

TAPROBANICA, ISSN 1800–427X. November, 2024. Vol. 13, No. 02: pp. 69–81, pls. 12–19.  
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 Natural Sciences, University of Indonesia, Depok 16424, INDONESIA.  
<http://www.taprobanica.org>  
<https://doi.org/10.47605/tapro.v13i2.332>



urn:lsid:zoobank.org:pub:37286D7B-934E-4AF3-903F-626410ABB9DC

## NOTES ON THE *Ophisops beddomei* COMPLEX (SQUAMATA: LACERTIDAE) WITH THE DESCRIPTION OF A NEW ALLIED CRYPTIC SPECIES FROM WESTERN INDIA

Section Editor: Thasun Amarasinghe

Submitted: 30 September 2024, Accepted: 24 November 2024

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### Abstract

The lacertid *Ophisops beddomei* was considered to be widely distributed in the northern and central Western Ghats, and some parts of western India. Recent studies, however, provide evidence of it being a species complex that harbours several morphologically cryptic species. In an attempt to resolve this species complex, we provide a re-description of *O. beddomei* sensu stricto based on type specimens and fresh material from near the type locality. Additionally, we describe a new species based on a series of 15 specimens from the states of Gujarat and Maharashtra in western India. The new species is allied to *O. beddomei* and can be diagnosed from all its congeners by the following suite of characters: a small-sized *Ophisops* (adult, SVL up to 36 mm); upper eyelid movable; supranasal fused with nasal; two frontonasals; prefrontals not in contact; enlarged tympanic scale present; 46–53 dorsal scales; 28–31 scales at mid-body; 19–21 lamellae underneath the fourth toe; six chin shields; 15–19 scales between symphysis of chin shields and ventral plates; large mental scale, extending beyond first supralabial; 8–11 femoral pores on either side interrupted by 0–1 poreless scales in males and 3–4 poreless scales in females; and subtle colour pattern differences. Molecular data for the mitochondrial cytochrome b gene further supports the distinctiveness of the new species and shows an uncorrected pairwise sequence divergence of 8% from *O. beddomei* sensu stricto. These are among the only lacertids that inhabit high-elevation plateaus and deciduous forests in the Western Ghats and surrounding hill ranges. The findings also indicate that many other similar habitats may harbour as yet undescribed endemic taxa.

**Keywords:** Endemic, hill ranges, Lacerta, plateau, Snake-eyed lizard, taxonomy

## Introduction

Members of the lacertid genus *Ophisops* Ménétries, 1832, commonly known as snake-eyed lizards, are diurnal, terrestrial lizards found predominantly in open, grassy habitats, with eight recognised species in South Asia and three in the Saharo-Arabia, West Asia, and Caucasus region (Agarwal *et al.* 2018, Patel & Vyas 2020). The first phylogenetic study of Indian members of the genus by Agarwal & Ramakrishnan (2017) identified two well-supported and deeply divergent clades that correspond to body size, one representing small-bodied members (SVL <45 mm) and the other large-bodied members (SVL >50 mm). The findings further suggest the presence of nearly 30 candidate species in India based on species delimitation using mitochondrial data. The majority of this diversity is within the small-bodied clade, with 26 candidate species in three species complexes, namely *Ophisops beddomei* (Jerdon, 1870), *O. jerdonii* Blyth, 1853, and *O. nictans* Arnold, 1989. A new species belonging to the small-bodied clade was recently described based on morphology, namely *O. agarwali* Patel & Vyas, 2020. Indian members of the large-bodied clade include the widespread species *O. leschenaultii* (Milne-Edwards, 1829), and *O. microlepis* Blanford, 1870. Two recently described species of this clade are *O. pushkarensis* Agarwal, Khandekar, Ramakrishnan *et al.* 2018, and *O. kutchensis* Agarwal, Khandekar, Ramakrishnan *et al.* 2018 (see Agarwal *et al.* 2018).

Colonel R.H. Beddome collected a few individuals of a lacertid from the ‘summit of the Brumagherries in Wynaad’ (now Brahmagiri in Karnataka) and sent one specimen to T.C. Jerdon, who described it as a new species, *O. beddomei*, initially in the genus *Pseudophiops* (Jerdon 1870). Beddome (1870), based on his collection of multiple specimens, also described the same population as a new species, namely *Pseudophiops monticola*. Both names were published in the same year, but Jerdon’s name, *P. beddomei* was published a few months earlier, thus has priority over *P. monticola*, which is considered as a junior subjective synonym of *O. beddomei* (Boulenger 1921, Smith 1935) as per the provisions in the code (ICZN 1999). After its description, the species was reported from parts of the Western Ghats and Peninsular India and to date, *O. beddomei* has been reported from the states of Karnataka, Kerala, Tamil Nadu, Goa, Maharashtra, Gujarat and Madhya Pradesh (Boulenger 1921, Smith 1935, Vyas 2003, Palot

2015, Agarwal & Ramakrishnan 2017, Patel & Vyas 2019, Mohapatra *et al.* 2023). The phylogenetic study by Agarwal & Ramakrishnan (2017) showed that *O. beddomei* is a species complex, having at least seven cryptic species. Examination of types of *P. monticola* and topotypical material allows us to present the first detailed morphological descriptions of *O. beddomei* *sensu stricto* and describe the northernmost, genetically divergent lineage as a new species.

## Material and methods

Specimens were collected in the field by hand, photographed, and euthanised with halothane within 24 h of capture following ethical guidelines for animal euthanasia (Leary *et al.* 2013). The specimens were fixed in a 4% formaldehyde solution and later stored in 70% ethanol. Tail tip tissues were collected for molecular work and stored in molecular-grade ethanol prior to specimen fixation. Material for the morphological examinations included a total of 51 alcohol-preserved specimens comprising 12 specimens of *O. beddomei*, 16 of the new species, and 23 specimens of the eight geographically proximate, closely related species; and high-resolution images of the type material of *O. microlepis* (list of comparative material examined is present in Sup. Material 1). Collection abbreviations are as follows: NHMUK: Natural History Museum, London; BNHS: Bombay Natural History Society, Mumbai; CESL: Centre for Ecological Sciences (Lizards), Bangalore; ZSI: Zoological Survey of India, Kolkata; HP: Harshil Patel field series; RV: Raju Vyas field series. Comparative data for known species of *Ophisops* was collected from the following publications: Boulenger (1921), Smith (1935), Vyas (2003), Agarwal *et al.* (2018), and Patel & Vyas (2020).

**Morphological analysis.** Specimen examination was made using a Leica S4E stereomicroscope to count meristic characters; mensural characters were taken on the right side using a digital calliper to the nearest 0.1 mm. We selected morphological characters based on previous taxonomic studies of lacertids (Arnold *et al.* 2007), especially of the genus *Ophisops* (Agarwal *et al.* 2018, Patel & Vyas 2020). We examined 22 metric and 17 meristic characters of the newly recognized species as well as of *O. beddomei*, which are: snout-vent length (SVL), measured from tip of snout to anterior edge of cloaca; tail length (TL), measured from posterior

edge of cloaca to tip of tail; trunk length (TRL), measured from posterior margin of fore limb insertion to anterior margin of hind limb insertion; head length (HL), measured from tip of snout to the posterior edge of tympanum; head height (HH), maximum distance between upper head and lower jaw; head width (HW), distance between posterior eye corners; length of forelimb (LFL), measured from top of shoulder joint to tip of 4th finger; length of hindlimb (LHL), measured from hip joint to tip of 4th toe; forearm length (FL), measured from elbow to distal end of wrist; length of femur (LFO), measured from hip joint to top of knee; length of tibia (CL), measured from top of knee to beneath wrist; eye diameter (ED), greatest horizontal diameter of eye; snout to eye distance (SE), measured from anterior margin of eye to tip of snout; nostril to eye distance (NE), measured from tip of nostril to anterior corner of eye; eye to ear distance (EE), measured from posterior edge of eye and tympanum; length of neck (NL), distance between posterior edge of tympanum and shoulder joint; tympanum diameter (TD), measured largest size; inter narial distance (IN), horizontal distance between nares; inter orbital distance (IO), taken at the posterior margin of orbit; length of cloaca crevice (LV), largest size; tail width (LBT), length of widest part of tail base; body width (BW), length of widest part of belly; supraciliary scales (SCS); supraciliary granules (SCG); supraocular scales (SOS); supralabials (SL) and infralabials (IL); loreal scales (LO); supra temporals scales (STS); chin shields (CS); dorsal scales (DS, number of scales on dorsum from behind occipital to above vent); mid body scales (RBS, scales in transverse rows at mid body); ventral scales (VS, number of enlarged scales on belly from forelimb insertion to above femoral pores); number of gular scales (GS) in a straight median series, including collar; number of collar scales (NCS) on ventral side; number of transverse series of ventral scales (NVS) counted in straight median series between collar and the row of scales separating the series of femoral pores; number of femoral pores (NFP); scale between femoral pores (SBFP); transverse subdigital lamellae, counted from the base of the digits to the claw and including the claw sheath on the finger 1 (LAM1F), finger 2 (LAM2F), finger 3 (LAM3F), finger 4 (LAM4F), finger 5 (LAM5F), toe 1 (LAM1T), toe 2 (LAM2T), toe 3 (LAM3T), toe 4 (LAM4T), toe 5 (LAM5T). These characters along with the observed values are presented in Sup. Tables 1

and 2. The description style follows Patel & Vyas (2020).

**Molecular analysis.** Genomic DNA was isolated from the preserved tail tissues of three specimens using Qiagen DNAeasy kits following protocols provided by the manufacturer. A fragment of the mitochondrial cytochrome b (*cyt b*) gene was amplified. Published primers Cb1 5'- CCATCCAACATCTCAGCATGATGAAA-3' & Cb2 5'-CCCTCAGAATGATATTTGTCCTCA-3' for *cyt b* (Kocher *et al.* 1989) were used for amplification and sequencing. A 22- $\mu$ l reaction was set containing 10  $\mu$ l of Thermo Scientific Dream Taq PCR Master Mix, 9 $\mu$ l water, 0.5  $\mu$ l of each primer, and 2  $\mu$ l template DNA, carried out with an Eppendorf Mastercycler Nexus GSX1. Thermo-cycles used for amplification were as follows: 94°C for 5 min (denaturation temperature 94°C for 30 s, annealing temperature 48°C for 50 s, elongation temperature 72°C for 1 min) x 30 cycles, 72°C for 10 min, hold at 4°C. The PCR product was cleaned using a QIAquick PCR Purification Kit and sequenced with an AB 3730 DNA Analyzer. Taxa were selected for the molecular phylogenetic analysis followed by Agarwal & Ramakrishnan (2017). Downloaded sequences were aligned with the newly generated *cyt b* sequences in MegaX (Kumar *et al.* 2018) using ClustalW (Thompson *et al.* 1994) with default settings. Data were subjected to phylogenetic reconstruction with the model as the sequence substitution model for each of the codon-based partitions respectively, based on the optimal partitioning scheme suggested by ModelFinder (Kalyaanamoorthy *et al.* 2017) for ML. ML was run for 1,000 non-parametric bootstrap replicates with a rapid ML search option. The tree was visualized and edited in FigTree (Rambaut 2012). The same dataset was subjected to phylogenetic analysis on the IQ-TREE (<http://iqtree.cibiv.univie.ac.at>) online portal (Minh *et al.* 2020). Newly generated sequences bear the following GenBank accession numbers OQ068393, OQ068394, and OQ068395. Apart from the newly generated sequences, we have used the dataset and sequences generated by Agarwal & Ramakrishnan (2017). The sequence evolution model used for the ML analysis is presented in Sup. Table 3.

## Results

**Phylogenetic relationship.** The phylogenetic relationship across Indian lacertids has been well resolved by Agarwal & Ramakrishnan (2017).



**Taxonomy*****Ophisops beddomei* (Jerdon, 1870)**  
(Figs. 2–5, 9; Table 1, Sup. Table 1)*Pseudophiops beddomei* Jerdon, 1870*Pseudophiops monticola* Beddome, 1870*Ophisops beddomei*—Smith 1935, Das 1996**Holotype.** NHMUK 1946.9.4.5, ‘Brummagherry Hills, Wynaad’ (=Brahmagiri Hills), Karnataka, India, collected by Colonel R. H. Beddome.**Material examined.** ( $n=11$ ) Syntypes of *Pseudophiops monticola*, NHMUK 1946.9.4.6–15 collected along with the holotype of *O. beddomei*; CESL 534, collected from near Munikal caves (11.95111°N, 75.96925°E; 1,420 m a.s.l.), Brahmagiri Hills, Karnataka, India by Saunak Pal.**Etymology.** The specific epithet ‘*beddomei*’ is a patronym honoring Colonel R. H. Beddome, who collected the type specimen. The suggested common name is Beddome’s lacerta or Beddome’s snake-eye.**Diagnosis.** The species was morphologically diagnosed as *Ophisops* based on the absence of a distinct collar, presence of a large transparent disc on the lower eyelid, and digits not fringed laterally (Boulenger 1921, Smith 1935). A small bodied *Ophisops* characterized by (1) snout-vent length up to 36 mm; (2) upper eyelid movable; (3) supranasal fused with nasal; (4) two (rarely three) frontonasals present; (5) prefrontals not in contact; (6) enlarged tympanic scale present; (7) 42–47 dorsal scales; (8) 30–32 scales at mid-body; (9) six chin (rarely five) shields, first two or three in contact medially; (10) 16–18 scales between symphysis of chin shields and ventral plates; (11) large mental scale, extending beyond first supralabial; (12) 8–12 femoral pores on either side interrupted by 0–1 poreless scales in males and 3–4 poreless scales in females.**Comparison.** Morphologically, *Ophisops beddomei* differs from all the large-bodied species based on its smaller adult size (SVL up to 40 mm vs. SVL >50 mm in *O. leschenaultii*, *O. microlepis*, *O. pushkarensis* and *O. kutchensis*). In the small-bodied clade, *O. beddomei* differs from *O. nictans* in having two frontonasals (vs. single frontonasal); lower eyelid immovable (vs. lower eyelid movable); dorsal scales 42–47 (vs. 31–35); ventral scales 22–27 (vs. 19–23); gular region unmarked (vs. gular region speckled) and a dorsolateral stripe from behind the eye onto the tail absent (vs. present). *O. beddomei* differs from *O. jerdonii* in having two frontonasals (vs.single frontonasal) and a dorsolateral stripe from behind the eye onto the tail absent (vs. present). It differs from *O. agarwali* in having six chin shields (vs. five chin shields); 16–18 gular scales (vs. 15) between symphysis of chin shields and ventral plates; three supraciliary scales (vs. four); dorsal scales 42–47 (vs. 49); ventral scales 22–27 (vs. 21); enlarged tympanic scale present (vs. absent) and mental extending up to or beyond first supralabial (vs. mental extending beyond the second supralabial). *Ophisops beddomei* is most closely related to the new species described herein (Table 1), and a comparison against the new species is provided in its comparison section.**Redescription.** Based on the syntypes [NHMUK 1946.9.4.10 (male) and 1946.9.4.12 (female)] of *Pseudophiops monticola* which is a junior subjective synonym of *Ophisops beddomei*. Head short (HL/SVL = 0.28–0.29), twice longer than wide (HL/HW = 2.05–2.09), depressed (HH/HL = 0.36–0.38), slightly broader than neck, upper head scales keeled and finely striated. Snout acute (IN/IO = 0.35–0.38), slightly projecting beyond lower jaw. Rostral wider than high, situated between supranasals dorsally and in contact with first supralabials. Paired supranasals fused with nasal, in contact medially, touching both the pair of postnasals posteriolaterally. A pair of almost equal sized frontonasals, roughly pentagonal, strongly in contact with supranasals and post nasals anteriorly; anterior loreal laterally and prefrontals posteriorly. A pair of roughly hexagonal prefrontals, not in contact with each other, a small pentagonal scale wedged between the prefrontals; touching the frontonasal anteriorly, and the anterior and posterior loreals laterally; posteriorly in strong contact with first anterior supraocular, first supraciliary granules and frontal. Frontal roughly hexagonal, elongate, broader anteriorly; touching the posterior scale separating prefrontals, in strong contact with prefrontals anteriorly, laterally touching first, second and third supraoculars, and posteriorly in strong contact with frontoparietals. A pair of frontoparietals, roughly pentagonal, in contact with each other medially, anteriorly in strong contact with frontal, laterally touches third and fourth supraoculars, posteriolaterally touching parietals and interparietal. Interparietal single, roughly pentagonal, posterior margins curved, with distinct pineal eye, anteriorly in strong contact with frontoparietals, laterally touching parietals and occipital posteriorly. A pair of

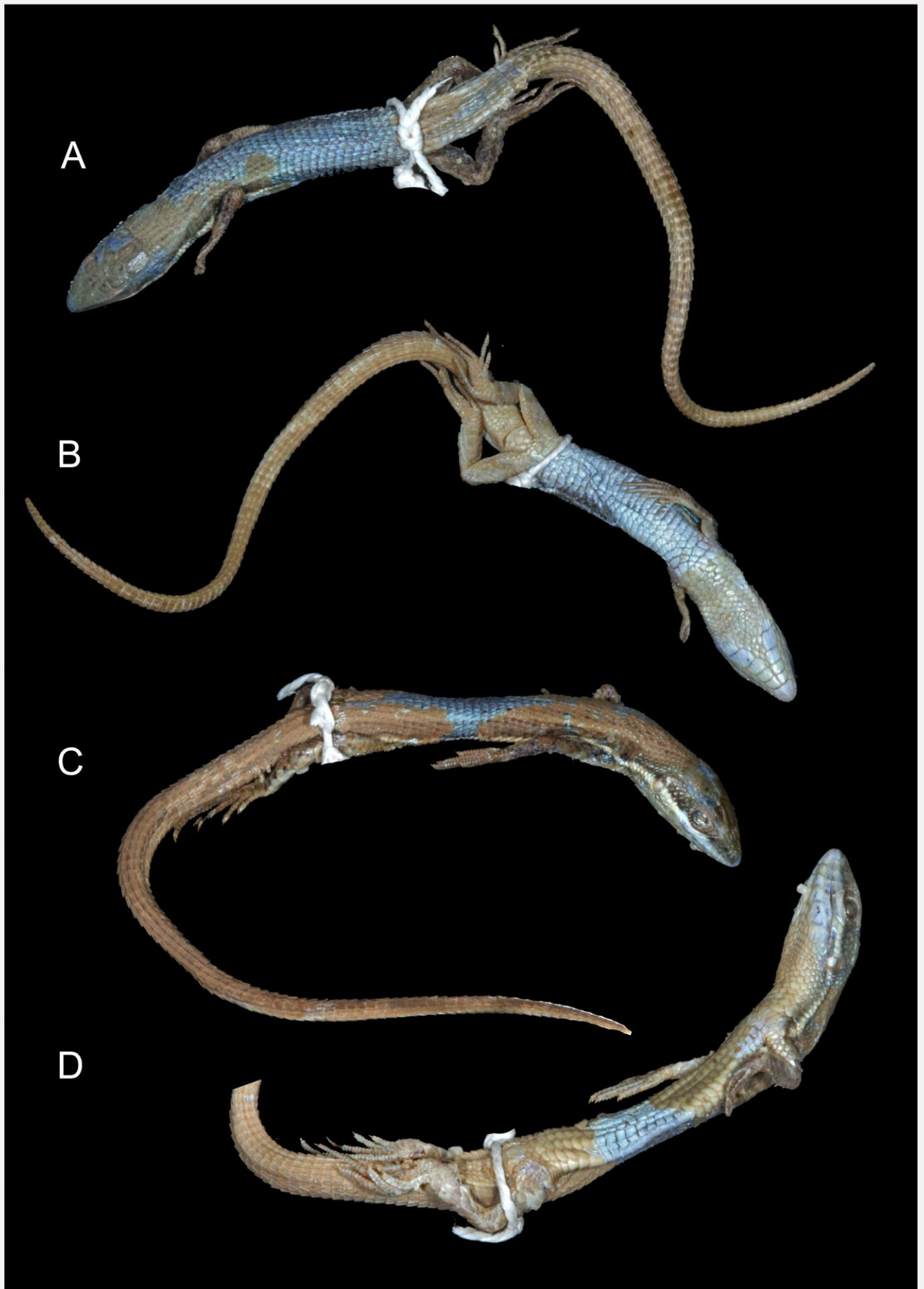
parietals, roughly pentagonal, longer than wide, separated from each other by interparietal, anteriorly in strong contact with fourth supraocular and frontoparietal on both sides, laterally touching two to three supratemporals on both sides, posteriorly in contact with three to four small dorsal scales on both sides. Occipital roughly pentagonal, slightly wider than long, laterally in contact with parietals and anteriorly with interparietal. Four supraoculars, the first and fourth smallest, and fourth supraocular broken into two scales on each side, separated from supraciliaries by a single row of 10–11 supraciliary granules on both sides. Nostril elliptical, laterally oriented, closer to the snout tip than to eye ( $NE/SE = 0.89–0.91$ ) and between three nasals; a nasal (fused with supranasal) and a pair of postnasals on each side. Postnasals smaller than the anterior loreal. Two loreals, anterior roughly rectangular, bordered by posterior loreal, prefrontal, frontonasal, postnasals, and the first and second supralabials; posterior loreal rhomboid, much larger than anterior, becoming broader posteriorly, bordered by preoculars, the first supraciliary, prefrontal, anterior loreal, and the second and third supralabials. Loreal region slightly concave with sharp canthus rostralis. Eye small ( $ED/HL = 0.16–0.17$ ); pupil round; supraciliary scales distinct, elongate, three on either side, the second one longest. Three preocular, first smallest, third largest. Three moderately enlarged postoculars. Tympanum elongate, small ( $TD/HH = 0.42$ ), covered anteriorly by a large tympanic scale, slightly smaller than the tympanum; eye to ear distance almost twice the eye diameter ( $EE/ED = 1.71–2.00$ ). Two to three supratemporals on each side, the first or second ones are longer. Temporal scales as large as or slightly bigger than postoculars, rough, subimbricate, arranged in four to five rows, uncarinate, except the last row. Eight supralabials (nine on the right side of the NHMUK 1946.9.4.12), the fifth (sixth on the right side of the NHMUK 1946.9.4.12) being largest and forming the lower border of the eye, gradually decreasing in size in either direction, except the first supralabial that is larger than the second and third. Seven infralabials on either side. Mental large, wider than long, in strong contact with the first infralabial and first pair of chin shields. Six chin shields on either side, the fourth being largest, gradually decreasing in size in either direction, two (NHMUK 1946.9.4.10) or three (NHMUK 1946.9.4.12) anterior chin shields strongly in contact with each other

medially, posterior three or four separated from each other by gular scales. Gular scales smaller, gradually increasing in size towards the collar, elongate, and subimbricate, those on neck as large as or slightly smaller than gular scales, weakly pointed and imbricate. 18 gular scales between symphysis of chin shields and ventral plates.

Body slender ( $BW/SVL = 0.13–0.14$ ), trunk not elongate ( $TRL/SVL = 0.45–0.53$ ). Dorsal pholidosis heterogeneous in shape, size, orientation and carination; composed of smaller, strongly pointed, keeled, imbricate scales throughout, 30–31 scales in a transverse row across midbody; 44–45 scales in longitudinal, vertebral series; scales on dorsal aspect strongly keeled, directed backwards, those on flanks, directed backwards and upwards, lowermost rows largest and smooth, others are feebly keeled; scales on the neck, near shoulder and hind limb insertion smaller, gradually increasing in size posteriorly and laterally. Ventral plates, heterogeneous, arranged in six transverse rows on belly, midventral series with 27–29 scales in a longitudinal series; ventral scales on pectoral region larger than those on neck, strongly imbricate; those on belly much enlarged, subimbricate, rectangular, except some on the single outermost row on either side cycloid. Indistinct collar, vaguely defined by a fold of skin with granular scales on shoulders and five larger cycloid imbricate scales ventrally. Preanal scale large, roughly hexagonal, smooth, anteriorly bordered by five or seven sub-equal scales and surrounded by another row of 15 cycloid, imbricate scales of variable size, those on posterior aspect smallest. Femoral pores 9 (in NHMUK 1946.9.4.12) or 11 (in NHMUK 1946.9.4.10) on each side, separated by one (NHMUK 1946.9.4.10) or four (NHMUK 1946.9.4.12) poreless scales.

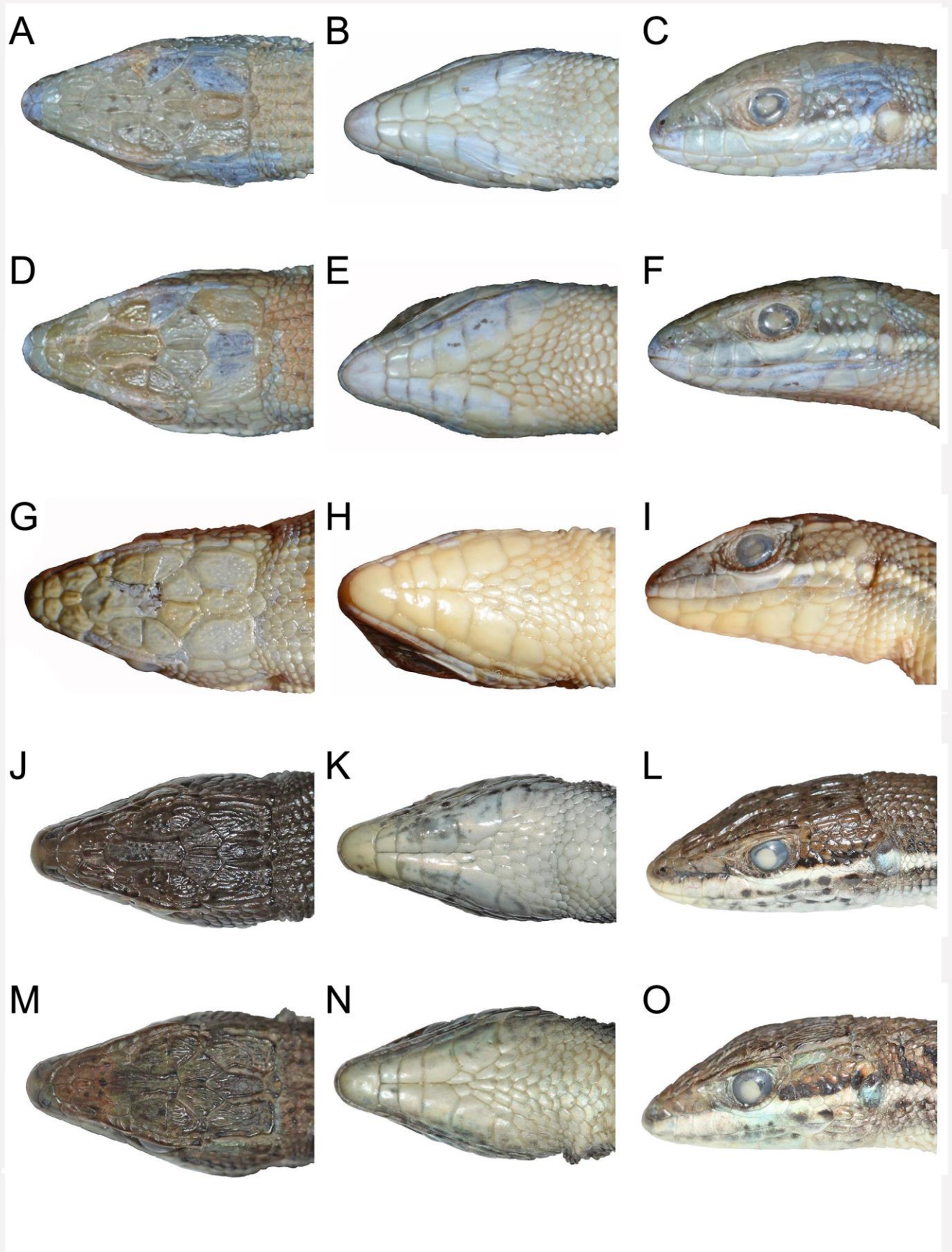
Scales on the fore limbs heterogeneous in shape and size, those on the palmar and plantar faces slightly smaller than or equal to the associated lamellae, imbricate, strongly keeled, uncarinate or bicarinate. Scales on dorsal surface of upper arm much larger than those on body dorsum, weakly pointed, strongly imbricate, smooth, except those under elbow, which are keeled. Ventral surface of upper arm with smaller, smooth, subimbricate scales. Scales on forearms similar to those on upper arms, three rows on anterior, inner surface larger and smooth, of which single median row much enlarged, subimbricate and somewhat rhombus

## Plate 12



**Figure 2.** Syntypes of *Pseudophiops monticola*: NHMUK 1946.9.4.10 (male) (A) dorsal and (B) ventral views; NHMUK 1946.9.4.12 (female) (C) dorsal and (D) ventral views.

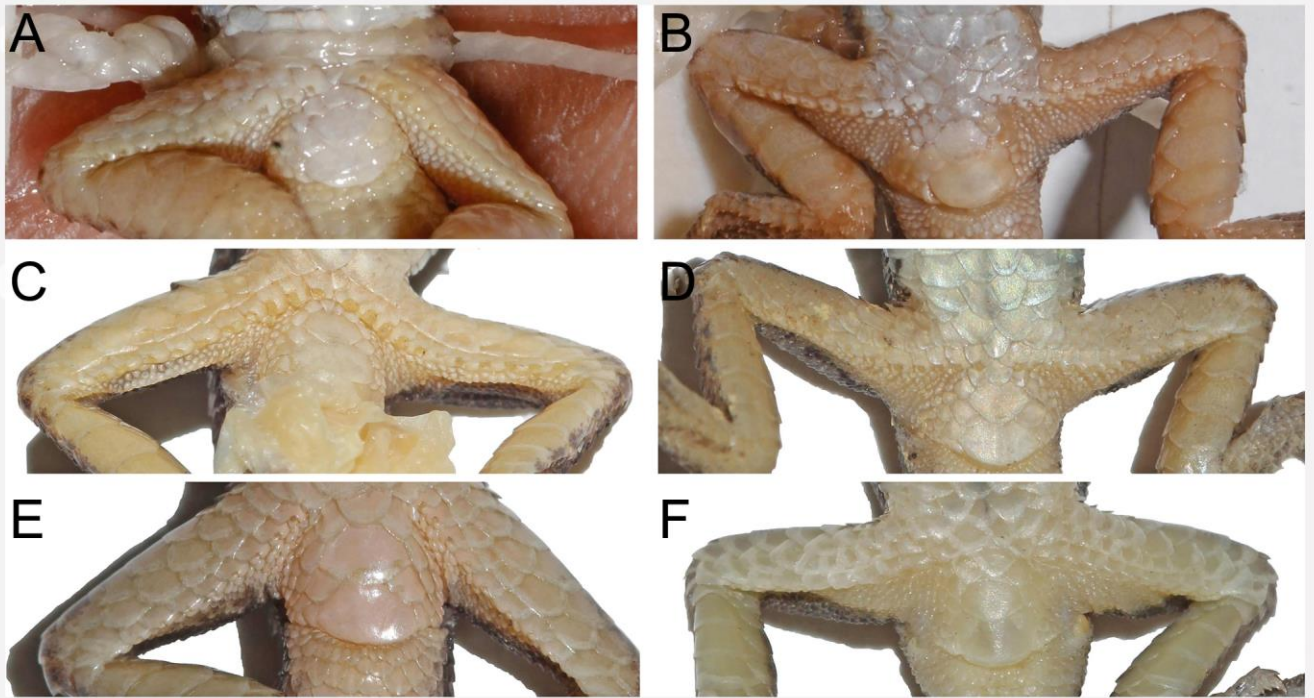
## Plate 13



**Figure 3.** Comparison of head scalation between *Ophisops beddomei* NHMUK 1946.9.4.10 (male) (**A**) dorsal, (**B**) lateral, (**C**) ventral views; NHMUK 1946.9.4.12 (female) (**D**) dorsal, (**E**) lateral, (**F**) ventral views; NHMUK 1946.9.4.15 (female) (**G**) dorsal, (**H**) lateral, (**I**) ventral views; and *O. venustus* sp. nov. BNHS 3138 (female) (**J**) dorsal, (**K**) lateral, (**L**) ventral views; BNHS 3142 (male) (**M**) dorsal, (**N**) lateral, (**O**) ventral views



## Plate 14



**Figure 4.** Comparison of preloacal region showing preloacofemoral pores in *Ophisops beddomei* (A) NHMUK 1946.9.4.10 (male), (B) NHMUK 1946.9.4.12 (female) and *O. venustus* sp. nov. (C) BNHS 3133 (male), (D) BNHS 3139 (female), (E) BNHS 3135 (female), (F) BNHS 3145 (female)



**Figure 5.** An adult male of *Ophisops beddomei* in life (CESL 534) from Munikal caves, Brahmagiri Hills, Karnataka, India

shaped; scales on outer surface of forearms smaller, imbricate and keeled; a column of two enlarged scale bordering the palm on ventral surface circular, imbricate and having serrated edges. Scales on hind limbs heterogeneous in shape and size, posterior surface of the thigh with much smaller, granular scales, becoming enlarged, pointed, strongly keeled, imbricate towards anterior surface, ventral surface of thigh covered with 2–3 rows of much enlarged, smooth, strongly imbricate scales, with anterior most single row largest and rhombus shaped; scales on dorsal surface of shank like those on forearm, ventral aspect of shank covered with two rows of much enlarged, imbricate, smooth scales, of which the median row is largest and roughly rectangular, posterior most 2–3 scales are bi- or tricarinate.

Tail almost twice the SVL (TL/SVL = 1.88–2.11). Fore limbs and hind limbs slender and relatively well developed; hind limbs longer than fore limbs; forearm and tibia short (FL/SVL = 0.12–0.14; CL/SVL = 0.15–0.18); digits long and slender, ending in a sharp and moderately curved claw; subdigital lamellae distinct, entire, distinctly keeled, bi or tricarinate on both manus and pes; number of subdigital lamellae in NHMUK 1946.9.4.12 including claw sheath: left manus 6-9-14-16-9; left pes 6-11-12-18-11. Scales on the dorsal and lateral aspect of the tail arranged in regular whorls, cycloid at the base, becoming gradually elongated distally, strongly keeled, imbricate and pointed. Ventral aspect of the tail with imbricate scales, strongly pointed backward and keeled; ventral scales near the base of the tail small and smooth, gradually becoming keeled, increasing in size of the dorsal body scales towards tip of the tail.

Measurements (in mm) are as follow: NHMUK 1946.9.4.10 (male) = SVL 28.5, TL 60.0, TRL 12.9, HL 8.2, HH 3.1, HW 4.0, FL 4.1, LFO 4.9, CL 5.0, ED 1.4, SE 3.4, NE 3.1, EE 2.4, NL 3.8, TD 1.3, IN 1.2, IO 3.8, LV 2.4, LBT 3.2, BW 3.9; NHMUK 1946.9.4.12 (female) = SVL 30.9, TL 58.0, TRL 16.3, HL 8.6, HH 3.1, HW 4.1, FL 3.8, LFO 4.5, CL 4.7, ED 1.4, SE 3.5, NE 3.1, EE 2.8, NL 4.4, TD 1.3, IN 1.2, IO 3.7, LBT 3.0, BW 4.1.

**Coloration.** In life, based on CESL 534 (Fig. 5). Dorsal ground colour dark brown, with a few black spots on the dorsolateral region; a prominent, off white ventrolateral stripe that runs from the labials, above the forearm insertion and terminating at the groin. Lateral body portion heavily mottled with black and off white

markings, the black patches are slightly wider than the lighter markings. Flanks, below ventrolateral stripe, with marbled lighter and darker markings similar to that on the lateral body markings with scattered sky blue spots. Limbs with scattered, irregular lighter brown and black reticulation; fingers with whitish and black reticulation. Head similar to dorsum in colouration, first five supralabials with off white, temporal region with dark markings, iris bronze. Venter of head and body immaculate yellow with a whitish sheen. Tail venter and undersides of the limbs immaculate pinkish white.

In preservative, overall, in a shade of brown on dorsum and off-white to bright white on the ventral aspect. Patches of greyish blue on the dorsum might likely be an artefact of preservation. The lateral aspect of the head bears a white stripe running from the supralabials to the hind-limbs.

**Variation.** Other syntypes match the description above in most aspects, except for details presented here and in Sup. Table 1: 1<sup>st</sup> and 2<sup>nd</sup> chin shields of right side in NHMUK 1946.9.4.15, partially fused hence we counted that as a single chin shield (Fig. 3H). The species has a single, small, post-femoral mite pocket on each side of the tail base and a well developed mite pocket on the side of the neck, in front of the shoulder.

**Distribution, habitat and natural history.** This species was observed on flat and mildly undulating plateaus with grass and other low vegetation (Fig. 11A). A specimen (CESL 534) of this species was collected from the type locality on 10<sup>th</sup> March 2012. The locality is at elevations of 1400–1500 m asl on the southern edge of the Brahmagiri Hills, Karnataka, and is the only specific locality for *Ophisops beddomei* sensu stricto.

***Ophisops venustus* sp. nov.**

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(Figs. 3, 4, 6–10; Table 1, Sup. Table 2)

*Ophisops beddomei*—Vyas 2003, 2007a,b; Patel et al. 2018; Patel & Vyas 2019, 2020 [partim]  
*Ophisops* sp.—Patel et al. 2019

**Holotype.** BNHS 3133, adult male, from a forest patch near Dhulda (20.94941°N, 73.66281°E; 280 m a.s.l.), Dang District, Gujarat, India, collected by Harshil Patel & Vaibhav Naik on 15 December 2014.

**Paratypes.** ( $n=12$ ) BNHS 3134, adult male, collection details same as holotype; BNHS 3135, adult female, from a plateau near Piprol (20.50513°N, 73.32426°E; 535 m a.s.l.), Dharampur, Valsad District, Gujarat, India, collected by Harshil Patel on 06 July 2013; BNHS 3136–37, adult males, from Governor hill (20.56794°N, 73.74650°E; 961 m a.s.l.), Saputara, Dang District, Gujarat, India, collected by Harshil Patel & Vaibhav Naik on 13 January 2014; BNHS 3138, adult female, from near Ahwa (20.74886°N, 73.69060°E; 462 m a.s.l.), Dang District, Gujarat, India, collected by Harshil Patel & Vaibhav Naik on 15 January 2014; BNHS 3139, adult male, from Kelda (21.65941°N, 73.81047°E; 412 m a.s.l.), Dediapada, Narmada District, Gujarat, India, collected by Harshil Patel, Mitesh Patel, Kaushal Patel & Vaibhav Naik on 06 November 2016; BNHS 3140, adult female, BNHS 3141, adult male, from fort Salher (20.72476°N, 73.93879°E; 1435 m a.s.l.), Satana, Nashik District, Maharashtra, India, collected by Harshil Patel, Mitesh Patel, Nirmal Patel & Vaibhav Naik on 08 October 2017; BNHS 3142–43, adult males, from Don hill (20.72816°N, 73.86117°E; 966 m a.s.l.), Dang District, Gujarat, India, collected by Harshil Patel, Mitesh Patel, Nirmal Patel & Vaibhav Naik on 09 October 2017; BNHS 3144–45, adult females, from Datar hill (21.49075°N, 70.50704°E; 792 m a.s.l.), Junagadh, Junagadh District, Gujarat, India, collected by Harshil Patel, Mitesh Patel, Pranav Vaghashiya, Devendra Chauhan & Vaibhav Naik on 03 November 2019.

**Other examined material.** BNHS 589, from Ahwa (20.74886°N, 73.69060°E; 462 m a.s.l.), Dang District, Gujarat, India; BNHS 1562-1, BNHS 1562-2, Bhuvero (22.52824°N, 74.13162°E; 630 m a.s.l.), Ratanmahal, Dahod District, Gujarat, India, collected by Raju Vyas on 25 November 1999.

**Diagnosis.** The new species was morphologically diagnosed as *Ophisops* based on the absence of a distinct collar, presence of a large transparent disc on the lower eyelid, and digits not fringed laterally (Boulenger 1921, Smith 1935). A small bodied *Ophisops* characterized by (1) snout-vent length up to 36 mm; (2) upper eyelid movable; (3) supranasal fused with nasal; (4) two frontonasals present; (5) prefrontals not in contact; (6) enlarged tympanic scale present; (7) 46–53 dorsal scales; (8) 28–31 scales at mid-body; (9) 19–21 lamellae underneath the fourth toe; (10) six chin shields,

first three in contact medially; (11) 15–19 scales between symphysis of chin shields and ventral plates; (12) large mental scale, extending beyond first supralabial; (13) 8–11 femoral pores on either side interrupted by 0–1 poreless scales in males and 3–4 poreless scales in females.

**Comparison.** Morphologically *Ophisops venustus* sp. nov. differs from all the large bodied species based on its smaller adult size (SVL up to 40 mm vs. SVL >50 mm in *O. leschenaultii*, *O. microlepis*, *O. pushkarensis* and *O. kutchensis*). In the small bodied clade, *O. venustus* sp. nov. differs from *O. nictans* in having two frontonasals (vs. single frontonasal); lower eyelid immovable (vs. lower eyelid movable); dorsal scales 46–53 (vs. 31–35); ventral scales 22–27 (vs. 19–23); gular region unmarked (vs. gular region speckled) and a dorsolateral stripe from behind the eye onto the tail absent (vs. present). *O. venustus* sp. nov. differs from *O. jerdonii* in having two frontonasals (vs. single frontonasal); dorsal scales 46–53 (vs. 44–47) and a dorsolateral stripe from behind the eye onto the tail absent (vs. present). It differs from *O. agarwali* in having six chin shields (vs. five chin shields); ventral scales 22–27 (vs. 21); three supraciliary scales (vs. four); enlarged tympanic scale present (vs. absent) and mental extending up to or beyond first supralabial (vs. mental extending beyond the second supralabial).

*Ophisops venustus* sp. nov. is most similar to *O. beddomei* in having two frontonasals but differs in having higher numbers of dorsal scales (mean DS 49, range 46–53 vs. mean DS 44.2, range 42–47 in *O. beddomei*); lower number of collar scales on ventral side (mean NCS 4.1, range 4–5 vs. mean NCS 5.1, range 5–6 in *O. beddomei*); fewer supraciliary granules (mean SCG 7.4, range 4–10 vs. mean SCG 9.8, range 8–11 in *O. beddomei*). See Table 1; Fig. 1B–D.

**Description of holotype.** Adult male in relatively good condition apart from minor artefacts of preservation. Head short (HL/SVL = 0.29), more than twice longer than wide (HL/HW = 2.23), depressed (HH/HL = 0.38), slightly broader than neck, upper head scales keeled and finely striated. Snout acute (IN/IO = 0.33), slightly projecting beyond lower jaw. Rostral wider (1.6 mm) than high (0.9 mm), situated between supranasals dorsally and in contact with first supralabials. Paired supranasals fused with nasal, in contact medially, touching both the pair of postnasals posteriolaterally. A pair of almost equal sized frontonasals, roughly pentagonal, strongly in contact with supranasals and post

nasals anteriorly; anterior loreal laterally and prefrontals posteriorly. A pair of roughly hexagonal prefrontals, not in contact with each other, a pair of small pentagonal scales wedged between the prefrontals; touching the frontonasal anteriorly, and the anterior and posterior loreals laterally; posteriorly in strong contact with first anterior supraocular and frontal. Frontal roughly hexagonal, elongate (2.7 mm), broader anteriorly; touching the posterior scale separating prefrontals, in strong contact with prefrontals anteriorly, laterally touching first, second and third supraoculars, and posteriorly in strong contact with frontoparietals. A pair of frontoparietals, roughly pentagonal, in contact with each other medially, anteriorly in strong contact with frontal, laterally touches third and fourth supraoculars, posteriolaterally touching parietals and interparietal. Interparietal single, roughly pentagonal, posterior margins curved, with distinct pineal eye, anteriorly in strong contact with frontoparietals, laterally touching parietals and occipital posteriorly. A pair of parietals, roughly pentagonal, longer (2.3 mm) than wide (1.3 mm), separated from each other by interparietal, anteriorly in strong contact with fourth supraocular and frontoparietal on both sides, laterally touching two supratemporals on both sides, posteriorly in contact with five small dorsal scales on both sides. Occipital roughly pentagonal, slightly wider than long, laterally in contact with parietals and anteriorly with interparietal. Four supraoculars, the first and fourth smallest, fourth supraocular broken in to two scales on each side, separated from supraciliaries by a single row of 8 supraciliary granules on both sides. Nostril elliptical, laterally oriented, closer to the snout tip than to eye (NE/SE = 0.87) and between three nasals; a nasal (fused with supranasal) and a pair of postnasals

on each side. Postnasals smaller than the anterior loreal. Loreal region slightly concave with sharp canthus rostralis. Two loreals, anterior roughly rectangular and about the size of the second supralabial, bordered by posterior loreal, prefrontal, frontonasal, postnasals, and the first and second supralabials; posterior loreal rhomboid, much larger than anterior, becoming broader posteriorly, bordered by preoculars, the first supraciliary, prefrontal, anterior loreal, and the second and third supralabials. Eye small (ED/HL = 0.18); pupil round; supraciliary scales distinct, elongate, three on either side, the second one longest. Three preocular, first smallest, third largest. Three moderately enlarged postoculars. Two supratemporals on each side, the anterior ones are longer. Tympanum elongate, small (TD/HH = 0.36), covered anteriorly by a large tympanic scale, slightly smaller than the tympanum; eye to ear distance almost twice the eye diameter (EE/ED = 1.82). Temporal scales as large as or slightly bigger than postoculars, rough, subimbricate, arranged in three to five rows, unicarinate, except the last row. Eight supralabials, the fifth being largest and forming the lower border of the eye, gradually decreasing in size in either direction, except the first supralabial is larger than the second and third. Seven infralabials on either side. Mental large, wider (2.0 mm) than long (1.6 mm), in strong contact with the first infralabial and first pair of chin shields. Six chin shields on either side, the fourth being largest, gradually decreasing in size in either direction, three anterior chin shields strongly in contact with each other medially, posterior three separated from each other by gular scales. Gular scales smaller, gradually increasing in size towards the collar, elongate, subimbricate, those on neck as large as or slightly smaller than gular scales, weakly pointed

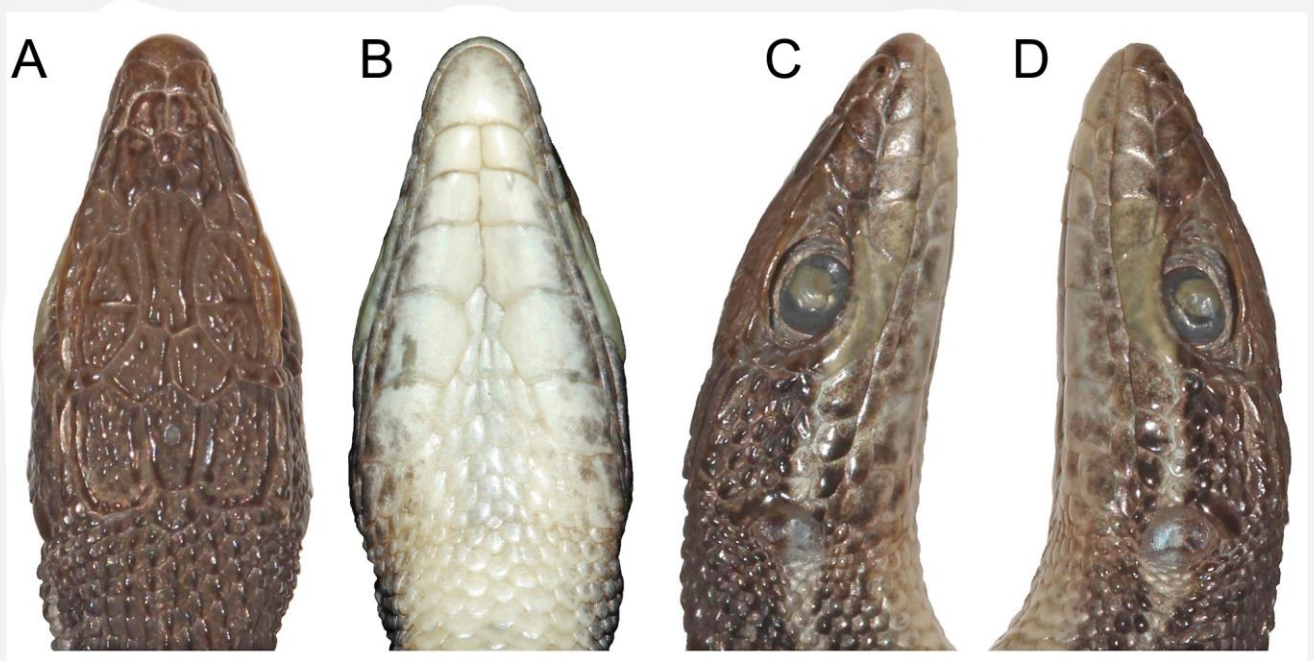
**Table 1.** Comparison of morphological characters between *Ophisops beddomei* and *O. venustus* sp. nov.

Character	<i>O. beddomei</i>		<i>O. venustus</i> sp. nov.	
	Mean±sd	Range	Mean±sd	Range
Supraciliary granules (SCG)	9.8±1.1	8–11	7.4±1.2	4–10
Supralabials (SL)	8.1±0.3	8–9	7.9±0.2	7–8
Infralabials (IL)	6.9±0.2	6–7	6.8±0.5	6–8
Supratemporals (STS)	2.0±0.5	1–3	2.2±0.6	1–3
Dorsal scales (DS)	44.2±1.6	42–47	49.0±2.2	46–53
Mid-body scales (RBS)	30.5±0.8	30–32	29.4±1.2	28–31
Ventral scales (VS)	25.0±1.5	22–27	23.4±1.5	22–27
Gular scales (GS)	16.9±0.7	16–18	16.7±1.1	15–19
Collar scales (NCS)	5.1±0.3	5–6	4.1±0.4	4–5
Transverse series of ventral scales (NVS)	27.0±1.5	24–29	25.5±1.5	24–29
Femoral pores (NFP)	10.3±1.1	8–12	9.3±1.0	8–11

## Plate 15



**Figure 6.** *Ophisops venustus* sp. nov. BNHS 3133 (holotype, male): (A) dorsal and (B) ventral views of the full body

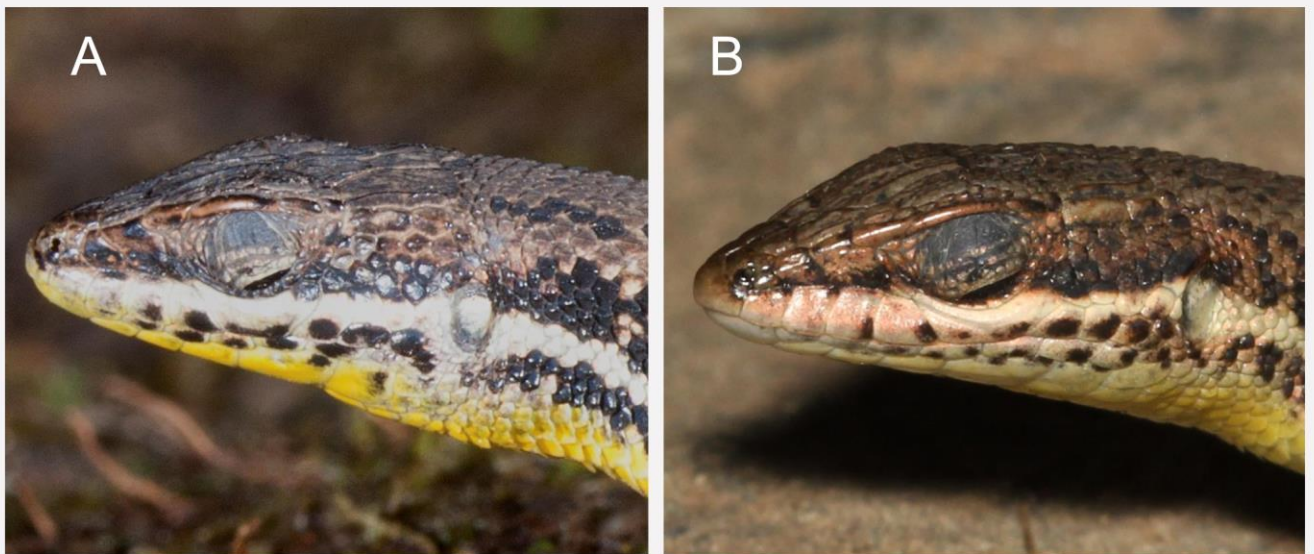


**Figure 7.** *Ophisops venustus* sp. nov. BNHS 3133 (holotype, male): (A) dorsal, (B) ventral, (C) lateral (right), and (D) lateral (left) views of the head

## Plate 16

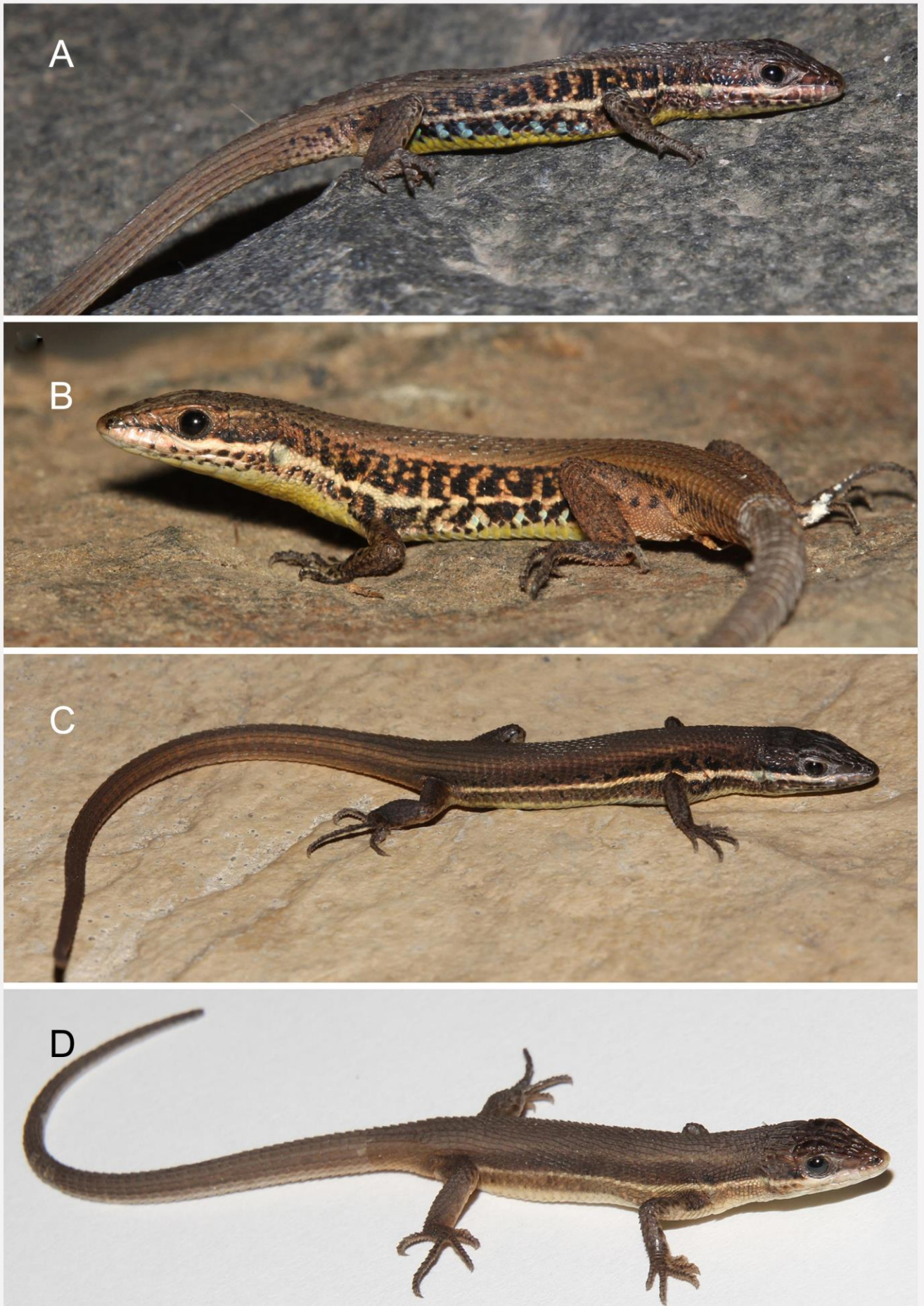


**Figure 8.** *Ophisops venustus* sp. nov. in life BNHS 3133 (holotype, male): (A) dorsolateral and (B) ventral views



**Figure 9.** Movable upper eyelid as observed in live individuals of (A) *Ophisops beddomei* CESL 534 and (B) *O. venustus* sp. nov. BNHS 3139

## Plate 17



**Figure 10.** *Ophisops venustus* sp. nov. (in life) paratypes: (A) BNHS 3141 (male), (B) BNHS 3139 (male), (C) BNHS 3144 (female), and (D) BNHS 3140 (female).

and imbricate; scales on pectoral region larger than those on neck, strongly imbricate; 15 gular scales between symphysis of chin shields and ventral plates.

Body slender (BW/SVL = 0.19), trunk not elongate (TRL/SVL = 0.43). Dorsal pholidosis heterogeneous in shape, size, orientation and carination; composed of smaller, strongly pointed, keeled, imbricate scales throughout, 28 scales in a transverse row across midbody; 47 scales in longitudinal, vertebral series; scales on dorsal aspect strongly keeled, directed backwards, those on flanks, directed backwards and upwards, lowermost rows largest and smooth, others are feebly keeled; scales on the neck, near shoulder and hind limb insertion smaller, gradually increasing in size posteriorly and laterally. Ventral plates, heterogeneous, arranged in six transverse rows on belly, midventral series with 24 scales in a longitudinal series; ventral scales on belly much enlarged, subimbricate, rectangular, except some on the single outermost row on either side cycloid. Indistinct collar, vaguely defined by a fold of skin with granular scales on shoulders and four larger cycloid imbricate scales ventrally. Preanal scale large, roughly hexagonal, smooth, anteriorly bordered by seven sub-equal scales and surrounded by another row of 15 cycloid, imbricate scales of variable size, those on posterior aspect smallest. Femoral pores 10 on right side and 11 on left side, medially in contact.

Fore limbs and hind limbs slender and relatively well developed; hind limbs longer than fore limbs (LFL/LHL = 0.64); forearm and tibia short (FL/SVL = 0.13; CL/SVL = 0.18); scales on the fore limbs heterogeneous in shape and size, those on the palmar and plantar faces slightly smaller than or equal to the associated lamellae, imbricate, strongly keeled, uncarinate or bicarinate. Scales on dorsal surface of upper arm much larger than those on body dorsum, weakly pointed, strongly imbricate, smooth, except those under elbow, which are keeled. Ventral surface of upper arm with smaller, smooth, subimbricate scales. Scales on forearms similar to those on upper arms, three rows on anterior, inner surface larger and smooth, of which single median row much enlarged, subimbricate and somewhat rhombus shaped; scales on outer surface of forearms smaller, imbricate and keeled; a column of two enlarged scale bordering the palm on ventral surface circular, imbricate and having serrated edges. Scales on hind limbs heterogeneous in shape and

size, posterior surface of the thigh with much smaller, granular scales, becoming enlarged, pointed, strongly keeled, imbricate towards anterior surface, ventral surface of thigh covered with 2–3 rows of much enlarged, smooth, strongly imbricate scales, with anterior most single row largest and rhombus shaped; scales on dorsal surface of shank like those on forearm, ventral aspect of shank covered with two rows of much enlarged, imbricate, smooth scales, of which the median row is largest and roughly rectangular, posterior most 2–3 scales are bi- or tricarinate; digits long and slender, ending in a sharp and moderately curved claw; subdigital lamellae distinct, entire, distinctly keeled, bi or tricarinate on both manus and pes; number of subdigital lamellae including claw sheath: left manus 6-10-13-15-9; right manus 6-9-13-16-10; left pes 8-11-14-20-12; right pes 8-11-15-19-12. Relative length of digits (measurements in mm in parentheses): right manus I (1.5) < V (2.3) < II (2.8) < III (3.7) < IV (4.1); right pes I (2.3) < II (3.5) < III (4.0) < V (4.1) < IV (6.0).

Tail twice the SVL (TL/SVL = 2.07). Scales on the dorsal and lateral aspect of the tail arranged in regular whorls, cycloid at the base, becoming gradually elongated distally, strongly keeled, imbricate and pointed. 16 scales on the 10th whorl behind the vent. Ventral aspect of the tail with imbricate scales, strongly pointed backward and keeled; ventral scales near the base of the tail small and smooth, gradually becoming keeled, increasing in size of the dorsal body scales towards tip of the tail.

**Coloration.** In life (Fig. 8), dorsal ground colour dark brown; a prominent, off-white ventrolateral stripe that runs from the labials, above the forearm insertion and terminating at the groin. Lateral body portion heavily mottled with black and lighter brown markings, the black patches are two to three times wider than the lighter markings. Flanks, below ventrolateral stripe, with marbled lighter and darker markings similar to that on the lateral body markings with six, bright, sky blue spots. Limbs with scattered, irregular lighter brown and black reticulation. Head similar to dorsum in colouration, first five supralabials with off white, temporal region with dark markings, iris bronze. Venter of head and body immaculate yellow with whitish sheen. Tail venter and undersides of the limbs immaculate pinkish white.

In preservative, similar to life colouration, except colours faded and shades of yellow and blue were completely lost.



**Variation.** The paratypes match the holotype in most aspects, except for details presented here and in Sup. Table 2: colouration of females in life differs considerably from males (Fig. 10); flanks in females, below ventrolateral stripe, lacks the bright, sky blue spots; belly of the females, off white. The species has a single, small, post femoral mite pocket on each side of the tail base and a well developed mite pocket on the side of the neck, in front of the shoulder.

**Etymology.** The specific epithet ‘*venustus*’ is a Latin first/second-declension adjective in the nominative singular given in masculine, which means ‘charming / elegant / beautiful’ refers to its elegant body colouration in life. Suggested English name is charming lacerta or charming snake-eye.

**Distribution, habitat and natural history.** *Ophisops venustus* sp. nov. appears to be distributed in the forests and plateaus of various hills (elevation between 250 to 1450 m asl) of two western Indian states: Gujarat and Maharashtra. The current distribution range of the new species covers the areas of northern Western Ghats, western ends of Satpura and Vindhya hill ranges, and Girnar hill complex (Fig. 12). These hills are covered with tropical dry and moist deciduous forests (Champion & Seth 1968) in two Indian States: Gujarat and Maharashtra. In Gujarat, the species is patchily distributed within a few protected areas (Girnar, Ratnmal, Shoolpaneshwar, and Purna Wildlife Sanctuaries) and surrounding reserved forests. This new species is found in the moist deciduous forests of Sanjay Gandhi National Park Mumbai and a few pockets of reserved forests around Amravati, Maharashtra. The entire distribution range of the species is biogeographically considered as part of the Semi-arid, Deccan Peninsula, and Western Ghats (Rodgers & Panwar 1998). There is a possibility that this new species occurs in two protected areas of Maharashtra, especially Yawal and Melghat Tiger Reserve because both these PAs are part of the Satpura Hill complex and in between two reported sites of the new species namely, Kelda (Dediapada, Narmada, Gujarat) and Chikhaldhara (Amravati, Maharashtra). The species is likely to occur in the neighbouring state of Madhya Pradesh, which shares a similar biotope in its bordering region with Gujarat and Maharashtra.

*Ophisops venustus* sp. nov. is diurnal, and individuals were seen active throughout the day, except for late afternoons. The species was seen

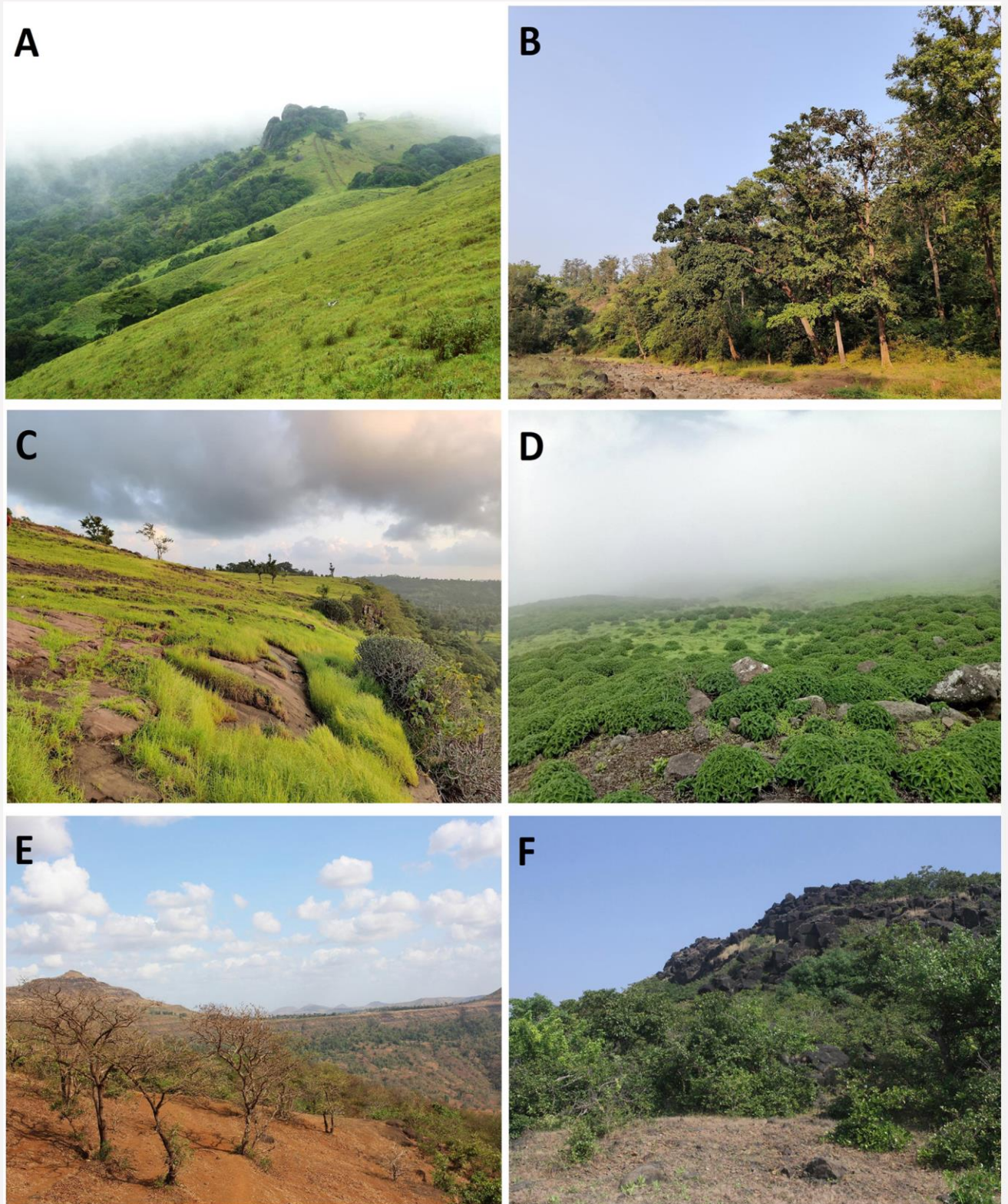
active throughout the year except peak monsoon. The species is abundant at higher elevation hills and plateaus with shrubs and grasslands, fewer individuals were found at the lower elevation hills with good forest cover (Figs. 11B–F). Many individuals of the species were found foraging on the ground. When disturbed, they flee under a nearby rock or boulder. At Saputara (Dangs, Gujarat) and Datar Hill (Junagadh, Gujarat), the species was seen taking shelter in a burrow at the base of the trunk of thorny bushes. These burrows were placed exactly at the base of the trunk, less than 10 mm in diameter, and a single burrow per plant. On a couple of occasions, we dug up the burrows and they were found to be 3–4 inches deep leading towards the roots of the plant. It is unclear if these burrows were created by *O. venustus* sp. nov. or by some other animal or arthropod.

## Discussion

Members of the genus *Ophisops* are characterized by a large transparent disc on the lower eyelid (Boulenger 1921, Smith 1935), and except for *O. leschenaultii* and *O. nictans*, all other members (including the members of *O. beddomei* complex) are said to have their lower eyelid fused with upper eyelid (Agarwal *et al.* 2018, Patel & Vyas 2020). However, in the present study, we have observed that the members of the *O. beddomei* complex have movable their upper eyelids (Fig. 9). This character was observed only in live individuals, because in preserved specimens, the upper eyelid only seems immovable and fused with the lower eyelid. Further studies involving live individuals of all the congeners are needed to verify the exact nature of the upper eyelid, which may serve as an important diagnostic character. Some of us (Patel & Vyas 2020), while describing *O. agarwali*, in the comparison section with *O. beddomei*, state that *O. agarwali* is similar to *O. beddomei* in having a single frontonasal, which is an error as both the species have two frontonasals and not one.

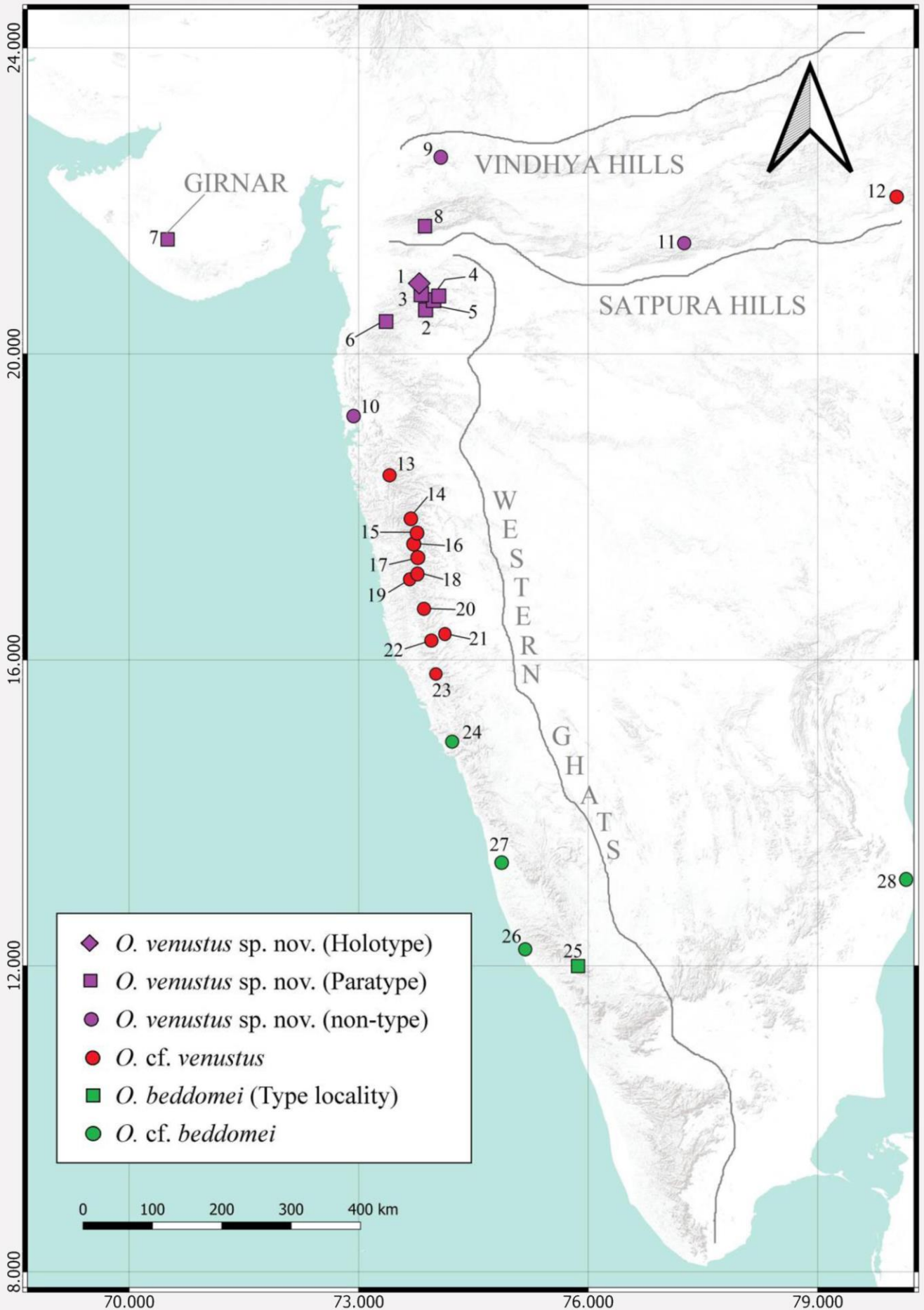
*Ophisops venustus* sp. nov. is the fourth species of *Ophisops* described in recent years from India after a gap of almost 150 years (Agarwal *et al.* 2018, Patel & Vyas 2020). *O. beddomei* is a species complex having seven lineages (Agarwal & Ramakrishnan 2017). These lineages are allopatrically distributed and the type localities of *O. beddomei* sensu stricto and *O. venustus* sp. nov. are > 1000 km apart (Fig. 12). Members of the *O. beddomei* complex are

## Plate 18



**Figure 11.** Habitats of (A) *Ophisops beddomei* at Brahmagiri Hills, Karnataka; and *O. venustus* sp. nov. at (B) Dhulda, Dang District, Gujarat, (C) Piprol, Valsad District, Gujarat, (D) Salher, Nashik District, Maharashtra, (E) Saputara, Dang District, Gujarat, and (F) Datar Hill, Junagadh District, Gujarat in India

# Plate 19



**Figure 12.** Map showing the distribution of *Ophisops beddomei* species complex; for locality details refer to Sup. Table 5

morphologically cryptic, and despite exhibiting high genetic divergence, *O. venustus* sp. nov. differs from *O. beddomei* sensu stricto in only a few overlapping meristic characters. Similar morphologically conserved and genetically distinct, cryptic diversity was observed in the *O. microlepis* complex as well (Agarwal *et al.* 2018). Diversification of the *O. beddomei* complex from other small-bodied lacertid species complexes took place around the mid-Miocene and lineages in the *O. beddomei* complex diverged from one another in the late Miocene to early Pliocene (Agarwal & Ramakrishnan 2017). These are the only *Ophisops* on the Indian subcontinent distributed in the higher elevation plateaus and deciduous forests, whereas other Indian congeners occupy the grasslands and arid habitats at lower elevations. The *O. beddomei* complex is likely to be much more widely distributed than currently known, as these lizards have been recorded from a range of habitats with plateaus and deciduous forest across the Western Ghats and parts of the Satpura Hills, Vindhya Hills, and Girnar Hill complex (Fig. 11, 12; Sup. Table 5). Similar suitable, unsampled habitats in peninsular India and Central India must be explored to map the range of this species complex, as the report of Mohapatra *et al.* (2023) and images of similar-looking species with two frontonasals from parts of Central India hint at their presence outside of the current known range. The habitats that these endemic lizards inhabit are often unprotected and under immense anthropogenic pressures making it vital that they receive conservation attention. Additionally, these habitats are understudied and consequently often overlooked on account of being classified as wastelands (Putz & Redford 2010, Parr *et al.* 2014, Veldman *et al.* 2015a, 2015b). Further detailed taxonomic studies of populations of each species complex within the genus *Ophisops* across their range are required to resolve the taxonomic identity of putative new species. The present study is a step forward in resolving the cryptic diversity of the *O. beddomei* complex.

#### Author contributions

All the authors contributed equally.

#### Acknowledgments

We are grateful to the Principle Chief Conservator of Forests of Gujarat Forest Department and Maharashtra Forest Department for granting permission to carry out our work; V. Naik, M. Patel, N. Patel, A. Chavda, B.

Dudhatra, D. Chauhan, K. Patel, and P. Vaghashiya for accompanying us and for their help with fieldwork; P.D. Campbell (NHMUK) for sharing images of the material under his care and for hosting ZAM during his visit to examine the type specimens at NHM; S. Arvindekar for helping with molecular data curation and analysis; the Director, Asst. Director, and other staff of BNHS, R. Khot for providing help and assistance in registering and examining specimens; W. Böhme, I. Agarwal, and two other anonymous reviewers for valuable comments on the earlier draft of this manuscript.

#### Research permits

This study was conducted with research permissions granted by the Forest Department of Gujarat State (No. WZP/5585/22/C/590-92/3-8-1990, B/WPS/8/9388-92/2013-14, and WPS/T4/682/B/2931/2016-17).

#### Funding information

The Critical Ecosystem Partnership Fund (Western Ghats) and the Open Taxonomy Initiative, supported by K. Shanker and S.P. Vijayakumar at the Evolutionary Ecology Lab, Centre for Ecological Sciences (CES), Indian Institute of Science (IISc), Bangalore, for funding part of the fieldwork and for access to specimens (to SP); The Singinawa Conservation Foundation and Max Planck Society's IMPRS 'From Molecules to Organisms' program supported the work conducted by ZAM.

#### Supplemental data

<https://doi.org/10.47605/tapro.v13i2.332>

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Published date: 30 November 2024