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Roosting habits of disk-winged bats, especially *Thyroptera discifera*

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Roosting habits of disk-winged bats of the genus *Thyroptera* (Chiroptera: Thyropteridae) have been unknown to very poorly known except for those of the commonly encountered *T. tricolor*. Many secondary literature publications state that roosting habits of *Thyroptera* in general are those of *tricolor*, known to roost almost exclusively in vertical, unfurling large leaves, especially of native *Heliconia* and introduced banana (genus *Musa*). However, so far as known, no other species of *Thyroptera* chooses such roosts. Until 1993, the only species of *Thyroptera* known were *tricolor* and *discifera*—they had been the only two known for 139 years. During this long period, the unique roosting habits of *tricolor* often were attributed to the genus as a whole, as sometimes still happens today. Now there are three more known species—*lavali*, *devivoi*, and *wynneae*. In this paper, we correct misconceptions concerning roosting habits in *Thyroptera*, summarize what is known for all five species, and provide the first detailed observations on roosting in *discifera*. *Thyroptera discifera* has been found roosting attached to the underside of a palm leaflet or leaflets in Brazil and in conically curled portions of dead banana leaves in Costa Rica.

Los hábitos de selección de refugios de los murciélagos de ventosas del género *Thyroptera* (Chiroptera: Thyropteridae) han sido desconocidos o muy poco conocidos, con excepción a los hábitos de *T. tricolor*, que es la especie que se encuentra comúnmente. Muchas publicaciones de literatura secundaria afirman que los hábitos de selección de refugio de los *Thyroptera* en general son los mismos que los de *tricolor*, que son conocidos por descansar casi exclusivamente en hojas grandes verticales y parcialmente enrolladas, especialmente hojas de *Heliconia* nativa y banano introducido (género *Musa*). Sin embargo, por el momento no se conoce ninguna otra especie de *Thyroptera* que elija este tipo de refugio. Hasta 1993, las únicas especies de *Thyroptera* conocidas eran *tricolor* y *discifera* y habían sido las únicas dos especies conocidas durante 139 años. Durante este largo período, los hábitos particulares de selección de refugios de *tricolor* frecuentemente se atribuyeron a todo género, como a veces todavía sucede hoy en día. Actualmente se conocen tres especies más en este género: *lavali*, *devivoi* y *wynneae*. En este artículo, corregimos los conceptos erróneos sobre selección de refugios en *Thyroptera*, resumimos lo que se conoce de las cinco especies y brindamos las primeras observaciones detalladas sobre la selección de refugios de *discifera*. *Thyroptera discifera* se ha encontrado descansando adherido a la parte inferior de un folíolo o folíolos de palma en Brasil y en porciones de hojas muertas de plátano enrolladas cónicamente en Costa Rica.

Keywords: Banana leaves; Brazil; Costa Rica; *Mauritia*; *Musa*; Neotropics; palm fronds.

Introduction

The Neotropical disk-winged bat genus *Thyroptera* (Chiroptera: Thyropteridae) contains five known living species occurring from within southern México into southern Brazil and northern Bolivia. The genus is characterized by a number of synapomorphies, the most distinctive being the circular or oval, moist, adhesive disks on the wrists and ankles that are used in attachment to and movement along the roost leaves. Historically, the genus was believed to consist of two species—*Thyroptera tricolor* and *T. discifera*. A third species, *T. lavali* was described based on specimens from a single locality in Perú and is now known from several localities across northern South America (García *et al.* 2018; Lee 2019; Morales-Martínez *et al.* 2021). *Thyroptera devivoi* Gregorin *et al.* 2006 was described from two localities in eastern Brazil, one in Guyana, and has subsequently been reported from northeastern Colombia by Rodríguez-Posada *et al.* (2017) and additional Brazilian localities by Semedo *et al.* (2020). *Thyroptera wynneae* Velazco *et al.*, 2014 is known from a locality in eastern Perú and three in southeastern Brazil (Hoppe *et al.* 2014).

Thyropterids are seldom captured in the standard mist nets used to sample bats, undoubtedly contributing to our lack of understanding of distributions and ecology. Most observations and specimens of thyropterids are based on individuals found at the roost sites. Tschapka *et al.* (2000) described the echolocation calls of *T. discifera* as very low intensity and consisting of several frequency-modulated harmonics, which perhaps allow the flying bats to detect mist nets and avoid capture. *Thyroptera tricolor* is the most widely distributed and most frequently encountered species and summaries of the natural history of the genus are primarily based on what is known about that species. Much of what has been written about roosting in the

genus, especially in *discifera*, is in secondary sources and those derived from other secondary sources, and assumes that it is as in *tricolor*. Herein, we review what has been written on roosting in *discifera* and provide new data on roost sites, documenting that this disk-winged bat roosts in the cones formed by dead banana leaves and attached to the underside of palm fronds.

Thyroptera tricolor, the best known and most widely distributed of the species, has frequently been reported as roosting, head up, inside live, still partially rolled *Heliconia* leaves, sometimes of *Musa* (banana) and, occasionally of other genera. As noted above, this roosting predilection of *T. tricolor* has often been assumed to characterize *T. discifera* also, especially in the secondary literature. However, as outlined here, *discifera* has different roosting habits and perhaps never has been found in rolled new leaves.

Findley and Wilson (1974) stated "disk-winged bats are known to roost only inside the rolled new leaves in members of the banana family (Musaceae) or related plants" (p. 562) and that *Heliconia* and *Calathea* are "two genera that provided most bat roosts" (p. 563). Additionally (p. 569), they stated "*Thyroptera* may roost on other types of foliage than musaceous leaves, but none has ever been found in such situations" (but *Calathea* is not musaceous), and "This species is limited to rolled leaves of musaceous plants as roosting sites" (p. 570). In Wilson and Findley (1977:2), we read that *tricolor* is found "occasionally in *Calathea* (Marantaceae)" and that "Morphological specializations of the bats [*tricolor*] probably limit them to rolled leaves as roosting sites" (p. 3). Wilson (1978:2) wrote *tricolor*, unlike *discifera*, "roosts in rolled *Heliconia* leaves and is never found in the open." Kunz (1982:2) stated, "the ... disks ... of *Thyroptera tricolor* restricts [*sic*] this bat to roosting on the smooth inner surfaces of unfurled [*sic*] leaves ..."

Brosset and Charles-Dominique (1990:543) wrote concerning *tricolor*, "Observed in small groups, harems or bachelor ♂♂, not only in the classical roost of the species: the terminal buds [*sic*] of *Heliconia* and banana-trees, but also in such ... places as between tails of shirts drying on a wire, or between plastic sheets stocked in the station-houses. This species ... adopts artificial [roosts] ... in human settlements ... which suggests that *Thyroptera* may sometimes be short of natural roosts." In this regard, an adult male *tricolor* (USNM 541439), taken in Chiriquí at Escopeta Camp, *ca*. 23 km NNE San Félix (= San Félix at 8° 17′ N, -81° 52′ W), *ca*. 900 m, was found alive and adhering to the front of an automobile on 1 July 1980 (R. Izor, *pers. comm.*). The surrounding area is mostly heavily grazed grassland with brush and/or scrubby forest along watercourses. Possibly the bat had been transported there on the vehicle.

Simmons and Voss (1998:133–134) found *tricolor* in the usual semi-furled live *Heliconia* leaves and also in scrolled, dead, hanging leaves of *Phenakospermum guyannense* (Strelitziaceae) along with semi-furled live leaves of the same species. Velazco *et al.* (2014:18) also mention *Phenakospermum* as providing roosts for *tricolor*. Velazco *et al.* (2021:128, 130), writing about *tricolor* in northeastern Peru, found six roosts "at the same locality ... all of them in the rolled new leaves of large *Heliconia* sp. ... about 3.5–4.5 m above the ground in young secondary growth ..." Group size ranged from 4 to "about 12."

Pine (1993:218), because of the great rarity of *lavali*, hypothesized that it might roost in the forest canopy. Morales-Martínez *et al.* (2021:476) stated, incorrectly, that Pine had specifically mentioned palms. Solari *et al.* (1999:155) wrote concerning *lavali* "caught from a palm more than 5 m high, where we suppose it was roosting," and Solari *et al.* (2004:293) wrote "probably roosts in palms." Reid *et al.* (2000:44–45) collected three *lavali*, each on a different occasion, in or adjacent to a *Mauritia* palm swamp. García *et al.* (2019:3) reported a specimen of *lavali* captured in a "morichal, junto a el tapón." Franger J. García (*in litt.*) informs us that in Venezuelan Spanish this means in a stand of the palm, *Mauritia flexuosa*, next to the dam.

Pérez *et al.* (2012:1107) reported Guatemalan national park personnel's having found a *tricolor* "inside a dry unfurled banana leaf" but surmised that it was "probably *Heliconia*." By "dry leaf" they presumably meant dead leaf. This is the only account that we know of that reports such a roost for *tricolor*.

Rosa *et al.* (2020:1) state that they "observed a *T. devivoi* colony of 15 living under a dead palm leaf." But (page 4) an estimated 10–15 individuals "dwelling inside the sheath of a dead palm leaf that was hanging in the forest canopy." Judging from their two figures (p. 3) and the "2.5 m height roost entrance facing downwards" (p. 5), the roost was not "hanging in the forest canopy." The roost, as figured, shows a cone-shaped configuration like that of the banana leaf cones described in later accounts here for *discifera*. The species of palm was not indicated. The bats were in the roost for at least four days (p. 1) and the locality was in Chapada das Mesas National Park, Carolina Municipality, Maranhão, Brazil (p. 2). Morales-Martínez *et al.* (2021:476) state that Rosa *et al*. incorrectly described "shelters" (plural) of *devivoi* (Rosa *et al*. also wrote that *Thyroptera* roost in "still furled" leaves). Morales-Martínez *et al.* (2021:476), however, thought that the bat captured from the colony reported by Rosa *et al*. might be a *lavali*, rather than *devivoi*, based on the figure showing no frosting on the venter. They also identified the skull figured by Rosa *et al*. as of a *Myotis*, rather than of a *Thyroptera*. They themselves (p. 473) reported a *lavali* mist-netted in an "open *Mauritia flexuosa* palm swamp" that had been cleared at La Chorrera, Amazonas, Colombia. They conclude (p. 476) "*lavali* is associated with swamp-forest habitats with high *Mauritia flexuosa* palms."

Gregorin *et al.* (2006:239) reported two specimens of *devivoi* as having been caught "under an eaté palm leaf" but didn't state if more had been present. Voss *et al.* (2016:12) indicate that Gregorin *et al*. reported *lavali* as roosting in vegetation, but this is not the case.

Two *Thyroptera wynneae* were recorded by Velazco *et al.* (2014:15, 18) as roosting in the dark interior of a lobe of a

partially rolled dead *Cecropia* (Urticaceae) leaf hanging by its petiole, about 2 m above the ground. This roosting site resembles those of *discifera*, as described later in this article, in dead leaves of the non-native banana plant.

Uncritical treatments of roosting in Thyroptera

Various authors have treated the genus as a whole, as then known, and including *discifera*, as roosting in partially rolled, live *Heliconia* and/or banana leaves: Dalquest and Walton (1970:174), Tello (1979), Hill and Smith (1984:212), Patterson (1992:18) citing Taddei (1988), and Rosa *et al.* (2020:2). Other somewhat more complicated uncritical comments follow:

Perhaps the first to write concerning *Thyroptera*'s roosting was Dobson (1878:347) who wrote "... is ... peculiar ... in possessing such highly specialized climbing organs as the adhesive disks." G. M. Allen (1939), wrote (confusingly) that *Thyroptera* are "at times found in the rolled fronds of bananas or in curled large leaves" and "one of their favorite roosting places is inside the long narrow tube formed by an unrolled banana frond." Cockrum (1962:250) cited Allen as stating that *Thyroptera* "usually roost individually" but there is no such statement in Allen's book. Krumbiegel (1955) published redrawn illustrations (of *tricolor*) from Carvalho (1940), and inexplicably, in Krumbiegel's renditions, most of the figured bats were inverted so that they are shown head-down. Matthews (1971), concerning both species of *Thyroptera* then known, stated "These bats roost singly or in groups of up to about half a dozen head upwards in the large curled, faded [?] leaves of heliconias, bananas and other plants," but gave no sources.

Eisentraut (1975:143), writing of the family as then known, stated that suction disks enable "these bats to maintain a firm hold on smooth branches and leaves and to crawl on them," but provided no sources. Eisentraut wrote further, "These bats prefer rolled-up leaves, for example, of bananas, for their sleeping site during the day; several ... can usually be seen sitting one behind the other, with their heads up" (p. 143–144).

Yalden and Morris (1975:220) wrote "Thyropterids ... rest in a head-upwards position, usually beside [*sic*] a curled leaf ..." Concerning *discifera*, Ascorra *et al.* (1993:547) wrote "This species is usually encountered in rolled leaves of *Heliconia* spp. or *Calathea* spp. but we found no individuals in our searches of these leaves [at a specific site in Perú]." They gave no sources and cited no observations to substantiate their comment.

Nowak and Paradiso (1983) and Nowak (1991, 1999) made no mention of differing habits in the species then known, and seemed to imply that all might be found in rolled leaves, and stated, incorrectly, that all might generally be found only one or two per shelter.

Bezerra et al. (2005:169) wrote "Thyropterids roost inside the rolled leaves of some species of Heliconiaceae ... Roosts inside curled leaves of ... (*Musa* sp.) have also been reported for *T. discifera*" and cited Wilson (1978), Torres *et al.* (1988), and Nowak (1999) for the latter comment.

de Lima and Gregorin (2007:141) write that *discifera* uses rolled banana and *Heliconia* leaves for shelters citing Kennedy (2002). Pérez *et al.* (2012:1107) incorrectly stated that Medellín *et al.* (1986) had recorded *tricolor* from an unfurled *Heliconia* leaf.

Lee's (2019:418) accounts of *Thyroptera* sometimes attribute habits of *tricolor* to the genus in general, etc. He wrote "... [*tricolor*] roost attached to the undersides [presumably meaning inner sides] of waxy furled leaves ... *Musa* ... *Heliconia*, *Calathea* ... and *Phenokospermum* (Streliziaceae), dead leaves of *Cecropia* ... and palm fronds ... Thyropterids must change roosts almost daily ... diameter of the furl becomes too great after a day or two. Disk-winged bats ... roost in a head-up position ... approximately 4 m aboveground."

Various authors have written that *Thyroptera* are restricted to the lowlands. The latest of these is Morales-Martínez *et al.* (2021:471) who wrote "*Thyroptera* species inhabit lowland, moist, Neotropical forests." However, authors have recorded *tricolor* from as high as 1,650 m, and Pine has observed disturbed *Thyroptera* exiting from a *Heliconia* leaf at 1,550 to 1,600 m in the Monteverde Reserve, Puntarenas, Costa Rica. Timm and LaVal (2018) reported that *tricolor* was common in the Lower Montane Rain Forest at 1,650 and higher at Monteverde, as well as in the Lower Montane Wet Forest (1,500 to 1,650 m), Premontane Wet Forest (1,300 to 1,500 m), Premontane Moist Forest (700 to1,300 m), and the Tropical Wet Forest (500 to 700 m) there along the Caribbean slopes of northeastern Costa Rica.

Helpful publications on the roosting habits of Thyroptera discifera

Of specimens captured by Robinson and Lyon (1901), fifteen were cataloged as USNM 102923–102928, 105419–105423, 143782–143784. The captures date from 17 and 21 July 1900 at San Julián, Distrito Federal, Venezuela, a settlement at about 10° 37′ N, -66° 50′ W, at sea level according to Paynter (1982) and located near Caraballeda, *ca*. 11 km E La Guiara on the Caribbean coast. Most of their labels we've seen state "in plantain" but the field catalog states at least some were caught "under dead leaves of plaintan [*sic*]." Eleven of these specimens form the basis of the name *Thyroptera discifera major* Miller, 1931. Robinson and Lyon (1901:156) wrote that one individual, "was placed under an inverted tumbler, to the vertical surface of which it adhered with ease, the vacuum spots under its disks glistening like globules of quicksilver." Concerning the bats caught on 21 July, "The young, although still nursing and clinging to their mothers, were able to fly with ease ... The surface of these disks appears to be constantly moist, so as to insure perfect contact with smooth surfaces ... Young nursing bats cling to their mother's neck or breast with claws and teeth and are carried about as she flies, even when they almost equal her in size and when their weight makes her flight labored

and slow ... the claws are so small and weak as to be almost useless; nevertheless, the young manage to hold on with no risk of falling. The mammae of the female are strap-like, broad and flat, 3 mm wide by 2 mm long. Seizing one in his teeth, the young holds on like a bulldog, dangling by the strength of his jaws alone. One of the young that was brought in hung in this way for twenty minutes, and in all that time made no effort to grasp its mother with its claws."

Thomas (1928:257) reported four males and seven females of *discifera* collected by Hendee at Cumeria [probably = Cumaría and Cumaria according to Tuttle 1970], Perú (-9° 51′ S, -74° 01′ W)—for more on this locality see Pine (1993). These bats were "caught roosting in banana leaf." John Edwards Hill of the British Natural History Museum informed Pine "The majority of [these] specimens ... are ... here and are BM(NH) 28·5·2·96–104. Collector's numbers 1290 and 1297 are not in this registration ... all are labelled 'Caught roosting in banana leaf' in accordance with Hendee's collector's notes which are also here, in the archive ... number 1290 has not been registered but is in the collection ... labelled 'Caught with 12 others roosting in banana leaf.'" Hendee's no. 1297 is now cataloged as FMNH 46160 in the Field Museum, its tag bearing the note "Caught with 12 others in banana leaf." This *may* mean that the specimen was one of thirteen bats captured of a group numbering more than thirteen or that there were thirteen bats roosting in the leaf but not all were captured. Only eleven specimens have been accounted for—the same number originally listed by Thomas as having been captured. Unfortunately, the phrase "roosting in banana leaf" is vague. It could refer to something other than a rolled, young banana leaf.

Hill noted "The collection contains a further series 28.7.21.18–25 (4 ♂♂, **4** ♀♀) from Iquitos [-3° 51′ S, -71°13′ W], Loreto, Peru, 400 ft., also collected by Hendee ... on 9 January 1928. These are marked 'In dry banana leaf' or (28.7.21.22) 'Roosting in dry banana leaf!'" These specimens were reported by Thomas (1928) but no natural history information was provided.

Wilson (1978:2) wrote "The only natural history information recorded for this species is that of Robinson and Lyon (1901) ... One group of 10 was caught by a native with a single sweep of his hand [= "with one grasp of his hand" according to Robinson and Lyon] as they roosted under [and hanging from] a dead banana leaf ... A second group of seven was subsequently captured in the same manner. Both groups contained [adult] males, [adult] females, and flying young. The month of capture for both groups was July." According to Robinson and Lyon, however, the native who caught the seven reported that two or three of the second group had escaped. Earlier, Wilson stated, "Both tightly clustered groups were found by natives who captured them by hand as the bats clung to the under surfaces of dead banana leaves. This roosting habit is quite different from that of *T. tricolor*, which roosts in rolled *Heliconia* leaves" (Wilson 1976:308, 310). Robinson and Lyon (1901:155), however, specified a "closely grouped" arrangement as having been observed by the native only for the first group taken—nothing being said about the roosting arrangement of the second group. It seems that the first group at least must not have been roosting single-file as *T. tricolor* does.

Wilson (1978:2) wrote, concerning both *discifera* and *tricolor*, "the colony structure seems similar, with various combinations of sexes and ages represented in a single group." Kunz (1982:14, 16) stated "Virtually nothing is known of the roosting habits of *T. discifera*, but, judging from the similarity of its foot and wrist disks, its roosting habits are probably similar to those of *T. tricolor*."

Hall (1981:181) wrote, "*T. discifera* so far has been found clinging to the under surface of banana leaves. *T. bicolor* roosts in rolled leaves of *Heliconia*." Hall mistakenly used the word *bicolor* here instead of *tricolor*.

Czaplewski (1987:25) wrote that "*Thyroptera discifera* ... unlike *T. tricolor*, roosts in more open situations beneath leaves ..."

Torres *et al.* (1988:434) were apparently the first to clearly describe *discifera* as roosting in a hanging dead banana leaf. They found a group of 15 *discifera* on 25 January 1985 "in a banana plantation at La Cayoba, ca. 30 km N Magdalena [presumably = Magdalena at -13° 20′ S, -64° 08′ W at 233 m, as given by Paynter (1992)] on the E bank of the Itonamas River," Prov. Itenez, Depto. Beni, Bolivia. "The bats were inside a dry, furled banana leaf suspended 1.6 m above the ground. The sex ratio of 14 individuals was four males and 10 females. Of 10 specimens studied in detail, three were young with cartilaginous, evenly tapered metacarpo–phalangeal joints and seven were adults with knobby joints." These authors' observations are in keeping with the ones reported in this paper concerning *discifera* in Costa Rica.

Emmons (1990:83, 1997:92) wrote that "*T. discifera* is poorly known, but it has been found roosting beneath open, dead banana leaves."

Patterson (1992:18) reported two specimens of *T. discifera* "secured the same day from the leaves of banana trees" at Aveiros ("= Aveiro; -3° 15′ S, -55° 10′ W; right bank of lower river [Tapajós] opposite Boim"; p. 6).

Velazco *et al.* (2014:19) wrote that possibly thyropterids roosting in downward opening roosts may hang head down. They also noted that *tricolor* was the only *Thyroptera* known to roost in partially rolled up *Heliconia* and other green leaves.

Turcios-Casco *et al.* (2020:422) provided a photo of a dead, shredded, hanging "*Musa* × *acuminata*" leaf in Costa Rica and which had a colony of *discifera* in it, and a photo of individuals inside. The situation seems to have been in every way similar to some observations given below.

Previously unpublished and new observations on roosting behavior in T. discifera

On 3 November 1983, Toby V. Barrett (*pers. comm.*) captured five *discifera* at Balbina (*ca.* -1° 50′ S, -59° 30′ W), Ama-

zonas, Brazil (Field numbers for the bats, an adult female, an immature female, and three immature males, all in fluid, were "morcegos 4–8." These specimens are currently uncataloged in the Field Museum). The five were part of a group of no more than 12 attached to the underside of a green leaf of a palm, *Mauritia carana*. The bats were about 12 m above ground and were exposed, visible from the ground, and were collected by cutting down the palm. A frond of *Mauritia carana* consists of radiating strap-like leaflets. The bats were hanging underneath one leaflet along a mid-portion of its length, but some may also have been attached to a corresponding section of an adjacent leaflet (there is some ambiguity in notes and diagrams developed in the course of Pine's communication with Barrett when the latter's memory was fresh). Although Barrett wasn't sure, he thought that each bat was separated from its fellows rather than being in contact with any of them. The collecting locality was characterized by "campina" vegetation and was low-lying but not flooded. The substrate was a wet white sandy soil, possibly a low-humic gley or a quartz sand. The vegetation did not exceed 20 m in height and included many palms (*Mauritia carana*, *Euterpe* sp., and *Desmoncus* sp.) along with numerous *Glycoxylon* (Sapotaceae).

On 30 November 2019, a group of 5 to 7 *discifera* was found in a dry, semi-furled banana leaf at Sylvan Camp and Falls (8.66° N, -83.14° W) in Puntarenas Province, in southwestern Costa Rica by Reid and Jon Hall. Reid had previously observed a bat flying low in this banana plantation and decided to search for bats, focusing on semi-furled, in-a-cone-shape, leaves (as observed by Reid in the painted woolly bat, *Kerivoula picta*, in Thailand). The roost was a cone with the apex at the top closed, and with the lower opening about 1.7 m above ground. The bats were huddled together and roosting in a roughly horizontal manner such that only the backs were visible. One bat, a male, was captured for photos. Unlike most roosting bats, these bats can be removed from the roost without the other bats exiting.

On 20 December 2019, a second observation was made in the same banana patch at Sylvan Camp and Falls, during a bat bioblitz (short duration census of species). Nils Bouillard and Loren Ammerman were present, along with eight students. The banana field was searched by all participants and one roost was found (by Rhianna Connie Dix) at a locality about 100 m from the first roost. All the roost members were caught. There were 7 bats, 6 males and 1 female, and the identification confirmed as *discifera*. This would seem to be an unusual combination sex-wise, and the individuals were not aged. The roost was similar in appearance to the first roost, and at about the same height above ground.

At Cocalito Beach, Drake Bay, near La Paloma Lodge (8° 41′ 46″ N, -83° 40′ 42.8″ W), Puntarenas Province, in southwestern Costa Rica, in late November 2020, Gómez and Tracie Stice observed a colony of *discifera* roosting in a dead, brown, vertically hanging portion of a banana leaf, dangling from the main stalk, and that was partially rolled to form a bugle-like structure with the big open end at the bottom. This roost site was similar to the roosts reported above as at Sylvan Camp and Falls. The cone was lopsided with length 53 cm on one side and 41 cm on the other. The entrance had a diameter of 20 cm and a height of 240 cm from the ground. Stice reports that (*in litt*.) "As we gazed up, into a shadowy fold, we could see more than a half-dozen fluffy rear-ends packed into the leaf." Thus, their heads were upward, unlike the usual situation in bats but as in *tricolor*. The bats were observed for only one day. On returning a few days later, it was discovered that the leaf had fallen off. Upon searching several other dead leaves in the banana grove on the occasion of the observations made on that single day and on later occasions, no other roost was found.

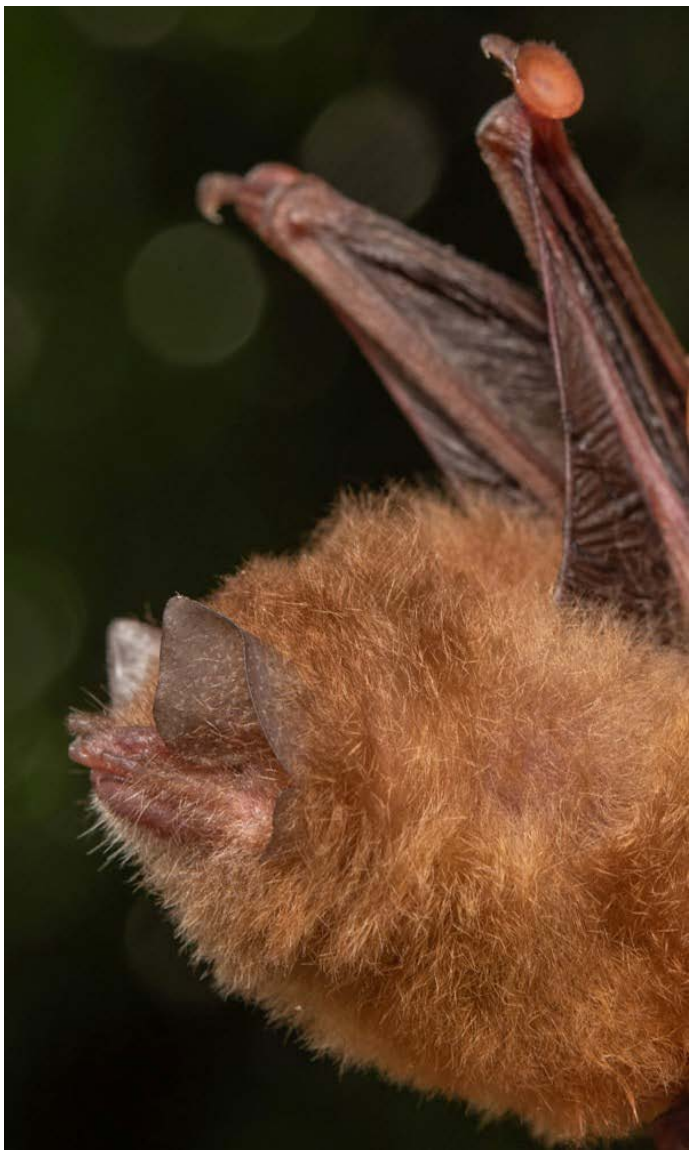

Figure 1. An adult male disk-winged bat, *Thyroptera discifera*, that was observed as part of a roosting colony in a portion of a shredded dead banana leaf and formed a cone-shaped refuge. Note the similar dorsal and ventral coloration and the circular, adhesive disk (seen here at an angle) on the wrist just below the thumb. Photograph taken at Sylvan Camp and Falls, Puntarenas Province, southwestern Costa Rica on 13 January 2020; courtesy of Twan Leenders.

At Sylvan Camp 13 January 2020, a group of students and biologists, led by Reid and Twan Leenders, located *discifera* in the same roost as on 20 December. One bat, a male, was taken out for photos (Figure 1). Since 13 January, the bats have not been located at Sylvan Camp, despite numerous attempts by groups of students and bat enthusiasts. However, on 23 March 2022, Vino de Backer and one other person observed a bat leaving one of the leaf cones in the same banana patch, presumably *discifera*.

Roosting *discifera* were discovered by Gómez at a second site near La Paloma Lodge (8° 41′ 40.8″ N, -83° 40′ 40.5″ W) starting on 20 February 2021 and observed for over a month (Figure 2). The bats stayed in the same roost cone except that one individual was observed on 7 March 2021 in a lower cone formed from the same dead leaf and was assumed to have moved there from the colony above.

Figure 2. A "morado" banana (red banana in English, *Musa acuminata*) in a patch that also includes plantains near La Paloma Lodge at Drake Bay, Puntarenas Province, Costa Rica. Portions of shredded dead leaves hanging from the trunk roll back on themselves to create dark, cone-shaped, roosting sites for bats. The top arrow points to where the colony of perhaps nine disk-winged bats, *Thyroptera discifera*, was observed roosting for more than a month during February–March 2021. The lower arrow shows where a single individual was found roosting for a single day. Photograph taken on 7 March 2021 by Gómez.

Figure 3. Two *Thyroptera discifera* roosting in a portion of a dead banana leaf. There had been additional bats in that cone earlier in the evening, but they had already exited. Photograph taken near La Paloma Lodge Drake Bay, Costa Rica on 20 February 2021 by Gómez.

It stayed there for one day. The main conical roost was lopsided with length 50 cm on one side and 40 cm on the other (Figure 3). Height from ground to entrance was 169 cm with roost opening 20 cm wide. The cone that was occupied for one day by a single bat and that was beneath the other cone was of about the same dimensions. Although the bats were not handled, the number occupying the roost varied from only 2 to 5 some days to perhaps 10 or more on others.

Measurements of a roost cone discovered 4 November 2021 at Drake Bay included height 51 cm on longest side, 40 cm on shortest side, and roost opening 20 cm wide; height to entrance from ground 121 cm. The bats did not attempt to fly off when disturbed. A roosting group containing perhaps nine individuals was observed (Figure 4).

The observations of *discifera* using banana leaves as roosts is of interest in that it represents the incorporation of a non-native species for roost sites. The banana plant, also used by *tricolor*, was introduced into the New World tropics within the last 450 years.

Timm has observed *Artibeus jamaicensis* and *Carollia* also roosting in hanging cones of dead banana leaves.

It is clear that, aside from the situation with *tricolor*, there's a good deal that's still unknown concerning the favored roosting sites of the species of *Thyroptera*, and in spite of the new information presented here, that includes *discifera*. There are indications, however, that, in addition to *discifera*, *lavali* and *devivoi* may, at the least, roost occasionally in palms, especially palms of the genus *Mauritia*. The only records of *discifera*'s roosting or possibly roosting in association with native Neotropical plants are with their roosting under dead "plantain" leaves, which could mean either *Heliconia* or "cooking banana," and under a leaf of the palm *Mauritia carana* as recorded here. Otherwise, all certain records are of animals roosting under-

Figure 4. A colony of perhaps 9 *Thyroptera discifera* roosting in a portion of a dead banana leaf. This is the same plant identified in Figure 2 above and the bats were roosting in the top cone shown by the white arrow. Photograph taken near La Paloma Lodge, Drake Bay, Costa Rica on 4 November 2021 by Gómez.

neath dead banana leaves or inside shelters formed from such leaves. In areas where bananas are grown, it may be especially difficult to find *discifera* roosting in association with native plants. The finding of a *wynneae* inside a dead *Cecropia* leaf shelter similar to the dead banana leaf cones described here may indicate one sort of situation that *discifera* may be found in.

Voss *et al.* (2016:16) noted that no *Thyroptera* had ever been found in any natural roost other than in/on leaves, and that is in keeping with our findings.

Specimens examined of Thyroptera discifera

These include 33 specimens listed by Pine (1993:222) and the 9 listed below. The latter are all in the (U.S.) National Museum of Natural History, Washington, D.C. [USNM]. All skins with skulls unless otherwise indicated: NICARAGUA. Región Autónoma de la Costa Caribe Sur [formerly Zelaya]: Escondido River, 50 mi from Bluefields [See Genoways and Timm (2019:484) concerning this locality], 1 M, 2 F (USNM 51538–51540—in fluid but skull of 51538 removed). PANAMÁ. Chiriquí: 14.5 km NW El Volcán, Finca Santa Clara, 1200–1500 m [El Volcán = "El Hato del Volcán and Lava Flow" at 8° 47′ N, -82° 38′ W (Fairchild and Handley 1966)], 1 F (USNM 537583—in fluid); Panamá Oeste (formerly Canal Zone): Barro Colorado Is. (PC 21) [= Barro Colorado Island at 9° 09′ N, -79° 51′ W, Fairchild and Handley 1966], 1 F (USNM 14799). VENEZUELA. Distrito Federal: San Julian [= San Julián at sea level and at 10° 37′ N, -66° 50′ W (Paynter 1982)], 1 F [USNM 105419—fluid specimens USNM 102923–102925 from this locality and with sexual composition unrecorded by Pine (1993) are 2 M, 1 F].

Dedication

We dedicate this paper to mammalogist and natural historian par excellence, Dr. Alfred L. Gardner—field biologist first and foremost.

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