for field assistance and logistical support, specially to Pablo Rodríguez, Samuel Rodríguez, and Gabriel Cruz. We also thank Alena Reyes and Lucía Hechevarría for helping in identifying the tree species and Rolando Teruel for his useful comments that improved the manuscript. This work is a by-product of the project No. 170515457 granted to SRM by The Mohamed bin Zayed Species Conservation Fund.

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