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Description of the nest, eggs and nestling development of Maranhão Hermit *Phaethornis maranhaoensis*

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SUMMARY.—Maranhão Hermit *Phaethornis maranhaoensis* is endemic to Brazil, where it occurs in the states of Piauí, Maranhão, Tocantins, Pará, Mato Grosso and Goiás. Nothing has been published concerning its breeding biology. We present the first descriptions of the nest, eggs and nestlings of *P. maranhaoensis*, with data on nestling development. We found four nests in the understorey of closed-canopy forest in eastern Maranhão. All four nests were attached to the undersides of babaçu palm fronds (*Attalea speciosa*), and were constructed of plant material and moss, bound together with spider webs. Nests are similar to those of other *Phaethornis*, conical and attached to the tip of the frond. They were sited at a mean height of 71.5 ± 21.3 cm above ground, and were 23.6 ± 1.8 cm in height, with an external diameter of 41.7 ± 2.7 mm, internal diameter 18.4 ± 3.7 mm, and the incubation chamber was 24.5 ± 3.1 mm deep ($n = 4$). Eggs are white and elliptical, measuring $11.9 \pm 0.2 \times 7.8 \pm 0.1$ mm, with a mean mass of 0.4 ± 0.05 g ($n = 4$). Our observations indicate that the species' breeding season occupies November–April.

Reproduction is a fundamental process in the natural history of all living organisms, but there are surprisingly large gaps in our knowledge of this process, even in relatively well-studied groups such as birds (Heming *et al.* 2013). Birds possess several different reproductive strategies and exploit a wide variety of nesting sites, which often hinder their identification and monitoring. Xiao *et al.* (2017) estimated that few or no breeding data are available for c.40% of the world's bird species. The lack of data on parameters such as the timing and duration of the breeding season, nest structure, and egg and clutch size, is especially apparent for Neotropical species. In fact, many taxa are known only from a few localities, with few or no data whatsoever on any aspect of their natural history (e.g. Alteff *et al.* 2019, Cleere & Sharpe 2020).

Phaethornis is a hummingbird genus endemic to the Neotropics, where it occurs from Mexico to southern Brazil and northern Argentina (Schuchmann 1999). It is the second most speciose trochilid genus, with between 25 and 29 species currently recognised (Dickinson & Remsen 2013, del Hoyo & Collar 2014, Clements *et al.* 2019, Winkler *et al.* 2020). In Brazil, as many as 18 species occur, making it the genus with the largest number of species nationally (Piacentini *et al.* 2015). Maranhão Hermit *P. maranhaoensis* is often considered a synonym of Cinnamon-throated Hermit *P. nattereri*, but the two possess apparently allopatric distributions (Mallet-Rodrigues 2006), and here we follow Piacentini *et al.* (2015) and treat *P. maranhaoensis* as a species. *P. maranhaoensis* is endemic to Brazil, found in the states of Piauí, Maranhão, Tocantins, Pará, Mato Grosso, and Goiás. The core of its geographic range lies within the Cerrado domain, although it also occurs in adjacent parts of Amazonia and the Caatinga (<http://www.wikiaves.com.br>). Few data are available on the natural history of *P. maranhaoensis* and its breeding biology is practically unknown (Piacentini & Ribenboim 2017, Hinkelmann & Boesman 2020a). Here, we provide the first description of the nest,

eggs and nestlings of *P. maranhaoensis* from the Cerrado of Maranhão, with information on the growth of the nestlings.

Methods

Our observations were made in the Inhamum Environmental Protection Area (APA do Inhamum; 04°53'30"S, 43°24'53"W), municipality of Caxias, eastern Maranhão, Brazil. The APA do Inhamum covers 3,500 ha, dominated by *cerrado sensu stricto*, with some tracts of closed-canopy savanna woodland (*cerradão*) and gallery forest. In some forested areas, trees reach heights in excess of 25 m, with a dense and shady understorey, whereas in other parts the vegetation comprises shorter, more widely spaced trees that do not form a continuous canopy. The region's climate is tropical with dry winters, type *Aw* in the Köppen-Geiger classification system (Peel *et al.* 2007), with two well-defined seasons—a dry season in July–November, and a wet season in December–May, with mean annual precipitation of 1,600 mm and mean temperature 27.8°C. The study area lies in the central Itapecuru basin, an area where natural vegetation is being converted rapidly into farmland to produce cash crops, and impacted by illegal fires during the dry season.

The nests described here were encountered opportunistically during general avifaunal surveys in the APA do Inhamum. Once identified, each nest was monitored at intervals of 48 hours. Nests, eggs and nestlings were measured using a metal ruler (accurate to 1.0 mm) and callipers (0.05 mm), while the eggs and nestlings were weighed with a digital scale (0.01 g). Nest architecture was classified according to Simon & Pacheco (2005).

Results

We identified four active nests during the 2019/20 breeding season. The first was found on 18 November 2019, in an advanced stage of construction. The second was discovered on 8 December 2019, in the initial stage of building, and the third was found on 17 March 2020, when it was almost completed. The fourth nest was identified on 4 April 2020, when it contained two eggs. These observations indicate that the breeding season of *P. maranhaoensis* is from November to April, possibly until early May. Nests were of the high-cup/pensile type, and all were attached to the underside of still-growing leaves of babaçu palms *Attalea speciosa* in the understorey of *cerradão*. Nestbuilding starts with small leaves and dry twigs, which are attached to the babaçu frond with spider web (Fig. 1A). We observed the exuviae of spiders (Araneae) and grasshoppers (Proscopiidae) in the material used to construct two nests, although it was impossible to confirm if this material was brought to the nest by the birds. Nests were conical in shape, with a long 'tail-like' appendage of leaves that serves as a counterweight (Fig. 1B). The outer layer of the nest was covered with plant material and moss, attached with spider web. The internal cavity that forms the egg chamber was lined with fine whitish plant fibres. Construction of the second nest, which was encountered in the early stage of construction, took 20 additional days to be completed. None of the nests was successful. The first nest was abandoned with two eggs, one of them broken and covered in ants, while the eggs at the second nest were predated, as were the nestlings in the fourth nest. One of the nestlings in the third nest died on the 13th day of life and the other on the 17th day, both possibly victims of an infestation of *Philornis* larvae.

The nests averaged 23.6 ± 1.8 cm in height (Table 1; $n = 4$ for all parameters), with a mean outer diameter of 41.7 ± 2.7 mm, inner diameter of 18.4 ± 3.7 mm and depth of 24.5 ± 3.1 mm. Nests were sited 71.5 ± 21.3 cm above ground. When incubating the eggs, the female faces the leaf to which the nest is attached, with its head pointing upwards (Fig. 2A). All of the clutches we observed were of two eggs and the incubation period was *c.*16 days

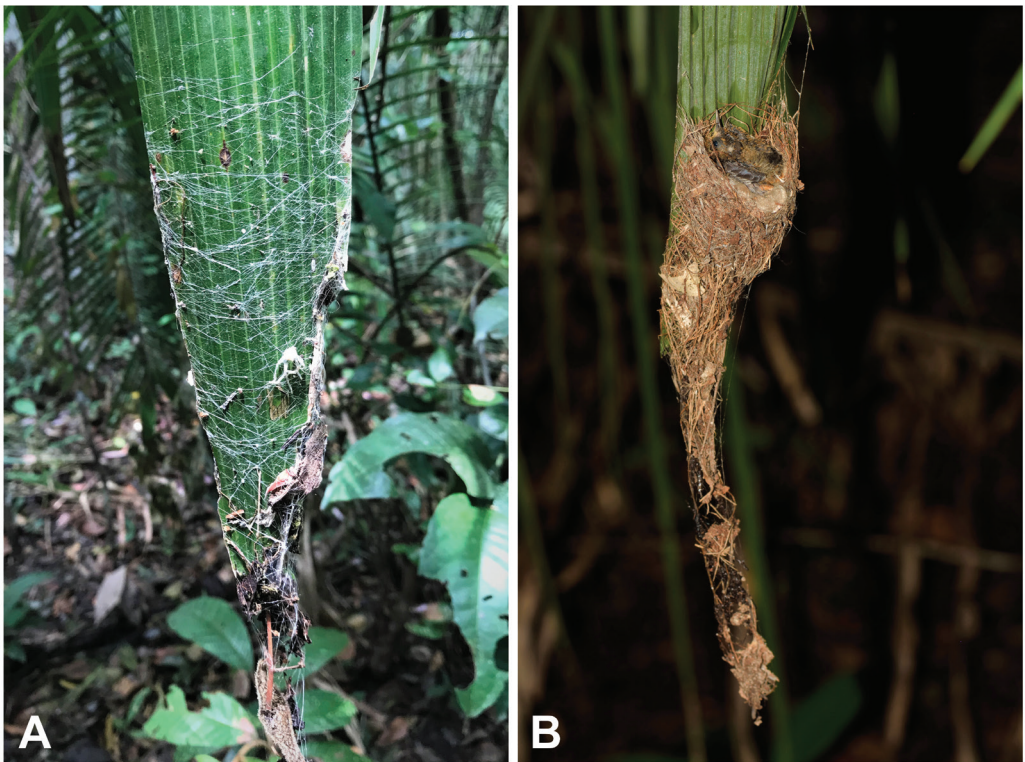


Figure 1. Architecture of a Maranhão Hermit *Phaethornis maranhaoensis* nest attached to the underside of an *Attalea speciosa* palm frond: (A) view of the upper surface of the frond, showing the spider web used to attach the nest; (B) completed nest containing two nestlings (A: Surama Pereira; B: Flávio Kulaif Ubaid).

($n = 1$). Eggs were white and elliptical (Fig. 2B), with a mean mass of 0.4 ± 0.05 g ($n = 4$) and measured $11.9 \pm 0.2 \times 7.8 \pm 0.1$ mm ($n = 4$). Whenever the chicks at nest 4 were observed, they were invariably facing the leaf (Fig. 2C).

TABLE 1
Measurements of four Maranhão Hermit *Phaethornis maranhaoensis* nests in the Inhamum Environmental Protection Area, municipality of Caxias, Maranhão, Brazil, in 2019/20.

	N1	N2	N3	N4	$\bar{X}$	S.D.
Outer diameter (mm)	45.0	40.9	38.6	42.2	41.7	2.7
Inner diameter (mm)	21.5	15.6	21.7	14.9	18.4	3.7
Depth of the chamber (mm)	25.0	27.0	26.0	20.0	24.5	3.1
Height of the nest (mm)	24.0	26.0	22.5	22.0	23.6	1.8
Height above ground (cm)	94.0	50.0	85.0	57.0	71.5	21.3

Nestlings hatch with their eyes closed, and are almost completely naked, with 11 paired neossophtiles on the spinal tract (*pteryla dorsalis*). When they hatched, the nestlings weighed 0.43 ± 0.06 g ($n = 3$) and were 18 ± 0.3 mm in length ($n = 2$). Their skin was pinkish flesh, with a darker dorsum, yellowish bill and tarsi, well-defined whitish labial commissure, and black around the eyes. On the 17th day of life, the body of the nestling was completely feathered, yellowish on the ventral surface and greyish on the dorsal. By this age, the characteristic

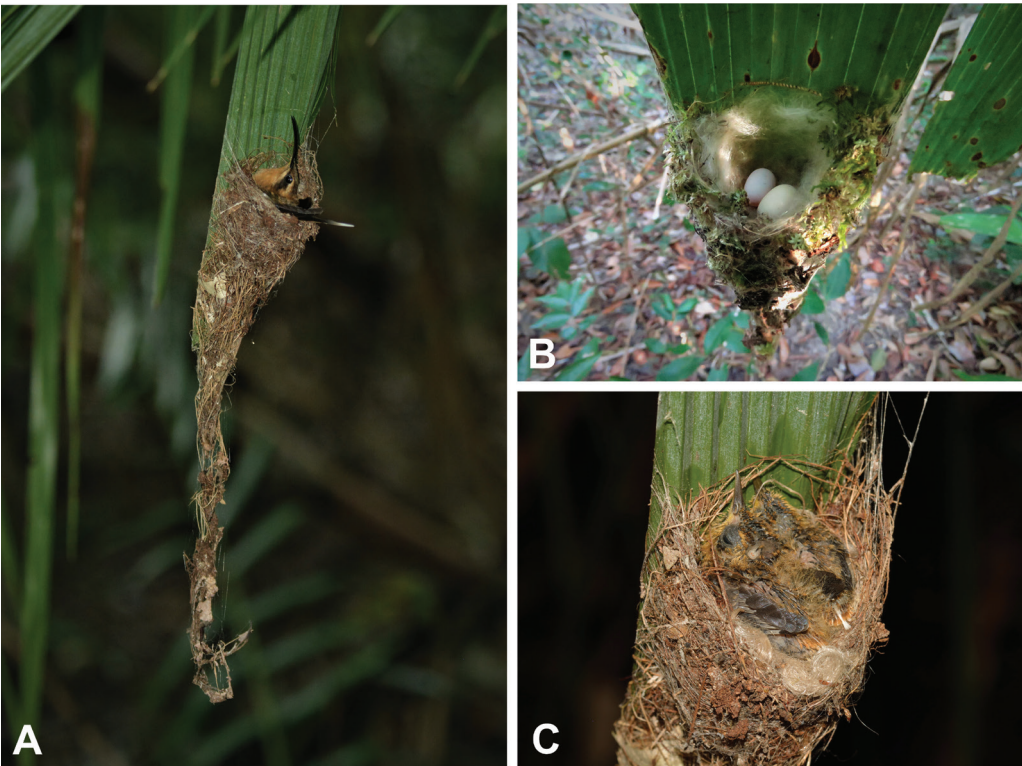


Figure 2A. Adult female Maranhão Hermit *Phaethornis maranhaoensis* incubating eggs; (B) clutch of two white, elliptical eggs; (C) detail of the nestlings when nearly two weeks old (A–C: Flávio Kulaif Ubaid; B: Surama Pereira)

white tips to the central rectrices were well defined, as were the black feathers on the wings, and the dark bill and nails. Growth of the two nestlings monitored from hatching is shown in Table 2. One nest was collected and deposited in the ornithological collection of the University of Brasília, UnB (COMB-N0735), and the others in the collection of the ornithology laboratory of the Maranhão State University (Caxias campus).

TABLE 2
Morphometric data for Maranhão Hermit *Phaethornis maranhaoensis* nestlings in the Inhamum Environmental Protection Area, municipality of Caxias, Maranhão, Brazil, 2019/20. *mean values ($n = 2$).

	Days of life													
	1	2	3	4	5	6	7	8	10	11	13	14	15	17
Mass (g)	0.4*	0.6*	0.7*	1.0*	1.0	1.4	1.7	2.2	2.5	2.8	3.2	3.3	3.3	2.9
Tarsus (mm)	-	-	2.1*	3.0	4.1	5.3	4.8	5.6	4.9	5.7	5.0	5.6	5.6	5.6
Cranium length (mm)	-	-	7.2	8.8	10.5	11.6	11.4	12.4	15.4	14.8	15.9	17.4	17.6	17.8
Culmen (mm)	-	-	3.0	3.1	3.3	3.4	5.6	6.0	5.7	6.2	6.0	6.3	7.3	7.4
Total length (mm)	18.0*	21.4*	22.4*	23.1	-	-	33.2	33.8	35.6	37.1	43.4	46.9	48	58.2

Discussion

The present study provides the first data on nest architecture and morphology of the eggs and nestlings of *P. maranhaoensis*. The description of the nest of Cinnamon-throated Hermit *P. nattereri* (Grantsau 1989) appears to be purely speculative (Piacentini & Ribenboim 2017), and requires clarification. Nests attached to the tip of the underside of pendent leaves, or palm fronds, is typical of *Phaethornis*, and has been observed in White-bearded Hermit *P. hispidus* (Melo & Greeney 2019), White-whiskered Hermit *P. yaruqui* (Hinkelmann & Boesman 2020c), Green Hermit *P. guy* (Snow 1974), Tawny-bellied Hermit *P. syrmatophorus* (Hinkelmann & Boesman 2020b), Koepcke's Hermit *P. koepckeeae* (Weske & Terborgh 1977), Needle-billed Hermit *P. philippii* (E. Endrigo; <http://www.wikiaves.com.br/334168>), Straight-billed Hermit *P. bourcierii* (Oniki & Willis 1982, Grantsau 1989), Long-billed Hermit *P. longirostris* (del Hoyo et al. 2020), Long-tailed Hermit *P. superciliosus* (Oniki & Willis 1982, 1983, Hudson 1984, Grantsau 1989), Great-billed Hermit *P. malaris* (Greeney et al. 2018, C. Veronese; <http://www.wikiaves.com.br/1741825>), Pale-billed Hermit *P. anthophilus* (Hinkelmann et al. 2020a), Dusky-throated Hermit *P. squalidus* (V. E. Florencio; <http://www.wikiaves.com.br/1939289>), Streak-throated Hermit *P. rupurumii* (R. Cavalcante; <http://www.wikiaves.com.br/3035401>), Little Hermit *P. longuemareus* (Skutch 1951), Minute Hermit *P. idaliae* (L. Freire; <http://www.wikiaves.com.br/496871>), Stripe-throated Hermit *P. striigularis* (Hinkelmann et al. 2020b), Grey-chinned Hermit *P. griseogularis* (Greeney et al. 2013), Reddish Hermit *P. ruber* (Oniki 1970, Oniki & Willis 1983, Muscat et al. 2014) and Scale-throated Hermit *P. eurynome* (D. Meyer; <http://www.wikiaves.com.br/211551>).

Like nest substrate, the architecture of the nest of *P. maranhaoensis* is similar to that of most of its congeners (e.g., Oniki 1970, Muscat et al. 2014, Greeney et al. 2013, 2018). Nests are constructed typically of plant fibres, with thick walls that shield the eggs and nestlings in lateral view. Nests of other species in the subfamily Phaethornithinae, such as *Glaucis* spp. and Saw-billed Hermit *Ramphodon naevius*, possess a simpler structure, with thinner walls, leaving the contents more visible from outside (Muscat et al. 2014, Lima et al. 2018).

Two-egg clutches are also typical of *Phaethornis* (Davis 1958, Skutch 1951, Schuchmann 1986, Muscat et al. 2014, Vereá 2016), although Lima et al. (2007) reported a Planalto Hermit *P. pretrei* nest with four eggs. Morphometrics of the eggs of *P. maranhaoensis* are also consistent with those of congeners of similar body size (Oniki 1970, Muscat et al. 2014), as was the nests height above ground in the understorey (Muscat et al. 2014, Greeney et al. 2018, Melo & Greeney 2019). The incubation period of *P. maranhaoensis* (16 days) is identical to that of *P. pretrei* (Lima et al. 2007), a slightly larger species, and similar to congeners such as *P. longuemareus* (14–15 days; Skutch 1951), *P. superciliosus* (17–18 days; Skutch 1964) and Sooty-capped Hermit *P. augusti* (20 days; Vereá 2016).

Greeney et al. (2013) recorded 11 pairs of neossoptiles on the dorsum of recently hatched *P. griseogularis*, which is also similar to *P. maranhaoensis*. In nestlings of *P. augusti*, the pterylae is darker than the skin, with feathers emerging from the fifth day onwards (Vereá 2016), while *P. pretrei* hatches entirely naked (Lima 2007). Unfortunately, few detailed descriptions of pterolysis and feather development in hummingbirds are available (Greeney et al. 2008), despite their potential for understanding phylogenetic relationships among species.

In general, the nest architecture and the eggs of *P. maranhaoensis* are similar to those of other *Phaethornis*. Our findings substantially advance our understanding of the species' natural history, which is still very poorly known. We encourage other researchers to focus on collecting such basic data for Neotropical birds, especially those that are still poorly known, to guarantee their effective, long-term conservation.

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