TAPROBANICA, ISSN 1800-427X. October, 2011. Vol. 03, No. 02: pp. 77-85.

A NEW SPECIES OF *Dendrelaphis* (SERPENTES: COLUBRIDAE) FROM THE WESTERN GHATS - INDIA

Sectional Editor: Indraneil Das *Submitted*: 07 October 2011, *Accepted*: 30 November 2011

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Abstract
A new species of the colubrid genus *Dendrelaphis* Boulenger 1890 is described from the Western Ghats, India. *Dendrelaphis girii* sp. nov. resembles *Dendrelaphis bifrenalis* (Boulenger, 1890) which inhabits Sri Lanka. It differs from the latter predominantly in the absence of a ventrolateral stripe, the much narrower and shorter postocular stripe and the broader snout. The description of *D. girii* sp. nov. underscores the notion that Sri Lanka and the Western Ghats are faunally more distinct than previously thought.

***Key Words*:** *Dendrelaphis girii* sp. nov., *Dendrelaphis bifrenalis*, taxonomy, reptilia, Sri Lanka

Introduction

The colubrid snakes of the genus *Dendrelaphis* Boulenger, 1890 are widely distributed, ranging from Pakistan in the West to the northern and eastern coast of Australia in the East and South and to southern China in the North (Ziegler & Vogel, 1999). Members of the genus *Dendrelaphis* are slender, diurnal species that are predominantly arboreal and feed mainly on lizards and amphibians. In 1858, Günther recorded a specimen of the genus *Dendrelaphis* with two loreal shields. It originated from Sri Lanka. He regarded it as a variety of *Dendrophis picta* (var. C.) (Gmelin, 1789) but pointed out that, in addition to the double loreal shield, the muzzle is elongate in comparison to *Dendrelaphis pictus*. Boulenger later described the form represented by Günther's specimen as *Dendrophis bifrenalis* (1890) on the basis of three syntypes. Four years later he elaborated on his initial description on the basis of the same three specimens (Boulenger, 1894). At some point, this species has again been regarded as a subspecies of *Dendrelaphis pictus* (Meise & Henning, 1932; Mertens, 1934).

Ferguson (1895) was the first to record *Dendrophis bifrenalis* from India and stated that it is not

uncommon in Trevandrum (today Thiruvananthapuram, Kerala). Subsequently, Wall (1921) confirmed the occurrence of this species in India, namely in Trevandrum and in Travancore (today a part of Kerala). Subsequent works (Smith, 1943; Mahendra, 1984; Sharma, 2007) have not presented new locality records. However, Whitaker & Captain (2004) doubted the occurrence of this species in India, assuming it to be a Sri Lankan endemic. Thus, despite the fact that Ferguson considered this species to be common, it has been recorded only sparsely. Indeed, no Indian specimen could be located by the authors during investigations in the majority of collections in Europe and several collections in the United States.

Recent species descriptions and revalidations suggest that levels of endemism harboured by Sri Lanka as well as the Western Ghats may be substantially higher than currently known (e.g. Mukherjee & Bhupathy, 2007; Van Rooijen & Vogel, 2008; 2009; Vogel & Van Rooijen, 2011a). This notion, as well as some observed differences in coloration between the Sri Lankan and Indian sister populations of *Dendrelaphis bifrenalis*, incited this study into the population systematics of this species.

Materials and Methods

Nineteen museum specimens were examined. This sample represented 13 specimens from Sri Lanka and 6 specimens from the Indian subcontinent. For each examined specimen, 21 characters including aspects of colour pattern, body proportions and scalation were recorded (Table 1). Eye-diameter and distance eye-nostril were measured with a slide calliper to the nearest 0.1 mm. These measurements were made on the left and right side and were subsequently averaged. Snout-vent length and tail-length were measured by marking the length on a piece of string and subsequently measuring the position of the mark to the nearest 0.5 cm. Snout-vent length was measured to the posterior margin of the anal plate. The number of ventrals was counted following Dowling (1951). Subcaudals were counted on one side, the terminal scute was excluded. The first sublabial was defined as the scale that starts between the posterior chin shield and the infralabials and that borders the infralabials (see Peters, 1964, fig. 7; Lillywhite, 2008). The last infralabial was defined as the infralabial still covered completely by the last supralabial. The posterior most temporal scales were defined as the scales of which more than half of the area lies in front of an imaginary line that runs from the apex of the last supralabial to the posterolateral corner of the parietal.

Characters were analyzed univariately using either χ^2 (stripe2) or ANCOVA (all others). Characters exhibiting significant or near-significant differences ($P<0.1$) between the populations were included in a Principal Components Analysis (PCA, e.g. Cramer, 2003). For PCA, morphometric variables were adjusted to a common SVL of 50.5 cm to correct for potential ontogenetic variation between the samples of the species (e.g. Thorpe, 1975, 1983; How *et al*., 1996; Turan, 1999). The following allometric equation was applied: $X_{adj} = X - \beta(SVL - SVL_{mean})$ where X_{adj} is the adjusted value of the morphometric variable; X is the original value; SVL is the snout-vent length; SVL_{mean} is the overall mean snout-vent length; β is the coefficient of the linear regression of X against SVL. All statistical analyses were carried out with the software SPSS (2006; SPSS for Windows. Release 14.0.2. Chicago: SPSS Inc.).

***Museum abbreviations*:** BMNH: The Natural History Museum, London, UK; BNHS: Bombay Natural History Society, Mumbai, India; FMNH: Field Museum of Natural History, Chicago, USA; MHNG: Muséum d'histoire naturelle, Geneve, Switzerland; NMW: Naturhistorisches Museum Wien, Austria; SMF: Natur-Museum und Forschungs-Institut Senckenberg, Frankfurt-am-Main, Germany; USNM: United States National Museum, Washington, USA.

Results

***Statistical analyses*:** Figure 1 shows the results of a PCA based on the characters VENT, SUBC, TAIL, INFR, TEMP, ATEMP, WSNT, STRIPE1, STRIPE2 and NECK. A clear separation of the two sister populations is in evidence.

Table 2 gives descriptive statistics as well as significance-levels of the differences. The most important differences are the lower number of gular scales, the broader snout, the narrower postocular stripe and the rudimentary ventrolateral stripe in *D. girii* sp. nov.

***Taxonomic evaluation*:** Evidently, the two sister populations differ in several aspects of their morphology and coloration. In addition, the two populations are reproductively isolated due to an extrinsic geographic barrier (the Indian Ocean). Therefore, the two populations are considered to represent separately evolving lineages, and therefore species, in accordance with the general lineage species concept (De Queiroz, 1998, 2007)

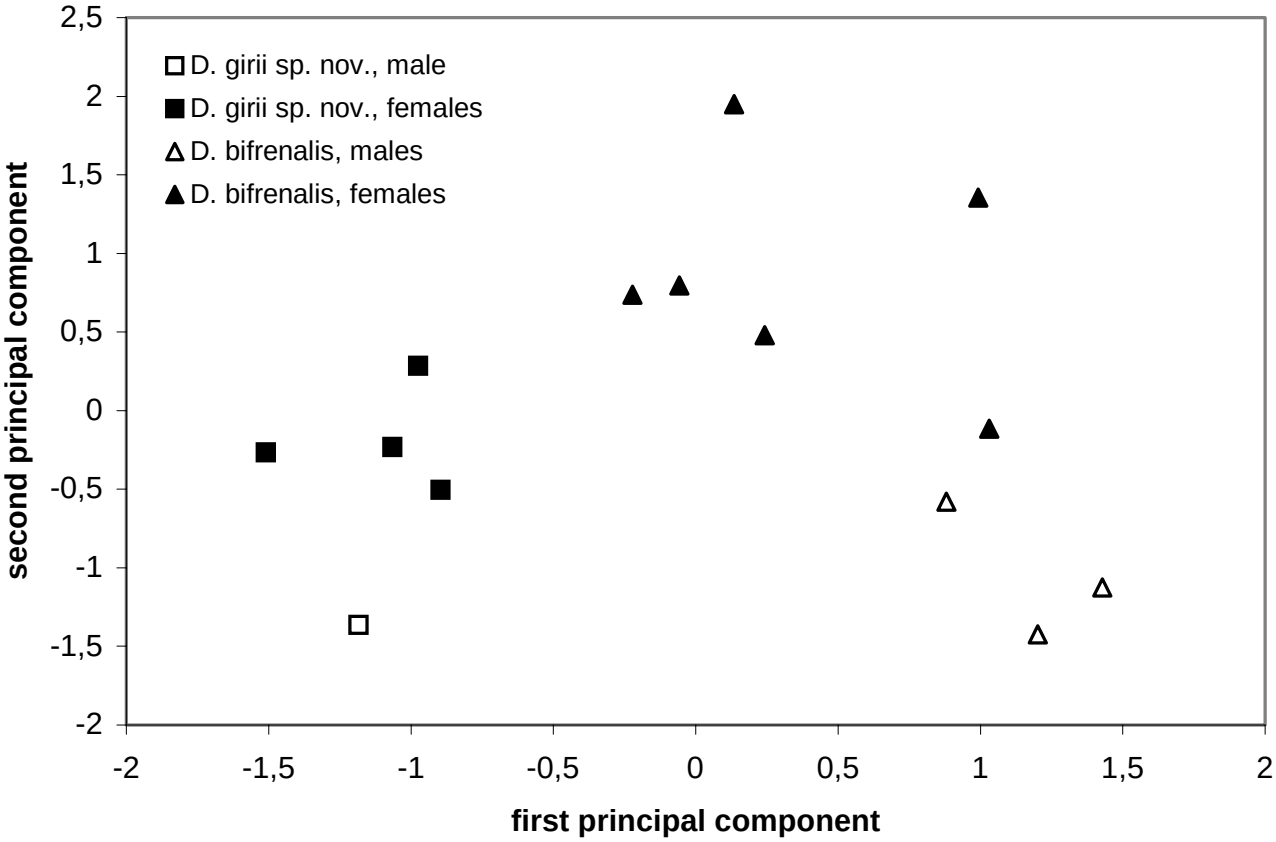

Fig. 1: Ordination of *Dendrelaphis girii* spec. nov and *D. bifrenalis* along the first two principal components, based on a PCA of the characters VENT, SUBC, TAIL, INFR, TEMP, ATEMP, WSNT, STRIPE1, STRIPE2 and NECK

Table 1: List of morphometric, meristic and coloration characters used in this study and their abbreviations

Abbreviation	Character
Morphometrics	
SVL	Snout-vent length
TAIL	Tail-length
HL	Head-length
EYED	Horizontal diameter of the eye
EYEN	Distance from centre of the eye to posterior border of the nostril
WSNT	Width of the snout
Scalation	
VENT	Number of ventrals
SUBC	Number of subcaudals
DOR1	Number of dorsal scale rows at 1 head-length behind the head
DOR2	Number of dorsal scale rows at the position of the middle ventral
DOR3	Number of dorsal scale rows at 1 head-length before the tail
TEMP	Number of temporals (L+R)
SL1	Number of supralabials (L+R)
SL2	Number of supralabials touching the eyes (L+R)
INFR	Number of infralabials (L+R)
SUBL	Number of infralabials touched by the first sublabial (L+R)
GUL	Number of gulars
LOR	Number of loreals (L+R)
POC	Number of postoculars (L+R)
VERT	Vertebral scales not enlarged (0), enlarged (1)
Coloration	
Stripe1	Percentage of temporal region covered by postocular stripe
Stripe2	Light ventrolateral stripe present (1), absent/rudimentary (0)
Neck	Black oblique bars on the neck (yes: 1; no: 0)

Table 2: Morphological and coloration characters of *Dendrelaphis girii* spec. nov and *D. bifrenalis*. Values of snout-width are SVL-adjusted.

	***D. girii* sp. nov.**	***D. bifrenalis***	**Significance P**
relative tail-length	0.37 [0.36-0.37]	0.38 [0.37-0.39]	0.02
subcaudals	144 [140-147]	148 [141-158]	0.07
ventrals	170 [166-173]	164 [156-172]	0.02
infralabials	20 [19-20]	20 [19-23]	0.09
temporals	16 [6-18]	12 [6-15]	0.03
anterior temporals	2 [1-3]	1.5 [1-2]	0.09
snout width	4.5 mm [4.0-4.6]	3.2 mm [2.6-3.5]	0.0002
percentage of temporal region covered by postocular stripe	17% [10-25]	60% [40-80]	0.0001
clear ventrolateral line present	0%	100%	0.002
black bars on the neck	0%	67%	0.007

***Dendrelaphis girii* sp. nov.**

Dendrophis bifrenalis: FERGUSON, 1895, WALL, 1921
Ahaetulla bifrenalis: SMITH, 1943
Dendrelaphis pictus bifrenalis: MEISE & HENNING, 1932, MERTENS, 1934
Dendrelaphis bifrenalis: MAHENDRA, 1984, De Silva, 1980, SHARMA, 2007, WELCH, 1988.

This chresonymy includes only citations based on specimens definitely identified as *Dendrelaphis girii* sp. nov.

***Holotype*:** BNHS 3494: adult male; Castle Rock, District Belgaum, Karnataka, India; *Coll*. Sameer Kehimkar & Varad Giri; Date. 30.IX.2004

***Paratypes* (5 specimens):** (1) BNHS 3495: subadult female; near Keri Village, South Goa, Karnataka, India; 25.V.2003 (2) BNHS 3273: adult female; Khandige Estate, Sirumalai Hills, Tamil Nadu, India; unknown (3) BNHS 3493: adult female; Amboli, District Sindhudurg, Maharashtra, India; 8.VII.2008 (4) BNHS 3491: sex unknown; Amboli, District Sindhudurg, Maharashtra, India; 20.VI.2005 (5) BNHS 3423: adult female; from near Bhimashankar, Pune District, Maharashtra, India; unknown. *Coll.* the same as holotype.

***Diagnosis*:** A species of *Dendrelaphis* characterized by the combination of: 1) two loreal scales on each side of the head; 2) 15 dorsal scale rows at midbody; 3) enlarged vertebral scales; 4) 166-173 ventrals; 5) 140-147 subcaudals; 6) 8-9 supralabials, 2 supralabials border the eye; 7) 6-8 temporal scales; 8) a long sublabial that touches 2-5 infralabials; 9) 1-3 gular rows; 10) a divided anal shield; 11) relative tail-length 0.36-0.37; 12) a black postocular stripe that covers less than a quarter of the temporal region and that barely extends onto the neck; 13) an absent or rudimentarily present pale ventrolateral line.

***Etymology*:** We want to dedicate this species to Varad Giri, the curator of the herpetological collection of the Bombay Natural History Society. He contributed enormously to the knowledge of the Indian reptiles by his own research and by making the BNHS collection easily available for all kind of researchers.

Description of the holotype (Fig. 2 & 3)**:** Adult male; dissected; body very slender; snout-vent length 65.3 cm; tail-length 37.3 cm; relative tail length 0.36; head distinct from neck; head-length 23.1 mm; snout width 5.5 mm; pupil round; eye-diameter 4.45 mm (left/right averaged); distance eye-nostril 4.85 mm (left/right averaged); 169 ventrals; 147 subcaudals; dorsal scales in 15-15-11 rows; 9 supralabials, 5th and 6th border the eye; 9/10 infralabials, infralabials 1–5 touch the first chinshield, infralabials 5 and 6 touch the second chinshield; 1 preocular; 2 postoculars; 2 loreals, anterior one larger than posterior one and more elongate; temporal formula 2:1:2:2 (L), 2:2:1:2 (R); first sublabial touches infralabials 6 through 9; vertebrals moderately enlarged, with straight posterior margin, width of the vertebral scale at the position of the middle ventral scale 2.8 mm; anal divided; parietal scales bordered posteriorly by 4 scales (not being temporal scales). Ground colour of body and tail bluish-grey mixed with brown (depending on the upper layer of the skin, which is partly damaged), the upper head brown (preservation artefact); supralabials whitish; 7th - 9th supralabials with dark dorsal margins, the preocular dark on its ventral part; a black postocular stripe starts behind the eye, covers only a small part of the temporal region, and extends to the upper jaw with a few spots behind the ankle of the jaw; no ventrolateral line present, belly and underside of the tail uniform whitish.

Fig. 2: BNHS 3494: adult male; Castle Rock, Belgaum District, Karnataka State, India; Holotype of *Dendrelaphis girii* sp. nov.

Fig. 3: *Dendrelaphis girii* (in life, specimen was not preserved); close-up of the head enlarged; Photos: Ashok Captain

***Description of the paratypes*:** A summary of morphological and coloration data of the paratypes is given in Table 3. Other important characters agree with features of the holotype.

Table 3: Morphological and coloration characters of the types of *Dendrelaphis girii sp. nov.*

Collection number BNHS	**3494**	**3423**	**3495**	**3273**	**3493**	**3491**
status	Holotype	Paratype	Paratype	Paratype	Paratype	Paratype
Sex	m	f	f	f	f	?
Snout-vent length (cm)	65.3	57.3	46.5	51.5	74.3	64.7
Tail-length (cm)	37.3	33.4	27.1	29.8	-	37.5
Head-length (mm)	23.1	20.7	17.6	18.9	26.3	22.9
Eye-diameter (mm)	4.4/4.3	4.0/4.0	3.6/3.8	3.2/3.5	4.7/4.9	4.4/4.4
Eye-nostril distance (mm)	5.0/4.7	4.5/4.8	3.8/4.1	4.0/4.1	6.1/5.6	5.3/5.4
Snout-width (mm)	5.5	5.3	3.9	4.7	6.9	-
Ventrals	169	166	167	173	171	170
Subcaudals	147	140	142	145	inc	144
Dorsal formula	15-15-11	16-15-11	15-15-11	15-15-11	15-15-11	17-15-11
Temporal formula	2122/2212	2222/22212	2221/2122	12/12	3221/22231	3222/3132
Supralabials	9/9	9/9	9/8	9/9	9/9	7/8
Supralabials touching the eye	5,6/5,6	5,6/5,6	5,6/5,6	5,6/5,6	5,6/5,6	4/4,5
Infralabials	9/10	10/10	10/10	10/10	9/10	10/10
Infralabials touched by first sublabial	6-9/6-9	6-8/7-9	6-9/6-9	6-10/6-9	6-8/6-8	6,7/6,7
Loreals	2/2	2/2	2/2	2/2	2/2	2/2
Postoculars	2/2	2/2	2/2	2/2	3/3	2/2
Vertebrals enlarged	yes	yes	yes	yes	yes	yes
Anal shield divided	yes	yes	yes	yes	yes	yes
Light ventrolateral stripe absent or rudimentary	yes	yes	yes	yes	yes	yes
Percentage of temporal region covered by postocular stripe	10	20	25	20	10	15
Locality	Castlerock, Belgaum Dist., Karnataka	Near Bhimashankar, Pune Dist., Maharashtra	Near Keri Village, South Goa, Karnataka	Khandige Estate, Sirumalai Hills, Tamil Nadu	Amboli, Sindhudurg Dist., Maharashtra	Amboli, Sindhudurg Dist., Maharashtra

Range*: *Dendrelaphis girii sp. nov. inhabits the Western Ghats, South India. It was found in the states of Karnataka, Tamil Nadu and Maharashtra.

Comparison with other species*:** Due to their double loreal shield, ***D. girii sp. nov. and ***D. bifrenalis*** occupy a unique position within the genus. A congeneric species with a double loreal shield has been described in the past, namely *Dendrelaphis biloreatus* (Wall, 1908). However, the presence of a double loreal in *D. biloreatus* appears to be based either on an anomalous specimen or on a misjudgement (Vogel & Van Rooijen, 2011b). Furthermore, *D. biloreatus* differs from *D. girii* sp. nov. and *D. bifrenalis* in its number of dorsal scale rows (13) and its number of ventral scales (190-199).

There are several differences between *Dendrelaphis girii* sp. nov and *D. bifrenalis*. The most obvious one is the light ventrolateral line, which is present in *D. bifrenalis* and missing or very faint in *Dendrelaphis girii* sp. nov. (see Fig. 3, 4).

Fig. 4: *Dendrelaphis bifrenalis*, live specimen from Kandy - Sri Lanka. Notice the conspicuous white ventrolateral stripe; Photo: Ruchira Somaweera

The postocular stripe is much broader in *D. bifrenalis*. In *D. bifrenalis* there are black oblique bars in the neck region of some, but not all specimens (8 specimens out of 12 in our data) (see Fig. 3-5). This pattern is not sex related. It is absent in *D. girii* sp. nov. For *Dendrelaphis girii* sp. nov. we had only 1 male, so it is not possible to compare the sexual dimorphism in this character. The snout of *Dendrelaphis girii* sp. nov. is much broader than that of *D. bifrenalis*. *Dendrelaphis girii* sp. nov. has, on average, fewer subcaudals and more ventrals than *D. bifrenalis*, but the ranges broadly overlap.

Fig. 5: *Dendrelaphis bifrenalis*, live specimen from Kiriella (near Ingiriya); alt. 210 m a.s.l. - Sri Lanka; Photo: Suranjan Karunarathna

Discussion

Dendrelaphis girii sp. nov. is undoubtedly a sister species of *D. bifrenalis*. Both species exhibit a double loreal shield, a unique character within the genus, and are phenetically very similar in other aspects of morphology as well. Possibly, the common ancestor of both species dispersed across the land bridge between India and Sri Lanka that came into existence due to Pleistocene lowering of sea levels (e.g. Voris, 2000; Pethiyagoda, 2005). Subsequent isolation would have provided the opportunity for independent evolution of the sister populations.

The Western Ghats and Sri Lanka together have been designated as one of the biodiversity hotspots of the world (Mittermeier *et al*., 2005) and are known to host a high level of endemism among reptiles (e.g. Das, 1996; Ishwar *et al*., 2001; Mittermeier *et al*., 2005; Gunawardene *et al*., 2007). Recent species descriptions suggest that biodiversity as well as the level of endemism harboured by this area may be substantially higher than currently known (e.g. Pethiyagoda, 2005; Wickramasinghe *et al*., 2007; Mukherjee & Bhupathy, 2007). This notion is underscored by recent insights into the taxonomy of the genus *Dendrelaphis*: one Sri Lankan endemic, *D. schokari* Kuhl, 1820 was resurrected from synonymy (Van Rooijen & Vogel, 2008), one South Indian species, *D. chairecacos* Boie, 1827, was resurrected from synonymy (Van Rooijen & Vogel, 2009), and two new species, *D. ashoki* Vogel & Van Rooijen, 2011a and *D. girii* sp. nov. (this report) have now been described from the Western Ghats. Furthermore, these results add to the notion that the faunas of Sri Lanka and the Western Ghats are more distinct than previously recognized (e.g. Bossuyt *et al*., 2004).

Specimens examined

Dendrelaphis girii sp. nov.:

BNHS 3423, Near Bhimashankar, District Pune, Maharashtra, coll. S. Kehimkar; BNHS 3495, Near Keri Village, South Goa, Karnataka, coll. S. Korajkar and team; BNHS 3273, Khandige Estate, Sirumalai Hills, Tamil Nadu, coll. S.P. Vijaykumar; BNHS 3494, Castlerock, District Belgaum, Karnataka, coll. V. Giri and S. Kehimkar; BNHS 3493, Amboli, District Sindhudurg, Maharashtra, coll. V. Giri and Team; BNHS 3491, Amboli, District Sindhudurg, Maharashtra; coll. V. Giri and S. Kehimkar

Dendrelaphis bifrenalis

MHNG 1553.9, Inde; MHNG 743.37b, 782.75, 743.36 "Ceylon"; NMW 23724, Kandy, Sri Lanka; SMF 25483 Polonaruwa, Ceylon; FMNH 142366, Ceylon; BM 1946.1.6., 1946. 1.10.194, 1946.1.10.20, **Syntypes**, BM 94.9.11.20, Ceylon; BM 1905.3.25.98, Pundaluoya, 4000 feet, Ceylon; USNM 267765, Labugama, Sri Lanka. A fourth specimen marked as type in the collection of the British Museum (BM 94.9.11.20), should not be regarded as part of the type series.

Acknowledgements

We would like to thank Suranjan Karunarathna (Sri Lanka), Ruchira Somaweera (Sri Lanka) and Ashok Captain (India) for their valuable pictures of these uncommon species. We are grateful to Varad Giri (BNHS) and two unknown reviewers for their critical reading of this manuscript and their constructive comments that greatly improved content and language of this paper. We thank Varad Giri and Asad Rahmahi (BNHS), Colin J. McCarthy and Patrick Campbell (BMNH), Gunther Köhler and Linda Acker (SMF), George Zug and Ron McDiarmid (USNM), Franz Tiedemann and Richard Gemel (NMW), Andreas Schmitz (MHNG), Alan Resetar (FMNH), for their assistance in sending us or letting us examine preserved specimens.

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