# Invisible but identifiable: p-chips as a reliable marking method for Amazonian bats

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A - Research concept and design, B - Collection and/or assembly of data, C - Data analysis and interpretation, D - Writing the article, E - Critical revision of the article, F - Final approval of the article

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**Abstract:**
Marking techniques are essential for studying bat ecology and informing conservation efforts, yet many existing methods present challenges related to size, tag detectability, and long-term retention. p-Chips, ultra-miniaturized transponders detectable via red laser light, offer a promising alternative to traditional banding or passive integrated transponder (PIT) tags. While their use has been successfully demonstrated in captive bats, their effectiveness in free-ranging populations remains largely untested. We individually tagged 31 species of bats with p-Chips during a 3-year study in the Peruvian Amazon. We documented 88 recaptures, with all p-Chips remaining functional over both short-term (within the same sampling season, ≤ 40 days) and long-term (across sampling seasons, more than 170 to more than 850 days) periods. Notably, no adverse effects such as scarring or tissue damage were observed. Red light-emitting diode (LED) illumination facilitated rapid visual detection of tags, reducing handling time. These findings support the use of p-Chips as a viable, detectable, minimally invasive, and cost-effective alternative to PIT tags, particularly for small-bodied species. We recommend further research to optimize p-Chip technology for broader application in wildlife tracking and conservation.

**Keywords:** technology, forearm, Chiroptera, mark-recapture, wild bats, long-term mark.

**Received:** 2025-05-14
**Revised:** 2026-04-11
**Accepted:** 2026-04-11
**Final review:** 2026-03-02

**Short title**
p-Chip marking in free-ranging Amazonian bats

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HYSTRIX
the Italian Journal of Mammalogy

# Invisible but Identifiable: p-Chips as a Reliable Marking Method for Amazonian Bats

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## Abstract

Marking techniques are essential for studying bat ecology and informing conservation efforts, yet many existing methods present challenges related to size, tag detectability, and long-term retention. p-Chips, ultra-miniaturized transponders detectable via red laser light, offer a promising alternative to traditional banding or passive integrated transponder (PIT) tags. While their use has been successfully demonstrated in captive bats, their effectiveness in free-ranging populations remains largely untested. We individually tagged 31 species of bats with p-Chips during a 3-year study in the Peruvian Amazon. We documented 88 recaptures, with all p-Chips remaining functional over both short-term (within the same sampling season, ≤ 40 days) and long-term (across sampling seasons, more than 170 to more than 850 days) periods. Notably, no adverse effects such as scarring or tissue damage were observed. Red light-emitting diode (LED) illumination facilitated rapid visual detection of tags, reducing handling time. These findings support the use of p-Chips as a viable, detectable, minimally invasive, and cost-effective alternative to PIT tags, particularly for small-bodied species. We recommend further research to optimize p-Chip technology for broader application in wildlife tracking and conservation.

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## Introduction

Individual identification of bats is critical for applied conservation research programs addressing population dynamics, aging, health, and mortality (e.g., van Harten et al., 2022; Humphrey and Oli, 2015; Jin et al., 2012; O'Shea et al., 2010; O'Shea et al., 2004; Cheng and Lee, 2002). Researchers have employed a variety of methods to mark bats individually for long-term monitoring (Kunz and Weise, 2009). Nevertheless, choosing the most effective marking technique remains a challenge, as available techniques vary in terms of cost, durability, practicality, and their impacts on animal health and behavior (Loeb et al., 2025; Reynolds et al., 2025; Lobato-Bailón et al., 2023; Markotter et al. 2023, Mellado et al., 2022; Kunz and Weise, 2009). Effectiveness may also depend on the species, necessitating the use of multiple complementary approaches (Kunz and Weise, 2009; Bonaccorso et al., 1976).

Historically, forearm bands have been widely used due to their relatively low cost and ease of application (Kunz and Weise, 2009). However, concerns over lethal and sublethal injuries, and potential interference with foraging activities in a range of species (Lobato-Bailón et al., 2023), have prompted researchers to explore alternatives (Loeb et al., 2025; Markotter et al., 2023; Kirkpatrick et al., 2019; Kunz and Weise, 2009; Sherwin et al., 2002; Barnard, 1989).

Passive integrated transponder (PIT) tags, a type of radio-frequency identification (RFID) marker, have frequently been employed to permanently mark bats over the last few decades (Fontaine et al., 2024; Escobar et al., 2022; Locatelli et al., 2019; Britzke et al., 2014; Rigby et al., 2012; Ellison et al., 2007; Neubaum et al., 2005; Kerth and Reckardt, 2003; Schooley et al., 1993; Barnard, 1989). These subcutaneous tags encode a unique identification number that is readable by RFID readers, which can even be adapted to automatically detect bats at roost entrances (Rivera-Villanueva et al., 2024; Adams and Ammerman, 2015; Britzke et al., 2014). Although PIT tags are commonly used and believed to have no adverse effects on the body mass, body condition, and/or reproductive success of bats (Waag et al., 2025; van Harten et al., 2019; Locatelli et al., 2019; Rigby et al., 2012; Neubaum et al., 2005), they have some limitations. Their application typically requires a large needle (12-gauge), which may be invasive for smaller species (Seheult et al., 2024). Tags are not externally visible; therefore, the use of a hand-held ID reader is required. Nevertheless, they can migrate or even be occasionally expelled from the body, in which case it may lead to detection difficulties or data loss (van Harten et al., 2021; Rigby et al., 2012; Kunz and Weise, 2009; Barnard, 1989). Finally, they are cost-prohibitive for large-scale studies (USD 5–10; Seheult et al., 2024), but these prices vary depending on the vendor and the quantity purchased. Generally, PIT tags are preferable to forearm bands due to their higher retention rates (van Harten et al., 2021; Ellison et al., 2007); however,

concerns over cost, detectability, potential safety issues for very small bats (forearm length < 30 mm), and tag loss in some studies (e.g., Rigby et al., 2012) warrant investigation into alternative technologies.

p-Chips (p-Chip Corp., Chicago, Illinois) are ultra-miniaturized semiconductor transponders (500 × 500 µm) that emit a unique ID when activated by red laser light (PharmaSeq, 2012). Although they were designed for a wide range of applications, including labeling, tracking, and authenticating items, their initial use in animals was the permanent identification of laboratory mice (Gruda et al., 2010; PharmaSeq, 2012).

Because the laser must be close to the tag (ca. 1 cm) to achieve a successful read, it is beneficial to inject the tag in an area with thin, translucent, and almost hairless skin. p-Chip tags are injected subcutaneously via a 21-gauge needle, which is less invasive than the 12-gauge needles commonly used for PIT tag injection. This makes p-Chips a promising alternative for marking bats, especially smaller species (Ngamprasertwong et al., 2022; Gruda et al., 2010). p-Chips (1–2 USD per unit) can also be five- to ten-fold less expensive than PIT tags (Seheult et al., 2024). However, it should be recognized that the hand-held reader is expensive (up to USD 3,000) because it is only available directly from the company; unlike PIT tags, there are no generic alternatives. p-Chips (p-Chip Corp.) were available in either preloaded or loose formats. In the latter case, they can be manually loaded into injectors, which can be sterilized between uses or discarded. Currently, PharmaSeq (the company that used to sell preloaded injectors) is no longer engaged in commercial sales of p-Chips or preloaded injectors. Researchers interested in using p-Chips may contact p-Chip Corp. directly to purchase them (p-Chip Corp., personal communication) and adapt other needles for use in injection (see Methods).

p-Chips have been successfully used for marking and identification in animals of various sizes, including fish (Spooner and Spurgeon, 2024; Moore and Brewer, 2021; Faggion et al., 2020), rodents (Clein et al., 2024; Warren et al., 2021; San Diego Zoo Wildlife Alliance, 2016), crayfish (Huber et al., 2023), salamanders (Moore et al., 2024), bees (Hamilton et al., 2019; Tenczar et al., 2014), ants (Robinson et al., 2014; Robinson et al., 2009), and even ectoparasites (Folk et al., 2024). Although most evidence comes from captive conditions, p-Chips have been shown to be effective identification markers for wild fish (Spooner and Spurgeon, 2024; Moore, 2020), demonstrating no significant adverse effects and a tag retention rate of up to 94% after more than a year, even in underwater conditions. In wild animals, p-Chips are expected to function indefinitely due to their polymer coating, which resists harsh conditions such as high temperatures, freezing–thawing cycles, and even exposure to chemicals (PharmaSeq, 2012). Therefore, p-Chips are a suitable, considerably smaller alternative to PIT tags. Although p-Chips still require the recapture of marked individuals, their

reduced size represents a promising avenue for innovation in small-sized species for which traditional marking techniques are impractical or invasive.

Seheult et al. (2024) tested p-Chips in 30 captive *Eptesicus fuscus* (forearm length: 40–48 mm), inserting them in the skin of the wings and tibia. They found that the tags remained functional for over a year (464 days after tagging) while requiring minimal handling due to rapid detection with the scanner. However, they also noted that visibility decreased over time, which may complicate recapture efforts. This issue could pose a significant challenge in free-ranging bats, where uncertainty about prior tagging might lead to excessive handling in an effort to locate a potentially nonexistent tag.

Given these challenges, further testing in more species and under non-captive conditions was recommended. The purpose of this study was to evaluate p-Chip tag efficacy in a free-ranging population of Amazonian bats by assessing their application, detectability, and retention across species.

## Methodology

This study was conducted at the Estación Biológica Los Amigos (EBLA), located in the southeastern Peruvian Amazon, at the confluence of the Los Amigos and Madre de Dios Rivers (12°30'–12°36'S, 70°02'–70°09'W). The region primarily consists of high and low terra firme forests, flooded palm forests, and meandering river floodplain forests (MINAM, 2015). According to the *Servicio Nacional de Meteorología e Hidrología del Perú* (SENAMHI), in Puerto Maldonado (~50 km away, the nearest site), temperature ranges from 16.6°C to 32.2°C, and monthly precipitation varies from 58 to 299 mm. At this site, an annual mark-recapture program for medium and large mammals has been ongoing since 2018, during which we were able to test this method for the individual identification of bats. Although sampling of bats has taken place since 2018, marking efforts began only at the end of our 2023 field season (end of July–beginning of August).

From 2023 to 2025, we captured bats using 6 × 3 m and 12 × 3 m mist nets at accessible sites along the trail system at the field station (Watsa et al., 2023; Figure 1). Bats were identified taxonomically using the dichotomous keys from López-Baucells et al. (2016) and Díaz et al. (2021), and aged based on epiphyseal ossification (Brunet-Rossinni and Wilkinson, 2009). To individually mark bats, p-Chips (USD 0.67 each in 2023; PharmaSeq) were subcutaneously implanted into the right mid-forearm region of each animal, primarily using preloaded 21-gauge needles (Figure 2, Video S1). To replicate the preloaded injectors developed by p-Chip Corp. (p-Chip Corp., personal communication), in 2025 we manually flattened 40 conventional 21-gauge needles using a press (Gruda et al., 2010),

then loaded them with loose p-Chips under sterile, controlled conditions. These needles were used to insert the p-Chips into bats and performed comparably to the preloaded needles. The forearm was selected as the implantation site to accommodate the wide range of body sizes included in this study, particularly smaller-bodied species, in which implantation in the metacarpals may be anatomically unfeasible or difficult due to needle gauge relative to bone width. We ensured that each p-Chip was inserted into a disinfected injection site while being careful that the chip remained right-side up to maintain detectability.

Individual tag numbers were checked using the handheld reader (model WA-6000) connected to a Windows 10 laptop or tablet via a USB connection. We purchased our reader from PharmaSeq for USD 3,000 in 2023, whereas Seheult et al. (2024) reported a cost of USD 2,000 for the model WA-4000. During preliminary tests, we identified instances where some p-Chips were unreadable or preloaded in a flipped orientation. For this reason, we checked them before injection by slightly exposing the p-Chip using the needle plunger to verify its readability and orientation before implanting it. Additionally, the ongoing bat research program involved collecting fur for toxicology analyses and wing punches for DNA barcoding, both serving as short-term external marks that helped confirm recaptures when p-Chip detectability was initially uncertain. Once red LED-assisted visualization reliably revealed the presence of tags under the skin, these auxiliary short-term marks were no longer needed for this purpose. No standardized measures of scanning time or handling time were recorded.

We defined eight sampling sites where we have conducted bat sampling since we began marking bats with p-Chips. In 2024, we ran out of p-Chips for sites 1, 5, and 7; however, we report our full sampling schedule (Supplementary Table S2) because recaptures were recorded at sites 1 and 7. Mist-net locations were georeferenced to measure distances between recapture events. We assessed tag functionality within and across years by recording the distance and time between recapture encounters of individuals.

Mist-netting effort was not standardized across sites or nights. Nets were installed in single-high configurations, but the number of nets deployed per night varied with logistical and environmental constraints and with the objectives prioritized by the ongoing research program since 2018. As a result, our mark–recapture assessment was opportunistic, and we therefore do not quantify recapture rates or success. Our observations of recapture events are reported to document p-Chip visual detection, readability, and retention under typical field conditions.

This study was conducted with permit RDG-000116-2021-DGGSPFFS (*Servicio Nacional Forestal y de Fauna Silvestre*; SERFOR), following the guidelines of the American Society of Mammalogists (Sikes et al., 2016) and under IACUC approval from Washington University in St. Louis and the San Diego Zoo Wildlife Alliance. The full handling protocol is provided in Watsa et al. (2023).

## Results

Bats were sampled and tagged from 2023 to 2025 (details in Supplementary Table S2). In 2023, p-Chips were implanted in 24 bats across eight species; in 2024, in 97 bats across 19 species; and in 2025, in 179 bats across 27 species (Table 1). In total, we implanted tags in 31 species across three families (Phyllostomidae, Emballonuridae, and Vespertilionidae), spanning a wide range of body sizes from small bats (forearm length < 36 mm) to very large bats (forearm length > 75 mm). The smallest tagged individual had a forearm length of 29.7 mm (*Mesophylla macconnelli*), whereas the largest individual was *Vampyrum spectrum* with a forearm length of 108.1 mm. p-Chip visual detection and reading were successful across this size range; however, standardized metrics were not collected (e.g., detection/reading time), precluding formal comparisons of efficiency among size classes.

Over the entire study period, we recaptured 57 individual bats (12 species) across 88 recapture events, because some individuals were recaptured more than once (Table 2; Supplementary Table S2). The smallest recaptured individual had a forearm length of 31 mm (*Hsunycteris thomasi*), and the largest had a forearm length of 87.5 mm (*Phyllostomus hastatus*). All recaptured individuals that were expected to carry a functional p-Chip, based on complementary marks (shaved hair or wing biopsy marks), retained the tag, which remained fully functional.

In all recaptured individuals, the injection site was not detectable, with no visible scarring, inflammation, or other apparent adverse effects, including in individuals recaptured more than one year after tagging. During the first sampling sessions, we sometimes had difficulty visually locating the p-Chip immediately after injection and during some recapture events. Visual detectability of the p-Chip varied among species. In bats with dark or thick skin (e.g., *Phyllostomus* spp. and *Vampyrum spectrum*), the tag was not externally visible under ambient light and could be confused with natural pigmentation patterns, skin markings, or minor wounds. We later found that placing a red LED backlight beneath the wing caused the p-Chip to appear clearly as a black, opaque square, even in dark-skinned species (Figure 2; Video S2). This technique consistently enabled rapid visual detection and tag reading across all species, regardless of size or skin characteristics. Scanning time was reduced to a few seconds per individual (< 15 s; approximate upper limit based on rough field

180 estimates), and tags were typically read on the first attempt with the handheld reader. After
181 implementing this technique and as the handling team gained experience, all implanted p-Chips were
182 successfully detected and scanned.

183 Notably, 16 individuals across six species were recaptured after more than 170 days after the marking
184 date (across sampling seasons), including the notable recapture event of a female *Carollia brevicauda*
185 captured more than two years after the marking date (859 days) (Table 2). The remaining individuals
186 were recaptured within short periods (0–40 days) after the marking date (Table 2; Supplementary
187 Table S2). Four individuals (3 species) were recaptured at distances over 1 km from previous capture
188 locations, while all other individuals were recaptured between 0 and 500 m from previous capture
189 locations (Table 2; Supplementary Table S2).

190 **Discussion**

191 Previously, Seheult et al. (2024) tested p-Chips in captive *E. fuscus*, while Ngamprasertwong et al.
192 (2022) used them to study roost fidelity in *Craseonycteris thonglongyai*, the smallest bat in the world.
193 Our results provide the first evidence of their use in free-ranging bats within a highly diverse
194 Amazonian high-terrace forest. p-Chips were inserted and successfully read in the forearm of 31 bat
195 species. The short-term functionality of the tags (within the same sampling season, up to 40 days)
196 was confirmed in 41 individuals across nine species, while long-term functionality (across sampling
197 seasons, > 170 days) was confirmed in 16 individuals across six species (Table 1; Supplementary
198 Table S2).

199 We demonstrate that inserting p-Chips in the forearm is feasible and effective. Although forearm
200 implantation may reduce visual detectability in large, dark-skinned species, the use of red LED
201 backlighting overcomes previously reported limitations in visual tag localization and enables reliable
202 tag detection across all species. This approach expands the applicability of p-Chips across
203 morphologically diverse bat taxa. After implementing pre-injection verification, we did not observe
204 any flipped p-Chips in preloaded syringes, except possibly during the initial sessions before
205 verification was applied. However, we do not rule out the possibility that tags may flip over time, as
206 noted by Seheult et al. (2024). Although we did not quantitatively assess p-Chip efficacy by species,
207 our observations suggest that p-Chip functionality is consistent across the species tested using the
208 methods we deployed. As with any marking technique, practice is required to achieve consistently
209 successful application. Although the fine-gauge needle used for p-Chip marking allows all species to
210 be tagged with minimal difficulty, handling and tagging very small species may be slightly more

211 challenging. Nevertheless, we expect that training in this technique would be straightforward for new
212 users when following our protocol.

213 Importantly, we did not detect any visible tissue damage or other adverse effects at the implantation
214 site in any recaptured individuals, including those recaptured more than one year after tagging.
215 Although our sampling design does not allow precise quantitative estimates of tag retention or loss in
216 free-ranging bats, these observations suggest that the implantation protocol used here (Watsa et al.,
217 2023) is unlikely to cause detectable morbidity or acute adverse effects associated with p-Chip
218 application. Observations from Seheult et al. (2024) in captive bats further support that mortality or
219 other adverse effects due to p-Chip insertion are highly improbable. Future work could assess tag loss
220 rates in wild bats. Although tag loss appears low in captive bats, estimating loss in free-ranging
221 individuals is challenging; targeted sampling at roosts with high site fidelity may be well suited for
222 this purpose. In addition, consistent with that study in captive bats, we recommend that future
223 evaluations also include other marking methods (e.g., bands, PIT tags) to allow quantitative
224 comparisons of efficiency. Finally, where possible, we recommend assessing whether p-Chips may
225 alter the behavior and physiology of wild bats.

226 Although the number of recaptured bats may appear low, recapture rates in the Amazon are commonly
227 low (e.g., Tavares et al., 2017; Ramos et al., 2010; Sampaio et al., 2003), including at EBLA (Bravo
228 et al., 2008). Comprehensive sampling in the Amazon is logistically challenging because much of the
229 habitat within a given site is inaccessible. Even in areas with established trails, such as EBLA, it is
230 difficult to sample large areas simultaneously. Recapturing free-ranging bats is further complicated
231 by the potential for long-distance movements; for example, *Artibeus lituratus* can travel up to 113
232 km (Arnone et al., 2016), and movement data for most species are scarce. Given these constraints,
233 our recapture records across time and space support the effectiveness of p-Chips as a marking method.
234 Several individuals were recaptured more than one year after marking (including one more than two
235 years after marking), sometimes at the same site, whereas a few were recaptured at more distant sites
236 within relatively short time intervals. Recaptures at the same site after more than a year may indicate
237 roost or foraging-area fidelity, although our sampling design does not allow stronger inference.
238 Together, these results highlight the potential value of p-Chips for large-scale mark-recapture
239 programs across Amazonian bat communities, an approach that has likely been uncommon because
240 of cost and feasibility constraints for some species. Future work could implement a systematic, long-
241 term sampling design that periodically surveys specific areas. Priority sites could include spatially
242 clustered, high-resource locations that attract bats from long distances (e.g., mammal clay licks) and
243 major roost sites.

Standardized protocols are essential to advance research using this technique. In particular, consistent placement of p-Chips is critical to ensure reliable localization during recapture events, especially given the absence of visible external marks after healing. This standardization is also crucial for eventually applying p-Chips across broader geographic contexts and among multiple research teams. In addition, although preloaded injectors are not currently available commercially, the process of modifying conventional needles and manually loading p-Chips is very straightforward. To our knowledge, there is no commercially available alternative with the same combination of extreme miniaturization and light-triggered close-range detection, although other small implantable RFID systems exist.

Our study contributes information on the long-term retention of p-Chips in free-ranging bats, the importance of proper insertion techniques, and the benefits of pre-injection confirmation and red LED backlighting to improve readability. These results suggest that p-Chips are an effective and minimally invasive method for longitudinal research on wild bats, offering a viable alternative to PIT tags, particularly for smaller species.

## Acknowledgments

This work was funded by Field Projects International (FPI) and the San Diego Zoo Wildlife Alliance (SDZWA). The inspiration for working with p-Chips originated from the Pacific Pocket Mouse Program at the SDZWA, where their application demonstrated promising potential for small vertebrate tracking. We extend our gratitude to the numerous volunteers and staff who contribute to FPI's annual research program; their dedication and effort were instrumental in making this study possible. We also acknowledge *Conservación Amazónica* (ACCA) for maintaining the Los Amigos Biological Station, where fieldwork for this research was conducted. Finally, we thank the anonymous reviewers of previous versions of this manuscript, whose comments greatly contributed to improving its quality.

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| Size category | Species | 2023 | 2024 | 2025 |
|---|---|---|---|---|
| Small | *Carollia benkeithi* | 3 | 8 | 12 |
| (FA: < 36 mm; n = 69) | *Glossophaga soricina* | | | 5 |
| | *Hsunycteris thomasi* | | | 1 |
| | *Mesophylla macconnelli* | | 1 | 3 |
| | *Micronycteris microtis* | | | 1 |
| | *Micronycteris minuta* | | 1 | 3 |
| | *Myotis nigricans* | | | 1 |
| | *Myotis riparius* | | 3 | 8 |
| | *Rhinophylla pumilio* | 1 | 2 | 15 |
| | *Thyroptera tricolor* | | | 1 |
| Medium | *Carollia brevicauda* | 5 | 23 | 27 |
| (FA: 36 – 55 mm; n = 127) | *Carollia perspicillata* | 2 | 17 | 34 |
| | *Chiroderma trinitatum* | | | 1 |
| | *Dermanura anderseni* | | 1 | |
| | *Dermanura gnoma* | | 1 | 2 |
| | *Gardnerycteris crenulata* | | 1 | 5 |
| | *Micronycteris hirsuta* | | 1 | |
| | *Saccopteryx bilineata* | | 1 | |
| | *Sturnira tildae* | | | 2 |
| | *Trinycteris nicefori* | | | 4 |
| Large | *Artibeus lituratus* | 1 | | 2 |
| (FA: 55 – 75 mm; n = 83) | *Artibeus obscurus* | 4 | 12 | 5 |
| | *Artibeus planirostris* | 2 | | 11 |
| | *Desmodus rotundus* | | | 1 |
| | *Lophostoma silvicola* | | 8 | 8 |
| | *Phyllostomus elongatus* | | 5 | 14 |
| | *Platyrrhinus infuscus* | | | 1 |
| | *Tonatia maresi* | | 3 | 3 |
| | *Trachops cirrhosus* | | 1 | 2 |
| Very large | *Phyllostomus hastatus* | 6 | 7 | 7 |
| (FA: > 75 mm; n = 21) | *Vampyrum spectrum* | | 1 | |

**Table 2.** Bats marked with p-Chips and recaptured at Estación Biológica Los Amigos, Peru. Only the individuals with the longest intervals and the greatest distances between initial capture/marking and subsequent recapture locations are shown. Each row corresponds to a unique individual. Full detailed results are available in Supplementary Table S2. For each individual, the table lists the marking date, the number of recapture events, the maximum number of days from marking to the last recapture, and the maximum distance between the marking site and recapture events. "Recapture site" indicates the site of the farthest recapture. Abbreviations: a, adult; j, juvenile; p, pregnant. *Captured as juvenile and recaptured as adult; †captured as adult non-pregnant and recaptured as pregnant; ‡captured and recaptured as pregnant.

| Bat individual | Date marking | Max. days to recapture | Max. distance traveled | Recapture times | Marking site | Recapture site |
|---|---|---|---|---|---|---|
| *Carollia brevicauda* ♀j,a* | 21/07/2023 | 344 | 1014 | 1 | 3 | 1 |
| *Artibeus obscurus* ♂a | 21/07/2023 | 334 | 234 | 1 | 3 | 3 |
| *Carollia benkeithi* ♀a | 26/07/2023 | 334 | 22 | 1 | 2 | 2 |
| *Carollia brevicauda* ♀a | 03/08/2023 | 859 | 192 | 1 | 2 | 2 |
| *Phyllostomus elongatus* ♂a | 11/06/2024 | 32 | 194 | 1 | 4 | 4 |
| *Carollia brevicauda* ♂a | 13/06/2024 | 30 | 319 | 1 | 4 | 4 |
| *Tonatia maresi* ♂a | 14/06/2024 | 366 | 471 | 1 | 4 | 8 |
| *Carollia brevicauda* ♀a,p† | 17/06/2024 | 345 | 90 | 3 | 4 | 4 |
| *Carollia brevicauda* ♀a | 18/06/2024 | 345 | 131 | 1 | 4 | 4 |
| *Artibeus obscurus* ♂a | 20/06/2024 | 17 | 1138 | 1 | 3 | 7 |
| *Carollia brevicauda* ♂a | 20/06/2024 | 355 | 160 | 2 | 3 | 3 |
| *Carollia brevicauda* ♀a | 20/06/2024 | 17 | 1190 | 2 | 3 | 7 |
| *Carollia brevicauda* ♀a | 20/06/2024 | 360 | 217 | 3 | 3 | 8 |
| *Lophostoma silvicola* ♂a | 20/06/2024 | 374 | 303 | 1 | 3 | 8 |
| *Lophostoma silvicola* ♀a | 24/06/2024 | 350 | 286 | 2 | 3 | 3 |
| *Carollia benkeithi* ♀a | 25/06/2024 | 343 | 74 | 3 | 2 | 2 |
| *Carollia benkeithi* ♂a | 25/06/2024 | 343 | 160 | 3 | 2 | 2 |
| *Carollia perspicillata* ♀a | 25/06/2024 | 3 | 435 | 1 | 2 | 1 |
| *Carollia brevicauda* ♂a | 08/07/2024 | 542 | 468 | 2 | 6 | 8 |
| *Carollia perspicillata* ♀a,p | 29/05/2025 | 17 | 458 | 1 | 4 | 8 |
| *Carollia perspicillata* ♂a | 30/05/2025 | 18 | 443 | 2 | 4 | 8 |
| *Carollia perspicillata* ♂a | 30/05/2025 | 33 | 468 | 1 | 4 | 3 |
| *Carollia perspicillata* ♀a | 30/05/2025 | 20 | 497 | 2 | 4 | 8 |
| *Carollia brevicauda* ♂a | 04/06/2025 | 28 | 365 | 1 | 2 | 3 |
| *Carollia brevicauda* ♀a,p‡ | 10/06/2025 | 176 | 421 | 8 | 3 | 8 |
| *Carollia brevicauda* ♂a | 11/06/2025 | 27 | 327 | 2 | 3 | 8 |
| *Carollia benkeithi* ♀a | 13/06/2025 | 25 | 360 | 4 | 3 | 8 |
| *Phyllostomus elongatus* ♀a | 16/06/2025 | 32 | 1102 | 1 | 8 | 1 |
| *Phyllostomus elongatus* ♀a | 19/06/2025 | 171 | 287 | 1 | 8 | 3 |

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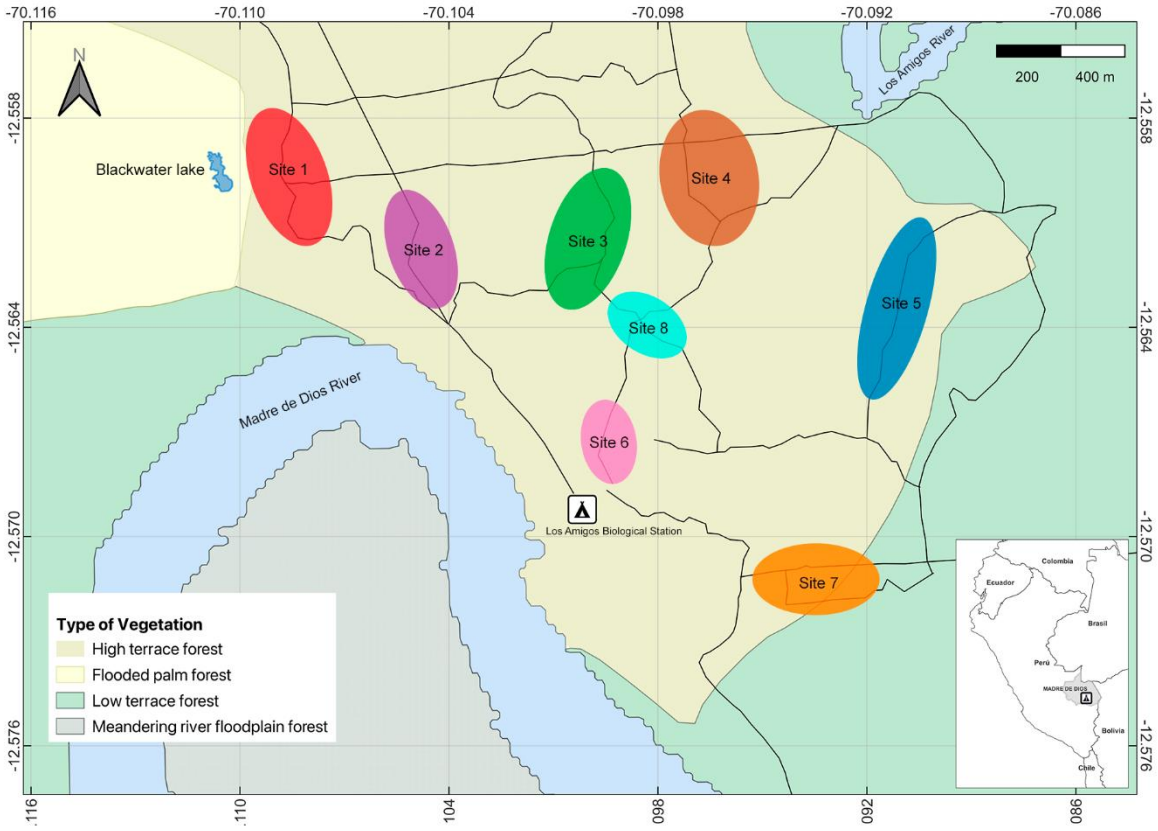
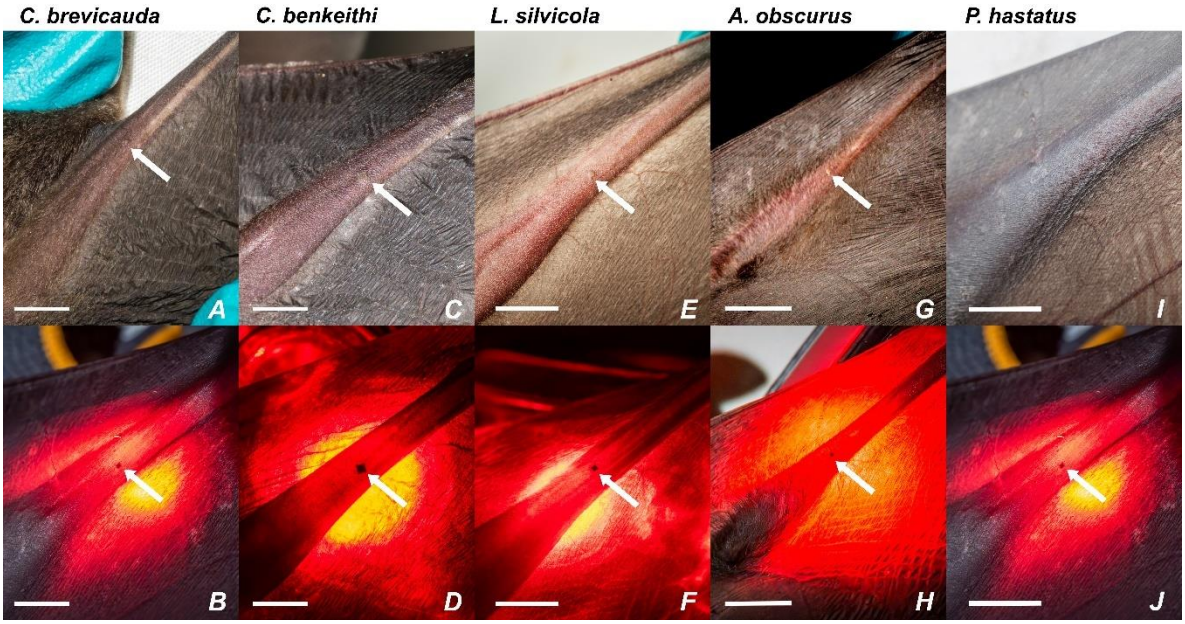
507 445 **Figure 1**



508 446 **Figure 2**



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| | *Myotis nigricans* | | | 1 |
| | *Myotis riparius* | | 3 | 8 |
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| | *Dermanura gnoma* | | 1 | 2 |
| | *Gardnerycteris crenulata* | | 1 | 5 |
| | *Micronycteris hirsuta* | | 1 | |
| | *Saccopteryx bilineata* | | 1 | |
| | *Sturnira tildae* | | | 2 |
| | *Trinycteris nicefori* | | | 4 |
| Large | *Artibeus lituratus* | 1 | | 2 |
| (FA: 55 – 75 mm; n = 83) | *Artibeus obscurus* | 4 | 12 | 5 |
| | *Artibeus planirostris* | 2 | | 11 |
| | *Desmodus rotundus* | | | 1 |
| | *Lophostoma silvicola* | | 8 | 8 |
| | *Phyllostomus elongatus* | | 5 | 14 |
| | *Platyrrhinus infuscus* | | | 1 |
| | *Tonatia maresi* | | 3 | 3 |
| | *Trachops cirrhosus* | | 1 | 2 |
| Very large | *Phyllostomus hastatus* | 6 | 7 | 7 |
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| *Carollia benkeithi* ♀a | 25/06/2024 | 343 | 74 | 3 | 2 | 2 |
| *Carollia benkeithi* ♂a | 25/06/2024 | 343 | 160 | 3 | 2 | 2 |
| *Carollia perspicillata* ♀a | 25/06/2024 | 3 | 435 | 1 | 2 | 1 |
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| *Carollia perspicillata* ♂a | 30/05/2025 | 18 | 443 | 2 | 4 | 8 |
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| *Carollia benkeithi* ♀a | 13/06/2025 | 25 | 360 | 4 | 3 | 8 |
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**Table 2**

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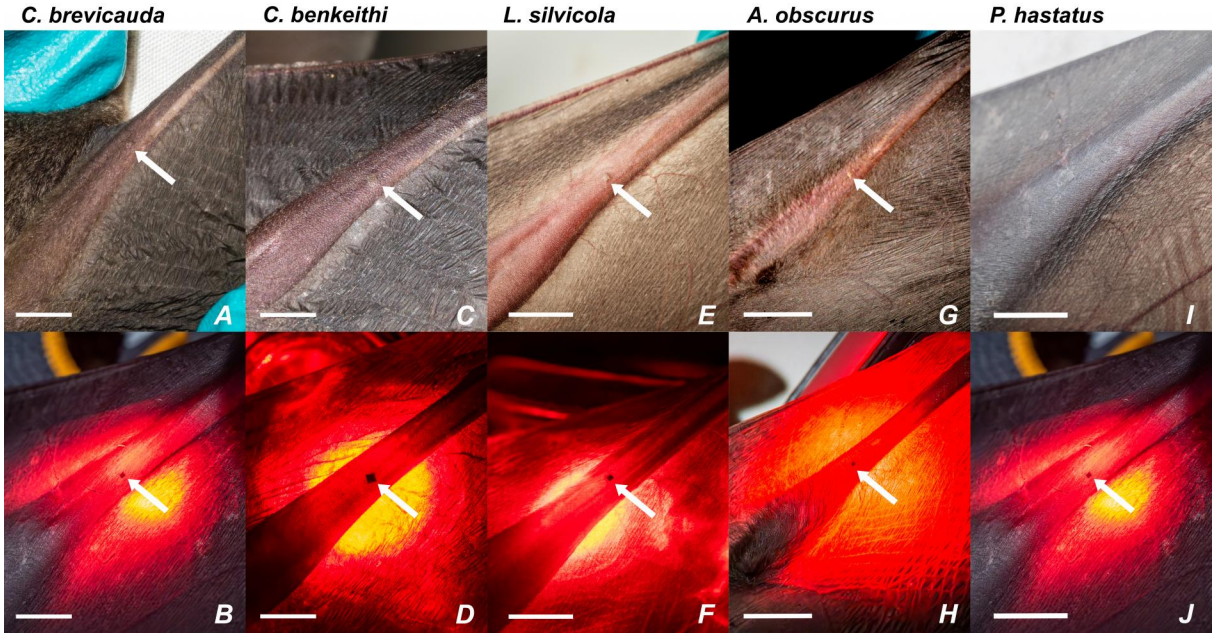


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## Tables

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## Figures

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Figure 2 - Download source file (37.41 MB)
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## Supplementary Online Material

File 1 - Download source file (156.7 kB)
Video S1. Demonstration of p-Chip placement and reading in a free-ranging Phyllostomus elongatus at the Estación Biológica Los Amigos (Peru). Video was too heavy to upload in the platform. The image uploaded are just previews of the video. During the review process, it will be available at this link: https://drive.google.com/file/d/1pIHgsqXfBpOb7tb8dfRu0pJMNg88YSR5/view?usp=sharing

File 2 - Download source file (22.54 kB)
Table S2. Details of bats marked with p-Chips and recaptured at Estación Biológica Los Amigos, Peru, including the complete sampling schedule since p-Chip tagging began. Each row corresponds to a unique individual. No active marking was conducted in 2024 at sites 1, 5, and 7. The first row in the timeline indicates the year (23 = 2023, 24 = 2024, 25 = 2025), while the second row represents the site (Figure 1 of the main manuscript). For each individual, the table lists the marking date, the number of recapture events, the maximum number of days from marking to the last recapture, and the maximum distance recorded between capture locations. Cells labeled ‘C’ indicate the initial capture/marking date, and cells labeled ‘R’ indicate a recapture event on that date. In some instances, individuals were recaptured twice on the same day, indicated by “2". Abbreviations: a, adult; j, juvenile; l, lactating; p, pregnant. *Captured as juvenile and recaptured as adult; †captured as an adult non-pregnant individual and recaptured as pregnant; ‡captured as pregnant and recaptured as pregnant.