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New records of *Sturnira bakeri* in northwestern Ecuador: field notes about the species

Nuevos registros de *Sturnira bakeri* en el noroccidente de Ecuador: notas de campo sobre la especie

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Despite *Sturnira bakeri* is a recently described species, little is known about its intraspecific variation, feeding and flying habits, and reproductive patterns. This research aimed to confirm the presence of this species in northwestern Ecuador by comparing voucher specimens with the available literature. Several specimens of *S. bakeri* were captured in northwestern Pichincha. I collected 2 vouchers, but I focused on a variable specimen (a specimen with some different traits) and compared it with the original species description. Field notes on their physical appearance, reproductive status and other habits are included. The presence of *S. bakeri* in northwestern Ecuador is confirmed based on craniodental characters (such as the presence of bicuspidate upper inner incisors, serrated inner cusps on the lower molars, oval sphenorbital fissure, basisphenoid pits shallow and divided by a midline septum) and measurements similar to previous studies, but with some morphological differences like the shape of the zygomatic arches. *Sturnira bakeri* was found in secondary forests and pastures, it lives in sympatry with *S. ludovici*, and eats fruits of some plant species: *Piper*, *Vismia*, *Cecropia*, *Drymonia*, *Anthurium* and *Psychotria*. Variable specimens complicate species taxonomical identification and species definition. The new records with data about diet and habits help to fill gaps in knowledge about the species in this zone of the neotropics.

Key words: Diet; habits; reproduction; sympatry; taxonomy.

A pesar de que *Sturnira bakeri* es una especie descrita recientemente, se sabe poco sobre su variación intraespecífica, hábitos de alimentación y vuelo, y patrones reproductivos. Esta investigación tuvo como objetivo confirmar la presencia de esta especie en el noroccidente de Ecuador mediante la comparación de especímenes voucher con la literatura disponible. Varios ejemplares de *S. bakeri* fueron capturados en el noroccidente de Pichincha. Recolecté 2 vouchers, pero me enfoqué en un espécimen variable (un espécimen con algunas características diferentes) y lo comparé con la descripción original de la especie. Se incluyen notas de campo sobre su apariencia física, estado reproductivo y otros hábitos. La presencia de *S. bakeri* en el noroccidente de Ecuador se confirmó por características cráneo-dentales (como la presencia de incisivos internos superiores bicúspides, cúspides internas aserradas en los molares inferiores, fisura esfenorbital ovalada, fosas basiesfenoideas poco profundas y divididas por un septo) y medidas similares a estudios previos, pero con algunas diferencias morfológicas como la forma de los arcos cigomáticos. *Sturnira bakeri* fue registrada en bosques secundarios y pastizales, vive en simpatría con *S. ludovici*, y come frutos de varias especies de plantas: *Piper, Vismia, Cecropia, Drymonia, Anthurium* y *Psychotria*. Los especímenes variables complican la identificación taxonómica y la definición de una especie. Los nuevos registros con datos sobre dieta y hábitos ayudan a llenar vacíos de conocimiento sobre la especie en esta zona del neotrópico.

Palabras clave: Dieta; hábitos; reproducción; simpatría; taxonomía.

Sturnira bakeri was formally described as a new species in 2014, the distribution of the species was restricted to the tropical dry forests from the southwestern coast of Ecuador (Velazco and Patterson 2014). A further study expanded its distribution towards the northwestern Perú, in tropical humid forests (Sánchez and Pacheco 2016). Another study reviewed museum specimens and determined the presence of the species in tropical dry and humid forests from southwestern Colombia, the same study reported voucher specimens with characters different to the original species description (Montoya-Bustamante *et al.* 2017).

Many species' original descriptions do not consider the natural intraspecific variation among individuals. They are made on just few specimens, which could hinder taxonomic identification (Jarrín and Clare 2013). The *S. bakeri* original description was made based on 3 specimens (Velazco and Patterson 2014). There are other similar examples of this in the *Sturnira* genus such as *S. aratathomasi* that was described with 3 specimens, *S. sorianoi* described with 3 specimens, and *S. mistratensis* described with only 1 specimen (Peterson and Tamsitt 1968; Vega and Cadena 2000; Sánchez-Hernández *et al.* 2005).

Another problem with species like *S. bakeri* is a lack of information about their feeding and flying habits, as well as their reproductive patterns (Velazco and Patterson 2014). A great part of the diet in Phyllostomid bats is known thank to seed dispersal studies (Saldaña-Vázquez *et al.* 2014; Arias and Pacheco 2019), but the taxonomical identification of seeds dispersed by bats is fairly difficult, which is caused by the limited number of field guides in neotropics about this topic (Kirkbride *et al.* 2006; Lobova *et al.* 2009; Magalhaes de Oliveira and Pereira 2016). Additionally, the diet of Phyllostomid bats is highly variable in space and time (Mello *et al.* 2011). Flying habits allows to understand which habitats or ecosystems are commonly frequented by bats, this is useful when researchers want to look for a specific species (Tirira 2017). Reporting pregnant females or females with juveniles, at specific times of the year, are the base for other researchers to search reproductive patterns, which can be useful in conserving species (Tirira and Burneo 2012).

This research aims to present a variable specimen of *S. bakeri* with interesting characters and compare it with other studies, thus supporting the presence of *S. bakeri* in northwestern Ecuador and contributing with the knowledge of intraspecific variation. I present some data about biological measurements to help in the identification of this species in this part of neotropics. I also provide field notes about feeding and flying habits, and reproductive status of specimens recorded.

As a part of the research project called "Effects of fragmentation on the taxonomic, functional, and phylogenetic structure of mammal communities in northwestern Ecuador", supported by Universidad Central del Ecuador (UCE), I had the opportunity to study living specimens of *S. bakeri* captured between January and August 2021. I captured bats using mist nets in 3 agro-ecological reserves: Pambiliño, Chontaloma and Mashpi Shungo; from northwestern Pichincha at the Andean Chocó. The reference ecosystem was the lowland evergreen forest (LEF) of the western Andes Mountain range, the weather here is quite warm and it presents intense rains most of the year (MAE 2013). I used 4 habitats to capture bats: primary forest (3 nights), secondary forest in natural regeneration (11 nights), secondary forest in assisted regeneration (4 nights) and pastures for cattle (3 nights). Two vouchers were collected and deposited in the Museo Ecuatoriano de Ciencias Naturales (MECN 6797 and MECN 6811) of the Instituto Nacional de Biodiversidad (INABIO) with the research license given by the Ministerio del Ambiente del Ecuador (MAE-ARSFC-2020-0.512). The specimen MECN 6811 held the principal characteristics of the species, but MECN 6797 had some craniodental differences, being a variable specimen.

I focused on the variable specimen (MECN 6797) to compare it with *S. bakeri* original holotype description from the mammal collection of Museo de Zoología de la Pontificia Universidad Católica del Ecuador (QCAZ; Velazco and Patterson 2014), and 2 later descriptions of the species. The first used specimens from the collection of Museo de Historia Natural de la Universidad Nacional Mayor de San Marcos (MUSM; Sanchez and Pacheco 2016), and the second used specimens from the collection of Universidad del Valle (UV; Montoya-Bustamante *et al.* 2017). The weight was taken in grams with a digital balance for both living specimens and vouchers. The age was determined by seeing the fused degree of hand-wing epiphyses (Jarrín and Kunz 2011). The body and craniodental measurements were taken in millimeters with a digital caliper (Appendix 1, 2; McCarthy *et al.* 2006).

Besides morphological measures, I collected seeds from captured specimens. A common method to obtain bat-dispersed seeds is to keep animals captured in mist nets into cloth bags for 1 hr to defecate, bats usually digest their food during this time because of their fast metabolism. I preserved the seeds in Eppendorf tubes with 70 % alcohol, and each sample was labeled with a unique number to avoid confusion. Although this is a useful method to obtain seeds, it is fairly common that bats usually defecate when they are recently captured in mist nets due to stress, I also preserved these samples (Arias and Pacheco 2019).

I dried all samples in paper envelopes inside a drying machine in the laboratory. Then I separated the dried seeds from other fecal residues. The taxonomical identity of the seeds was determined under the microscope using field guides (Kirkbride *et al.* 2006; Lobova *et al.* 2009; Magalhaes de Oliveira and Pereira 2016). The seeds were deposited at the MECN. I created a map with the known records of the species (Velazco and Patterson 2014; Sánchez and Pacheco 2016; Montoya-Bustamante *et al.* 2017; Romero 2019), and potential records (GBIF 2022; Figure 1). Finally, this note includes some data about the species feeding and flying habits, as well as data about reproductive status.

I captured 14 specimens of *S. bakeri* in the sampling sites. The variable specimen was different from the *S. bakeri* original description in characters such as: the absence of process of glenoid fossa, poorly developed sagittal crest, zygomatic arches with a little concavity at the middle, and clinoid process absent. Despite these differences, it holds the main characteristics used in the original description: serrated inner cusps on the lower molars, bicuspidate upper inner incisors, oval sphenorbital fissure, basisphenoid pits

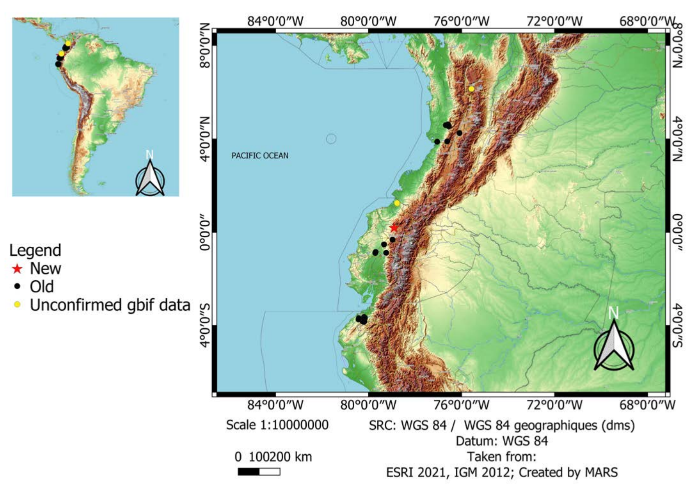

Figure 1. Current distribution of *Sturnira bakeri* in South America. It probably exists in western Andes range from western slopes of Colombia to northwest Perú less than 2,000 m.

Table 1. Comparisons of craniodental measurements (mm) in *Sturnira bakeri* from northwestern Ecuador.

Measurements	MECN 6797 ♀	(Velazco and Patterson 2014) Holotype QCAZ 1463 ♀	(Sánchez and Pacheco 2016) (*n* = 31)	(Montoya-Bustamante *et al.* 2017) (*n* = 7)
Braincase breadth	10.12	10.4	9.88 - 10.92	10.49 - 10.87
Condylocanine length	19.7	20.3	19.41 - 21.22	19.87 - 20.65
Condyloincisive length	20.5	21.1	19.96 - 21.97	20.54 - 22.5
Dentary length	14.37	15	14.32 - 15.86	14.07 - 15.07
Greatest length of skull	21.74	22.7	21.96 - 23.86	21.9 - 23.5
Length of mandibular toothrow	6.98	7.7	6.95 - 8.05	7.36 - 7.96
Postorbital breadth	5.83	5.9	5.58 - 6.42	5.8 - 6.21
Mastoid breadth	11.82	11.9	11.37 - 12.19	11.96 - 12.46
Maxillary toothrow length	6.77	6.9	6.44 - 7.11	6.52 - 7.23
Width at M2	8.13	8.3	7.87 - 8.65	7.62 - 8.29
Zygomatic breadth	12.98	13.5	12.87 - 14.34	13.43 - 14.33

shallow and divided by a low midline septum, tetracolor fur on the back and tricolor on the belly, and the IV metacarpal shorter than the III metacarpal (Velazco and Patterson 2014; Figure 2). The measurements of the voucher specimen were similar to those presented in previous studies (Table 1).

Sturnira bakeri can vary in dorsal fur coloration from light brown to slightly darker brown. Ventrally it can be light brown, whitish and even yellowish in appearance. Some adult individuals are totally grayish, this especially occurs in juvenile and sexually immature (Figure 3). In general, the lateral folds of the ears (pinna) are poorly marked, and some specimens lack them completely.

Pregnant females were captured in April (*n* = 2; the body measurements recorded for all the specimens are shown in Table 2). I found the species flying on secondary forests in natural regeneration (*n* = 5), secondary forest in assisted regeneration (*n* = 4), in pastures for cattle (*n* = 5), but it was not found in primary forest. *Sturnira bakeri* lives in sympatry with other species of the same genus such as *S. ludovici* (Velazco and Patterson 2014). I found 8 different seeds in the feces of the captured bats: *Anthurium* spp., *Vismia* spp., *Drymonia* sp., *Piper aduncum*, *Piper* sp., *Psychotria* sp., *Solanum* sp., and *Cecropia* spp. Seeds like *Drymonia* sp., *P. aduncum,* and *Psychotria* sp., are shared in diet with *S. ludovici* (Kirkbride *et al.* 2006; Lobova *et al.* 2009; Magalhaes de Oliveira and Pereira 2016; Figure 3).

The taxonomical identification of variable specimens is difficult when original descriptions are based on few specimens, this is because it fails in capturing all the possible natural intraspecific variation of species (Jarrín and Clare 2013). A species could be variable across different biogeographic distributions, complicating the taxonomical identification and compromising the species definition (Calderón-Acevedo *et al.* 2022). In fact, some characteristics could be variable depending on the development stage and sex, as example, it has been reported that there exists age and sex variation in skull characters in many mammalian species, including the human beings (Šrámek and Benda 2014; Avelar *et al.* 2017; Voyta 2017). This study, added to previous studies, show that *S. bakeri* can vary in morphology between different zones in the Neotropics (Sánchez and Pacheco 2016; Montoya-Bustamante *et al.* 2017), which will facilitate identification for other researchers. I consider that the best characteristics to identify *S. bakeri* are: serrated inner cusps on the lower molars and bicuspidate upper inner incisors, oval sphenorbital fissure, shallow basisphenoid pits, medium size (average ± standard deviation, and range and number of individuals in parenthesis; see Appendix 1 for measurements): FA = 43.42 ± 1.59 (41.11 - 47.32; *n* = 24), GLS = 22.50 ± 0.54 (21.74 - 23.5; *n* = 9), CIL = 21.24 ± 0.58 (20.5 - 22.5; *n* = 9), these data are based in sizes

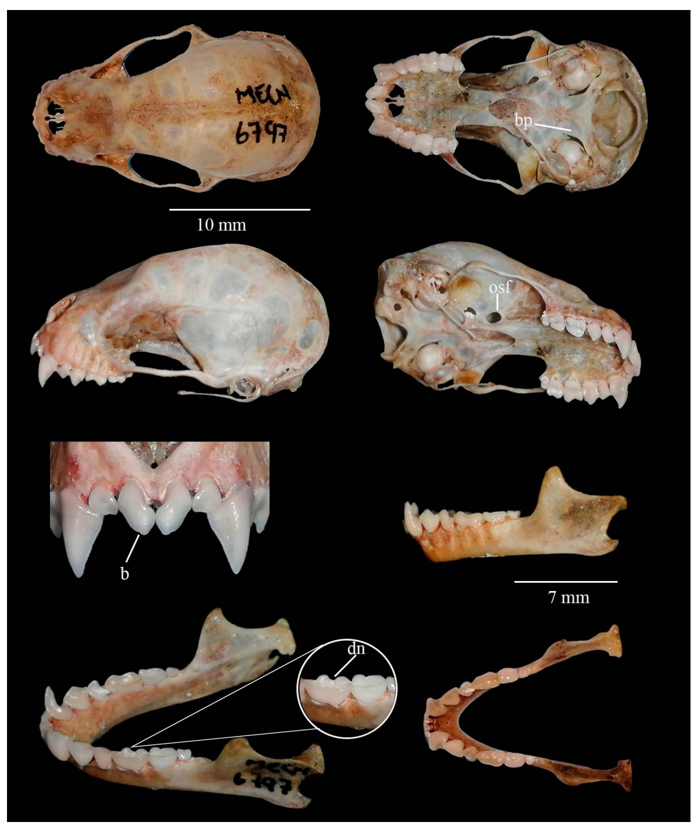

Figure 2. Details from the skull and jaws of *Sturnira bakeri* (MECN 6797). bp = basiesphenoid pits are shallow and divided by a low midline septum; osf = oval sphenorbital fissure; b = bicuspidate upper inner incisors; dn = deep notch at lower molars.

Table 2. Body measurements and another data for *Sturnira bakeri* captured in northwestern Ecuador. FA = Forearm length, EL = Ear length, HF = Hind foot length, TL = Total length, W = Weight on gr., Rep. S. = Age and / or Reproductive state.

Specimens	FA	E	HF	TL	W	Sex	Rep. S.
S. bakeri MECN 6797	41.81	13.56	12.36	55.8	17	♀	Adult
S. bakeri MECN 6811	43.32	13.71	12.4	59.73	23	♀	Adult
S. bakeri	44.7	13.71	13	55.78	24	♀	Adult
S. bakeri	45.63	14.86	14.4	63.15	23	♀	Pregnant
S. bakeri	41.81	13.56	11.5	55.8	17	♀	Juvenile
S. bakeri	47.32	10.25	11.1	69.56	25	♀	Pregnant
S. bakeri	44.83	12	11.3	57.53	18	♂	Juvenile
S. bakeri	43.14	12.1	11.6	58.42	25	♀	Adult
S. bakeri	44.31	11.19	11.14	60.84	26	♂	Adult
S. bakeri	41.3	11.1	11.5	59.35	20	♀	Adult
S. bakeri	43.15	14.52	10.52	64.98	28	♂	Adult
S. bakeri	41.95	11.81	11.18	61.36	23	♂	Adult
S. bakeri	43.55	11.88	12.56	55.18	22	♂	Adult
S. bakeri	44.07	12.36	11.43	52.75	21	♂	Adult
Minimum	41.3	10.25	10.52	52.75	17	-	-
Maximum	47.32	14.86	14.4	69.56	28	-	-
Mean	43.64	12.62	11.86	59.30	22.29	-	-
Standard deviation	± 1.67	± 1.38	± 1.00	± 4.47	± 3.36	-	-

from this study and previous studies (Velazco and Patterson 2014; Montoya-Bustamante *et al.* 2017), and a restricted distribution to the western slopes of the Andes (Jarrín and Clare 2013; Velazco and Patterson 2014).

Despite *S. bakeri* is considered as a least concern species (Tirira 2021), there exist threatens for the populations of the species in this part of neotropics due to fast habitat fragmentation in the Andean Chocó, which is caused by cattle ranching, agriculture, deforestation and gold mining activities (Jarrín and Kunz 2011). Other places where the species is known like the western ecosystems of tropical dry forest from Ecuador and Perú, are near to disappear due to cattle ranching and agriculture (MAE 2013), more studies will be necessary for monitoring the status conservation and reproductive patterns of the species.

In addition to the cited vouchers, biogeographical and genetic evidence supports *S. ludovici* presence in the western slopes of Ecuador (Jarrín and Clare 2013; Velazco and Patterson 2013; Molinari *et al.* 2017). The information about diet could be useful to understand niche partition with sympatric species such as *S. bakeri* (Macarthur and Levins 1967), but it is difficult to understand in which dimension of the niche they exactly differ without further studies. There is a hypothesis about that many bats differs in the temporal use of fruits depending on the state of ripeness (Freeman 1988), the fruit mass, size and hardness have been considered as important factors affecting the dietary specialization for Phyllostomid bats (Saldaña-Vázquez *et al.* 2014), this suggest that serrated inner molars on *S. bakeri* could be useful for hard not-quite ripe fruits, while flattened inner molars in *S. ludovici* could be useful for soft ripe fruit. Current research considers that there exist intrinsic factors (such as feeding behavior, mouth morphology, bite force and digestive physiology) an extrinsic factor (such as fruit physical characteristics, ingestible material of fruits, fruit secondary metabolites, fruit nutrients and energy, and spatio-temporal availability of fruits) determining the dietary specialization and community structure in Phyllostomid bats (Saldaña-Vázquez *et al.* 2014). Bats from the

Figure 3. Natural color variation and diet of *Sturnira bakeri*. From left to right: A-C = three adult males (the first male lacks lateral fold of the ears, third male has grayish skin). D = pregnant female, E-F = *Anthurium* spp., G-I = *Vismia* spp., J = *Drymonia* sp. , K = *Piper aduncum*, L = *Piper* sp., M = *Psychotria* sp., N = *Solanum* sp., O-P = *Cecropia* spp., Blue grids scales are 1 mm x 1 mm.

genus *Sturnira* have been considered to be specialist in the consume of *Piper* and *Solanum,* other species preferred by these bats are *Ficus*, *Cecropia* and *Vismia* (Saldaña-Vázquez *et al.* 2014; Arias and Pacheco 2019). The dietary items identified as *Anthurium, Psychotria,* and *Drymonia* are new for the diet composition of the genus.

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Appendix 1

Craniodental and body measurements used for this research.

Measurements	Description
Ear length (EL)	Distance from ear notch to ear tip.
Forearm length (FA)	Distance from the elbow (tip of the olecranon process) to the wrist including the carpals (this measurement is made with the bat wing at least partially folded).
Hind foot length (HF)	Distance along foot from anterior edge of calcar to most distant claw.
Total length (TL)	Dorsally, distance from tip of the last vertebra to nose tip.
Braincase breadth (BB)	Greatest breadth of the globular part of the braincase, excluding mastoid and paraoccipital processes.
Condyloincisive length (CIL)	Distance between a line connecting the posteriormost margins of the occipital condyles and the anterior most point on the upper incisors.
Condylocanine length (CCL)	Distance between a line connecting the posteriormost margins of the occipital condyles and a line connecting the anteriormost surface of the upper canines.
Dentary length (DENL)	Distance from midpoint of condyle to the anteriormost point of the dentary.
Greatest length of skull (GLS)	Distance from the posteriormost point on the occiput to the anteriormost point on the premaxilla (excluding the incisors).
Length of mandibular toothrow (MANDL)	Distance from the anteriormost surface of the lower canine to the posteriormost surface of m3.
Mastoid breadth (MB)	Greatest breadth across the mastoid region.
Maxillary toothrow length (MTRL)	Distance from the anteriormost surface of the upper canine to the posteriormost surface of the crown of M3.
Postorbital breadth (PB)	Least breadth at the postorbital constriction.
Width at M2 (M2-M2)	Greatest width of palate across labial margins of the alveoli of M2s.
Zygomatic breadth (ZB)	Greatest breadth across the zygomatic arches.

Appendix 2

Craniodental and body measurements considered in this study. See descriptions in Appendix 1. Modified from Velazco and Patterson (2014).