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Dispersal of *Hoffmannia excelsa* (Rubiaceae) by the Toltec fruit-eating bat (*Artibeus toltecus*) in central Veracruz, México

Dispersión de *Hoffmannia excelsa* (Rubiaceae) por el murciélago frugívoro Tolteca (*Artibeus toltecus*) en el centro de Veracruz, México

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In this note we report the fruit consumption and non-endozoochorous seed dispersal of a plant species that had not been mentioned in the diet of bats, and that does not present the typical characteristics of chiropterochory. This event was recorded while conducting night captures with mist nets in fragments of secondary vegetation in the metropolitan area of Xalapa de Enríquez, México. A female specimen of *Artibeus toltecus*, captured in June 2018 was carrying two fruits of *Hoffmannia excelsa* (Rubiaceae). Even though *H. excelsa* is a common shrub in central Veracruz, this is the first known record of dispersal in this species, carried out by bats. The consumption of this fruit, with ornithochorous characteristics, is possibly due to a situation of opportunism in the face of a temporarily abundant resource.

Key words: Bat; chiropterochory; diet; frugivory; neotropical; Rubiaceae.

En esta nota reportamos el consumo del fruto y dispersión no endozoócora de semillas de una especie vegetal que no había sido mencionada en la dieta de los murciélagos, y que no presenta las características típicas de quiropterocoria. Este evento fue registrado mientras realizábamos capturas nocturnas con redes de niebla, en fragmentos de vegetación secundaria en el área metropolitana de la ciudad de Xalapa de Enríquez, México. Un ejemplar hembra de *Artibeus toltecus*, capturada en junio de 2018, llevaba consigo dos frutos de *Hoffmannia excelsa* (Rubiaceae). Aunque *H. excelsa* es un arbusto común en el centro de Veracruz, éste es el primer registro conocido de dispersión en esta especie, llevada a cabo por murciélagos. El consumo de este fruto, con características ornitócoras, posiblemente obedece a una situación de oportunismo frente a un recurso temporalmente abundante.

Palabras clave: Dieta; Frugivoría; murciélago; neotropical; quiropterocoria; Rubiaceae.

The Toltec fruit-eating bat, *Artibeus toltecus*, is a small size species (38.7 ± 0.7 mm of forearm length,17.9 ± 2.1 gr in weight; n = 12). It is distributed from the north of México to the northwest of Ecuador and west of Colombia, in South America and lives mainly in wooded areas, in an altitudinal range that goes from 300 to 2,130 m (Webster and Jones 1982). This species is locally common in central Veracruz, México (Castro-Luna and Galindo-González 2012), and it is known that in Mesoamerica it feeds mainly of the Moraceae and Solanaceae families (Hernández-Conrique *et al.* 1997; García-Estrada *et al.* 2012; Hernández-Montero *et al.* 2015), although along its distribution range consumes fruits from plants of 13 taxonomic families: Actinidiaceae, Campanulaceae, Cannabaceae, Euphorbiaceae, Gesneriaceae, Hypericaceae, Lamiaceae, Melastomataceae, Muntingiaceae, Myrtaceae, Piperaceae, Rosaceae and Urticaceae (Lobova *et al.* 2009; Hernández-Montero *et al.* 2015; Castaño *et al.* 2018).

Phyllostomid frugivorous bats have developed remarkable plasticity in their use of food resources, but a few plant families make up the core of their diet throughout the year (Hernández-Montero *et al.* 2015; Sánchez and Giannini 2018). However, rare situations such as the supplementary consumption of insects during critical stages of nutrient demand (Orr *et al.* 2016), or the ingestion of pollen, leaves or fruits with ornitochorous characteristics (*e.g.*, red or purple color), may also occur (Galleti and Morellato 1994; Castro-Luna and Sosa 2009). In this study, we report a new plant species of the Rubiaceae family in the diet of the Toltec fruit-eating bat, which is rarely used as food by phyllostomid bats.

The study area is a fragmented landscape located in the metropolitan area of Xalapa de Enríquez, a city located in central Veracruz, México (19° 30′ N, 96° 58′ W to 19° 32′ N, 96° 56′ W: Figure 1); according to the political division, the capture site belongs to the neighboring municipality of Coatepec. The landscape is a mosaic of pastures, coffee and sugar cane plantations, urban areas, as well as riparian and secondary vegetation. The vegetation in the region was originally mountain cloud forest which, because of anthropogenic pressure, has been reduced to

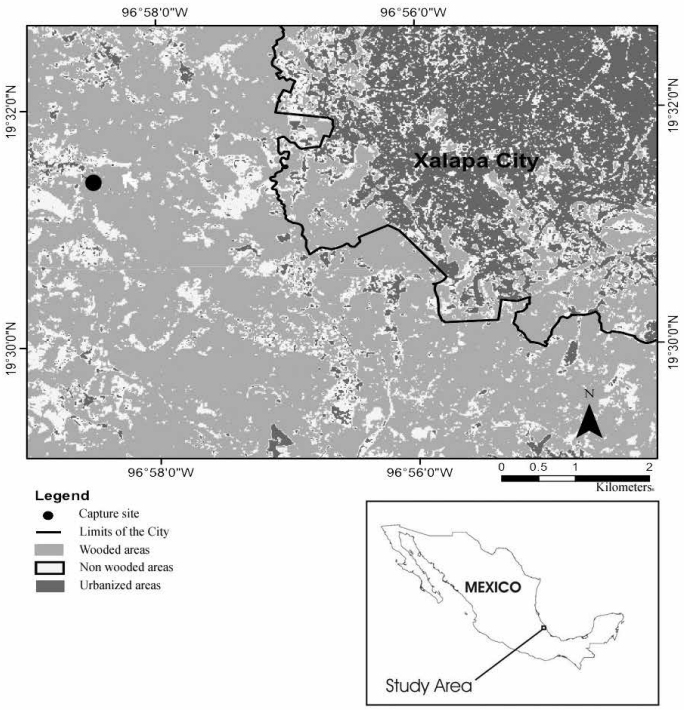

Figure 1. Geographical location of the capture site in the metropolitan area of the city of Xalapa de Enríquez in central Veracruz, México.

less than 10 % of its original area and now exists as isolated fragments with varying degrees of disturbance (Williams-Linera *et al.* 2002). The climate is cool to warm and humid with rain all year round and annual mean temperature ranges between 12 and 19 °C, with annual precipitation between 1,350 and 2,200 mm (García 1987).

The information we report here was generated while conducting a study on the diet of frugivorous bats in urbanized landscapes. We used six mist-nets (12 m long x 2.5 m height), disposed at the understory level, which remained active from dusk until completing six hours of sampling (Colorado-Durán 2020). When we captured a bat, it was kept in cloth bags for later taxonomically identification until the species level, using field keys (Medellín *et al.* 2008). To obtain excreta we used plastic sheets of 9 m long x 1.5 m wide, following the method proposed by Galindo-González *et al.* (2009).

Occasionally, we observed bats carrying fruits when captured in the net; this was the case that we present in this note. When this occurred, the fruit normally was in the bat's snout or next to it, in the net. No record was made if the fruit was on the ground or we were not sure the bat had carried it (*e.g.*, there were more bats in the net). For the taxonomic determination of the plant species, we collected voucher specimens of fruiting plants in the surroundings of the capture sites. We later determined them to the species level in the Herbarium of the Institute of Ecology, A. C.

On June 9, 2018, in a suburban site dominated by early stages of secondary vegetation, an adult female specimen of *A. toltecus* was captured, carrying two fruits of *Hoffmannia excelsa* (Rubiaceae). When detected in the mist net, the specimen had a fruit on its snout (the other fruit was attached, joined by a small stem fragment). However, before making the photographic record, the bat released the fruit, and the evidence was obtained as shown in Figure 2. The specimen did not show evidence of pregnancy or lactation and was released at the same capture site.

In the surroundings of the capture site, there were numerous shrubs of *H. excelsa* fructifying. The fruits obtained from the bat were cylindrical berries, reddish-pink, glabrous and shiny; one of them had the characteristic markings of the bat's bite (Figure 3). Inside, the fruits contained numerous tiny seeds (*ca*. 1 mm diameter).

According to the bibliographic review, this is the first report of *H. excelsa* seed dispersal by bats. Particularly striking is that the species of the Rubiaceae family are mainly dispersed by birds (Bremer and Erickson 1992) and not by frugivorous bats, at least in northern Mesoamerica. The dispersal syndrome hypothesis has been criticized as naive and overly adaptationist. However, studies from the past two decades strongly suggest that traits such as fruit or seed size, hardness, color, scent and chemical profile bear signatures that imply selection by animal mutualists (Valenta and Nevo 2020). The evidence suggests that

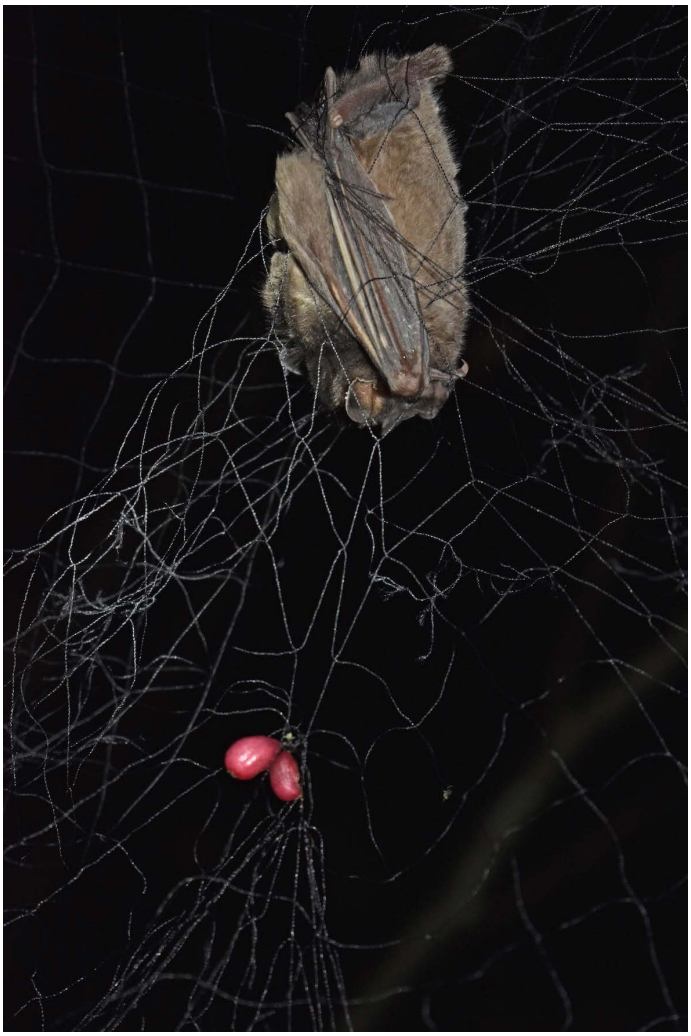

Figure 2. Toltec fruit bat (*Artibeus toltecus*) captured in Coatepec, Veracruz, México with a mist net while carrying two *Hoffmannia excelsa* fruits.

Figure 3. Fruit of *Hoffmannia excelsa* with bite marks from the bat *Artibeus toltecus* in Coatepec, Veracruz, México.

the interaction between bats and plants of the Rubiaceae family exists, but it is not frequent (Geiselman and Younger 2020). For example, the consumption of the pollen of this family by nectarivorous bats has been mentioned in Perú (Arias *et al.* 2009), and there are records of frugivory in South America (see Giannini 1999; Novaes *et al.* 2010; Preciado-Benítez *et al.* 2015; Castaño *et al.* 2018), as well as isolated events of consumption of the exotic *Coffea arabiga* (Gardner 1977). In all these cases, the fruits have characteristics of being dispersed by birds, which is not surprising since Rubiaceae is one of the most important families for tropical frugivorous birds (Snow 1981). In contrast, in Asia and the Pacific Islands, the reports of consumption of Rubiaceae by Pteropodid bats are frequent (*e.g.*, Aziz *et al.* 2017; Aung and Htay 2019; Geiselman and Younger 2020), being among the five families of plants most used as food by these bats (Muscarella and Fleming 2007).

It is interesting that although *H. excelsa* is a common shrub in the understory of the mountain cloud forest and riparian vegetation of the region (Hernández-Dávila *et al.* 2020), it does not seem to be frequently consumed by bats. We assume this, considering that there are no previous records of this interaction in the region (*e.g.*, Hernández-Montero *et al.* 2015; Colorado-Durán 2020). Some authors have mentioned that the consumption of some plant species occurs due to the large number of fruits available in the landscape (Zortéa 2007; Novaes *et al.* 2010), although it has also been reported the unusual consumption of plant species with ornitochorous characteristics (red or purple colors: Howe and Westley 1986), during emergency situations such as food shortage (Castro-Luna and Sosa 2009). In this sense, in the surroundings of the capture site, numerous shrubs of *H. excelsa* were fructifying at the moment we recorded this interaction. Therefore, the fruit consumption could have occurred by opportunism.

The observation of *A. toltecus* transporting *H. excelsa* fruits indicates that, like other phyllostomids, it can transport the fruits it eats to feeding roosts generally at some distance (20 - 250 m) from the tree where the fruit was picked (Galindo-González 1998). In this sense, it is important to recognize that we could not verify the consumption of the seeds by the bat, but only the fruit transportation and non-endozoochorous seed dispersal. We do not rule out that the ingestion of the seeds may occur due to their tiny size. However, this has to be experimentally verified in the future given the apparent rarity of this interaction. Non-endozoochorous seed dispersal has been poorly studied because of the difficulty to obtain information on these interaction events. This report contributes with a new species to the list of plants consumed and dispersed by bats and particularly *A. toltecus*.

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