

## TADPOLE AND BREEDING HABITATS OF *CHIASMOCLEIS SHUDIKARENSIS* (ANURA, MICROHYLIDAE) IN CENTRAL AMAZONIA, BRAZIL

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**ABSTRACT.** In this study we describe the tadpoles of *Chiasmocleis shudikarensis* based on 37 individuals and 14 development stages. The tadpole of *C. shudikarensis* is characterized by small size (15.6 mm total length in stage 36), body rectangular in dorsal view, oval in lateral view; eyes lateral; nostrils absent; tail triangular, gradually diminishing to a pointed tip; spiracle long and wide, its distal border projecting over the anal tube and with finger-shaped projections; mouth small and terminal with marginal papillae and jaw sheaths absent; upper lip narrow, fleshy, covering the oral opening; lower lip narrow with a U-shaped medial notch. We also provide comments on spawning sites and breeding period.

**KEY-WORDS.** Central Amazonia, reproduction site, tadpole morphology.

### INTRODUCTION

The microhylid genus *Chiasmocleis* is composed of 25 species distributed from Panama to tropical South America, north and east of the Andes (Frost, 2011). Despite this diversity, the larvae of only eight species have been formally described: *C. alagoanus* Cruz, Caramaschi and Freire, 1999 (Nascimento and Skuk, 2006), *C. albopunctata* (Boettger, 1885) (Oliveira-Filho and Giaretta, 2006), *C. anatis* Walker and Duellman, 1974 (Duellman, 1978), *C. carvalhoi* Cruz, Caramaschi and Izecksohn, 1997 (Wogel *et al.*, 2004), *C. hudsoni* Parker, 1940 (Rodrigues *et al.*, 2008), *C. leucosticta* (Boulenger, 1888) (Langone *et al.*, 2007), *C. panamensis* Dunn, Trapido and Evans, 1948 (Vera Candioti, 2006), and *C. ventrimaculata* (Andersson, 1946) (Schlüter and Salas, 1991; Duellman, 2005).

*Chiasmocleis shudikarensis* Dunn, 1949 appears to be endemic to the Guiana Shield and is distributed in Guyana, Surinam, French Guiana, and northern Brazil (Frost, 2011). Reproduction occurs from March to May and eggs are deposited on the water surface (Lima *et al.*, 2006). Hero (1990) described a few external features of the tadpole of *C. shudikarensis* (e.g. diagrammatic drawings and body coloration), but did not provide a detailed description.

Here we describe the tadpole of *Chiasmocleis shudikarensis*, based on individuals from Manaus, Brazil, in 14 developmental stages. We also provide comments on the spawning site, compare tadpoles

with other species of *Chiasmocleis* and comment on Hero's (1990) description of the tadpole of *C. shudikarensis*.

### MATERIALS AND METHODS

Newly collected tadpoles of *Chiasmocleis shudikarensis* were deposited in the Coleção Zoológica Paulo Bührnheim of the Universidade Federal do Amazonas (CZPB-UFAM). We collected CZPB-UFAM 112 from temporary isolated ponds at Reserva Florestal Adolpho Ducke (RFAD; 02°55' and 03°01'S, 59°53' and 59°59'W) on 13 January 2005, and CZPB-UFAM 111 at Fazenda Experimental of the Universidade Federal do Amazonas (Fazenda UFAM: 02°37'17" and 02°39'41"S, 60°03'29" and 60°07'57"W) on 12 May 2011, both near the city of Manaus, Amazonas state, Brazil. RFAD covers 10,000 ha of *terra firme* (non-flooded) rainforest, a well-drained forest not subject to seasonal inundation. Fazenda UFAM has an area of 3,000 ha of *terra firme* rainforest. The forest in both areas is characterized by a 30-37 m closed canopy with emergent trees growing to 40-45 m (Ribeiro *et al.*, 1999). The understory contains abundant sessile palms (*Astrocaryum* spp. and *Attalea* spp.; Ribeiro *et al.*, 1999). The climate is characterized by a rainy season from November to May and a dry season during the rest of the year (Marques Filho *et al.*, 1981). Mean annual temperature is approximately 26°C throughout the year (Marques Filho *et al.*,

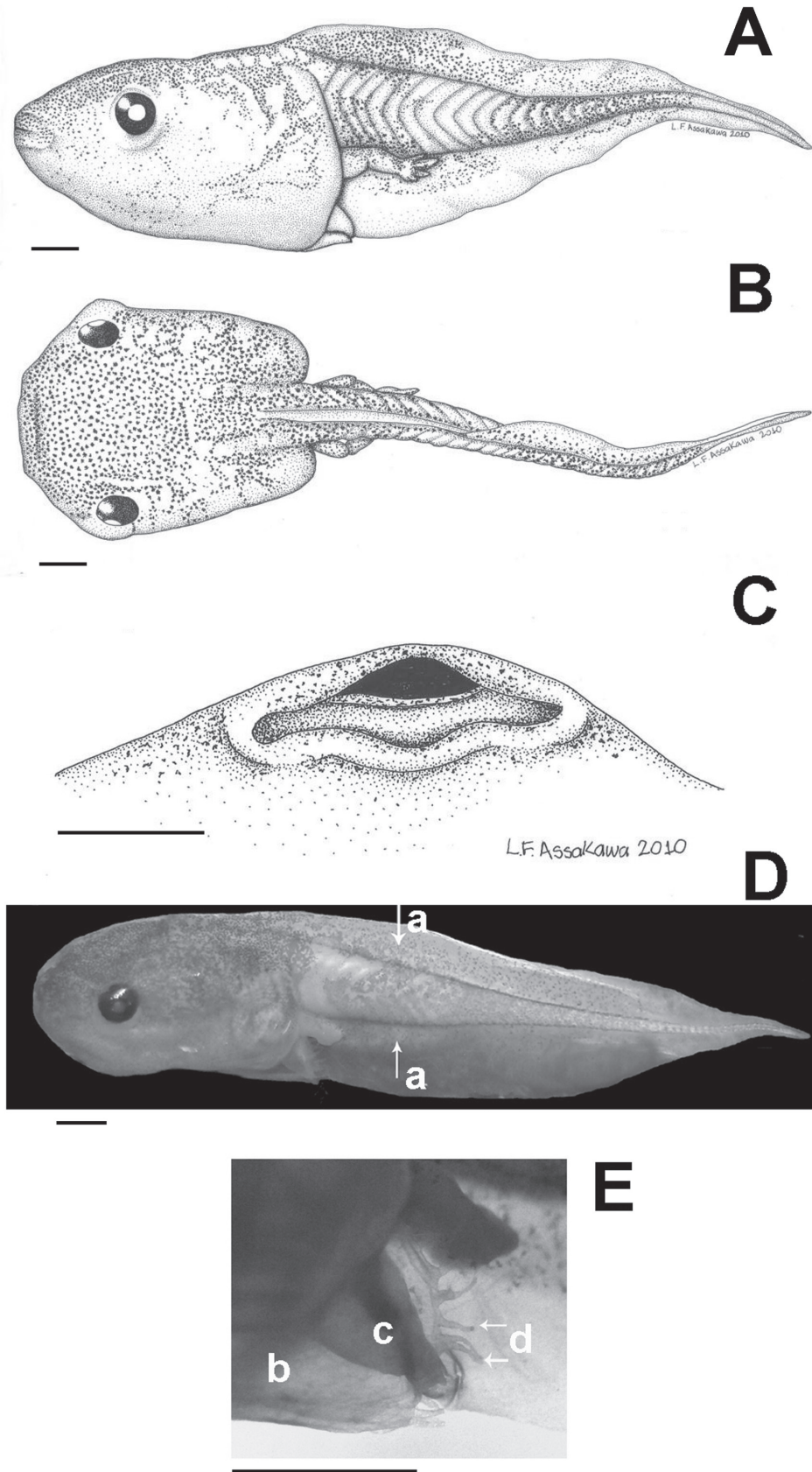


FIGURE 1. *Chiasmocleis shudikarensis* tadpole (INPA-H 8421) in stage 36. (A) Lateral view, (B) dorsal view, and (C) oral disc. Tadpole (INPA-H 8386) in stage 33 (D; a = thickening at the fins) and detail of the spiracle and vent tube (E; b = spiracle; c = vent tube; d = finger-shaped projections in the spiracle). Specimens from Biological Dynamics of Forest Fragment Project, north of Manaus, Amazonas, Brazil. Scale = 1 mm.

1981) and mean annual rainfall was 2,489 mm between 1985 and 2004.

Additional individuals were obtained from the Herpetological Collection of the Instituto Nacional de Pesquisas da Amazônia (INPA-H) which were collected at areas of the Biological Dynamics of Forest Fragment Project (BDFFP; 02°25'S, 59°48'W), located 80 km north of Manaus, Amazonas state, Brazil, within an area of approximately 500,000 ha of relatively undisturbed, *terra firme* lowland rainforest (Lovejoy and Bierregaard, 1990). The vegetation structure and climate characteristics of BDFFP are similar to RFAD.

Most tadpoles were preserved in formalin immediately after collection. Species identity was determined by rearing some tadpoles through metamorphosis. Twenty-one individuals were obtained from the INPA-H Collection: INPA-H 1556, six individuals collected by B. Zimmerman and J.-M. Hero on 02 June 1985 at BDFFP; INPA-H 1572, eight individuals collected by J.-M. Hero on 05 May 1987 at Reserva 1401/BDFFP; INPA-H 8386, two individuals collected by M. Tocher on 26 January 1993 at Fazenda Dimona/BDFFP; INPA-H 8421, four individuals collected by O. Pereira on 19 May 1996 at Reserva Colosso/BDFFP.

Tadpole stages follow Gosner (1960). Descriptive terminology and morphometric variables follow Altig and McDiarmid (1999). Measurements were taken with an ocular micrometer.

## RESULTS

### Tadpole description

*External Morphology* – The description is based on four tadpoles in stage 36 (INPA-H 8421). Body oval in dorsal (Fig. 1A) and in lateral view (Fig. 1B). Body and tail 43.2% and 56.8% of total length, respectively. Body wider than deep. Body highest in its posterior third and wider immediately posterior to eyes. Snout broad and truncate in dorsal view, rounded in lateral view. Eyes located laterally and directed laterally. Interorbital distance approximately four times larger than maximum eye diameter. Narial openings absent. Spiracle single, long and wide, positioned medially and ventrally (midventral on lower abdomen); distal border projecting over anal tube, visible in lateral view, with small finger-shaped projections (Fig. 1E). Vent tube positioned along ventral midline, attached directly to ventral fin, opening directed downward

(Fig. 1E). Tail musculature heavy, gradually diminishing to flagellate tip. Dorsal fin originating at tail-body junction, similar throughout anterior two-thirds of the tail, then diminishing abruptly to pointed tip. Ventral fin originating at posterior ventral terminus of body, deeper than dorsal fin along first two-thirds of the tail, slightly arched and diminishing abruptly to pointed tail. Mouth small ( $1.90 \pm 0.42$  mm), terminal (Fig. 1C). Upper lip narrow, fleshy, covering oral opening. Lower lip narrow with U-shaped medial notch. Jaw sheaths, papillae and tooth rows absent. Measurements of tadpoles at other developmental stages are presented in Table 1.

*Variation* – At stage 43 the external nares are located in the dorsal area and consist of a rounded whitish spot. In dorsal and ventral fins near the base of the tail there is a peculiar thickening, visible at stages 25 to 38 (Fig. 1D). The projections of the spiracle are visible at stages 25 to 35 and are reduced at stages 36 to 38.

*Coloration* – In life, dorsum greenish, venter whitish, tail fins translucent, tail muscle greenish with melanophores up to half its length, posterior third of tail muscle whitish. In fixed specimens, dorsum and tail musculature with dark melanophores, venter whitish with few melanophores on anterior portion; tail fins transparent with few melanophores on dorsal fin and posterior third of the ventral fin.

*Natural History* – Breeding adults, clutches and tadpoles were observed in temporary isolated ponds within forests. Clutches were laid on the water surface. The tadpoles of *Chiasmocleis shudikarensis* found at RFAD were in an isolated pond of approximately 80 cm deep and 22 × 8 m wide (approximately 176 m<sup>2</sup>), on clay soil. The hydroperiod of the pond was short (less than 60 days), but after heavy rainfall it collected water again and returned to its previous size. Eight species of tadpoles co-occurred with *Chiasmocleis shudikarensis*: *Ceratophrys cornuta* (Ceratophryidae), *Phyllomedusa bicolor*, *P. tarsi*, *P. tomopterna* (Hylidae), *Leptodactylus knudseni*, *L. mystaceus* (Leptodactylidae), *Chiasmocleis hudsoni* and *Ctenophryne geayi* (Microhylidae). Tadpoles of *C. shudikarensis* were observed near the water surface, but any movement in the water caused them to sink. The tadpoles were close to each other, forming small aggregations in the deepest part of the pond. When the tadpoles were near the edge of the pond (about 10 cm deep), they remained among

TABLE 1. Measurements (in mm) of 37 *Chiasmocleis shudikarensis* tadpoles in Gosner's (1960) stages 25 to 28, 30 to 38 and 43. For stages with three or more individuals, values are given as the mean  $\pm$  standard deviation, minimum and maximum. For stages with one or two individuals, the values are given for each individual.

Characters/Stages	Stage 25 (N = 3)	Stage 26 (N = 3)	Stage 27 (N = 1)	Stage 28 (N = 1)	Stage 30 (N = 2)	Stage 31 (N = 4)	Stage 32 (N = 1)	Stage 33 (N = 2)	Stage 34 (N = 1)	Stage 35 (N = 5)	Stage 36 (N = 7)	Stage 37 (N = 4)	Stage 38 (N = 2)	Stage 43 (N = 1)
Total length	6.12 $\pm$ 0.62 5.76 – 6.84	8.72 $\pm$ 0.48 8.16 – 9.00	10.2 4.3	11.04 5.52	9.92 4.56	13.32 $\pm$ 1.01 12.16 – 14.56	15.04 5.84	14.72 5.36	14.88 5.60	13.28 $\pm$ 1.41 10.88 – 14.24	15.66 $\pm$ 1.78 13.60 – 18.40	14.76 $\pm$ 2.23 12.00 – 16.80	11.76 14.08	9.60
Body length	2.85 $\pm$ 0.17 2.72 – 3.04	3.84 $\pm$ 0.49 3.52 – 4.40	4.3 5.9	5.52 5.52	4.56 5.64	5.47 $\pm$ 0.09 5.40 – 5.60	5.84 9.20	5.36 9.36	5.60 9.28	5.74 $\pm$ 0.28 5.44 – 6.16	6.75 $\pm$ 0.66 6.00 – 7.60	6.21 $\pm$ 0.25 6.00 – 6.48	5.60 5.84	5.04
Tail length	3.27 $\pm$ 0.46 2.96 – 3.80	4.88 $\pm$ 0.97 3.76 – 5.48	5.9 2.05	5.52 2.60	5.36 1.75	7.85 $\pm$ 0.95 6.72 – 8.96	9.20 2.90	9.36 10.32	9.28 —	7.53 $\pm$ 1.25 5.44 – 8.56	8.90 $\pm$ 1.98 6.80 – 11.92	8.55 $\pm$ 2.00 6.00 – 10.32	5.92 8.80	4.56
Maximum tail height	2.12 $\pm$ 0.46 1.85 – 2.65	2.08 $\pm$ 0.07 2.00 – 2.15	2.05 0.80	2.60 1.65	1.75 3.00	3.11 $\pm$ 0.53 2.75 – 3.90	2.90 1.75	3.10 3.65	— 1.70	2.52 $\pm$ 0.49 2.00 – 3.25	3.68 $\pm$ 0.69 2.70 – 4.60	2.84 $\pm$ 0.51 2.30 – 3.48	2.40 2.45	1.56
Tail muscle height	0.90 $\pm$ 0.09 0.85 – 1.00	0.92 $\pm$ 0.14 0.75 – 1.00	0.80 0.50	1.65 0.85	1.00 1.20	1.58 $\pm$ 0.14 1.44 – 1.75	1.75 1.00	1.40 1.85	1.70 1.25	1.57 $\pm$ 0.20 1.35 – 1.80	1.90 $\pm$ 0.13 1.75 – 2.04	1.56 $\pm$ 0.34 1.25 – 2.04	1.45 1.50	1.56
Tail muscle width	0.48 $\pm$ 0.03 0.45 – 0.50	0.58 $\pm$ 0.08 0.50 – 0.65	0.50 2.25	0.85 2.75	1.00 0.75	0.98 $\pm$ 0.03 0.95 – 1.00	1.00 3.00	1.00 1.05	1.25 3.15	0.90 $\pm$ 0.21 0.75 – 1.25	1.14 $\pm$ 0.13 1.00 – 1.25	1.00 $\pm$ 0.00 3.64 $\pm$ 0.32	0.90 3.44	1.32
Interorbital distance	1.87 $\pm$ 0.20 1.75 – 2.10	2.23 $\pm$ 0.23 2.00 – 2.45	2.25 0.50	2.75 0.75	2.50 2.88	2.85 $\pm$ 0.27 2.65 – 3.25	3.00 0.80	3.15 3.25	3.15 0.75	3.13 $\pm$ 0.28 2.75 – 3.50	3.88 $\pm$ 0.45 3.00 – 4.50	3.64 $\pm$ 0.32 3.25 – 3.96	3.44 3.50	3.24
Eye diameter	0.70 $\pm$ 0.05 0.65 – 0.75	0.68 $\pm$ 0.03 0.65 – 0.70	0.50 1.00	0.75 1.25	0.65 1.10	0.80 $\pm$ 0.07 0.75 – 0.90	0.80 1.25	0.75 1.50	0.75 1.50	0.78 $\pm$ 0.04 0.75 – 0.85	0.98 $\pm$ 0.06 0.85 – 1.00	0.92 $\pm$ 0.13 0.75 – 1.05	0.75 0.75	1.15
Oral disc width	0.75 $\pm$ 0.00 0.75 – 0.00	0.75 $\pm$ 0.00 0.75 – 0.00	1.00 1.00	1.25 1.25	1.10 1.25	1.26 $\pm$ 0.20 1.00 – 1.50	1.25 1.50	1.50 1.50	1.50 1.50	1.45 $\pm$ 0.11 1.25 – 1.50	1.91 $\pm$ 0.42 1.50 – 2.50	1.49 $\pm$ 0.16 1.25 – 1.60	1.50 1.50	1.65

submerged decaying leaves. At Fazenda UFAM, the tadpoles were found in an isolated pond approximately 100 cm deep and 10  $\times$  10 m across (approximately 100 m<sup>2</sup>) on clay soil. Tadpoles of *Chiasmocleis hudsoni* and *Ctenophryne geayi* co-occurred in this pond.

## DISCUSSION

The characteristics of *Chiasmocleis shudikarensis* tadpoles differ from those described by Hero (1990): the spiracle is not a short tube with midventral position but is instead long and wide, with distal border projecting over the anal tube, visible in lateral view; the body is not depressed/globular; and the tail muscle is not narrow, instead diminishing only on the posterior third of the tail. The figure in Hero (1990) depicts a tadpole with body depressed, snout broad and bluntly rounded in dorsal view, rounded in lateral view, spiracle single and median posterior, anal tube medial, and caudal musculature slender. Based on comparisons with the figure in Schlüter and Salas (1991) and tadpoles collected by us (unpubl. data), we conclude that the tadpole described by Hero (1990) as *C. shudikarensis* is actually *Ctenophryne geayi*.

General morphology of the tadpoles of *Chiasmocleis shudikarensis* is similar to those described for other species in the genus *Chiasmocleis*, including an oval body, a flagellum on the tip tail (also present in the majority of species), lateral eyes, absence of narial openings, medial spiracle, and terminal mouth with fleshy anterior labium (Duellman, 1978, 2005; Schlüter and Salas, 1991; Wogel *et al.*, 2004; Nascimento and Skuk, 2006; Oliveira-Filho and Giarretta, 2006; Vera Candioti, 2006; Langone *et al.*, 2007; Rodrigues *et al.*, 2008). The more distinctive characteristics of the tadpole of *C. shudikarensis* are the ventral fin being deeper than the dorsal fin along the first two-thirds of the tail, the presence of the peculiar thickening at the fins in the base of the tail, and the spiracular opening with finger-shaped projections. The presence of a peculiar thickening on the fins was also observed in tadpoles of *C. alagoanus*, *C. panamensis*, *C. leucosticta* (Nascimento and Skuk, 2006; Vera Candioti, 2006; Langone *et al.*, 2007), and *Dermatonotus muelleri* (Lavilla, 1992; F. Nomura, personal communication).

The tadpole of *Chiasmocleis shudikarensis* is smaller than tadpoles of *C. anatis* (total length (TL) = 32.5 mm, stage 37; Duellman, 1978),

*C. albopunctata* (TL = 18.3-21.5 mm, stage 38; Oliveira-Filho and Giaretta, 2006), and *C. leucosticta* (TL = 19.6 mm, stage 36; Langone *et al.*, 2007), and larger than *C. hudsoni* (TL = 11.0-12.1 mm, stage 33; Rodrigues *et al.*, 2008). It is distinguished from *C. albopunctata* by the insertion of the dorsal fin (dorsal fin inserted at the final third of body in *C. albopunctata*; Oliveira-Filho and Giaretta, 2006), from *C. hudsoni* (Rodrigues *et al.*, 2008) and *C. panamensis* (Vera Candiotti, 2006) by the presence of a flagellum, and from *C. albopunctata* (Oliveira-Filho and Giaretta, 2006), *C. carvalhoi* (Wogel *et al.*, 2004), *C. leucosticta* (Langone *et al.*, 2007), and *C. panamensis* (Vera Candiotti, 2006) by the absence of two symmetrical semicircular flaps hanging over the mouth from above. It differs from *C. alagoanus* (Nascimento and Skuk, 2006), *C. carvalhoi* (Wogel *et al.*, 2004), and *C. ventrimaculata* (Schlüter and Salas, 1991) in lacking a pair of curved, bracket-shaped, light-cream lines between the eyes.

The clutches and tadpoles of *Chiasmocleis shudikarensis* were found in lentic habitats similar to those described for all other species of this genus (Duellman, 1978, 2005; Schlüter and Salas, 1991; Wogel *et al.*, 2004; Nascimento and Skuk, 2006; Oliveira-Filho and Giaretta, 2006; Vera Candiotti, 2006; Langone *et al.*, 2007; Rodrigues *et al.*, 2008). Tadpoles of *C. shudikarensis* were found only in isolated ponds clumped within a limited part of the RFAD and Fazenda UFAM, syntopically with tadpoles of *C. hudsoni* (Rodrigues *et al.*, 2010).

#### RESUMO

Neste estudo, nós descrevemos os girinos de *Chiasmocleis shudikarensis* utilizando 37 indivíduos em 14 diferentes estádios de desenvolvimento. O girino de *C. shudikarensis* é caracterizado pelo pequeno tamanho (comprimento total = 15,6 mm no estágio 36), corpo retangular em vista dorsal e oval em vista lateral; cauda triangular, diminuindo gradualmente até a ponta; olhos laterais; narinas ausentes; espiráculo longo e largo, cuja borda se projeta além do tubo anal; espiráculo com projeções digitiformes na borda; boca pequena e terminal, sem papilas ou mandíbulas queratinizadas; lábio superior estreito, carnoso, cobrindo a abertura bucal; lábio inferior estreito com um entalhe mediano em forma de U. Fornecemos também comentários sobre o local e período de produção da espécie.

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