



## A new species of *Eutropis* (Squamata: Scincidae) from Sri Lanka

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### Abstract

A new species of lygosomine scincid lizard of the genus *Eutropis* is described from the dry and intermediate zones of the lowlands (0–190 m asl) of Sri Lanka. *Eutropis tammanna* sp. nov. is compared with congeners from Sri Lanka and those from southern Peninsular India, and is diagnosable by molecular data and by the following combination of morphological characters: body size small, up to 52.3 mm; transparent window-like disk absent on lower eyelids; prefrontals in broad contact; a single pair of nuchals; postnasal absent; ear opening larger than adjacent scales; dorsal scales with 6–7 keels; midbody scale rows 28–29; paravertebral scale rows 37–40; ventral scales 41–48; lamellae under fourth toe 15–16; dark labial bars present in both sexes, which are more distinct in males; dark postocular stripe absent; males brown on dorsum, with dark flanks speckled with cream; females similar to males, the pattern less contrasting, lacking paired series of black markings, pale vertebral stripes or dark longitudinal stripes on dorsum. In addition, the rostral, labials, and gular region of presumed breeding males are bright flame scarlet.

**Key words:** *Eutropis tammanna* sp. n., Scincidae, systematics, morphology, Sri Lanka, Bayesian, ND2, DNA, SH test

### Introduction

The genus *Mabuya* Fitzinger, 1826 (sensu lato), contains a number of medium-sized to large (SVL to 137 mm), terrestrial scincids, with generally robust habitus, snout obtusely pointed, palatines in contact, nostril situated in a single nasal, eyelids moveable, lower eyelid of scaly or with a transparent window, supranasals present, dorsal scales keeled, limbs well-developed and pentadactyle, tympanum deeply sunk, pterygoids separated, pterygoid teeth present, presacral vertebrae 26, and preanal scales not enlarged (de Rooij, 1915: 158; Smith, 1935: 258–259; Taylor, 1963; Horton, 1973a; 1973b; Greer, 1977; Mausfeld et al., 2002). As traditionally defined, the genus contains 115 nominal species, from both the Old and New World tropics and subtropics (Horton, 1973b; Bauer and Günther, 1992; Mausfeld et al., 2000; Mausfeld and Böhme, 2002; Mausfeld and Schmitz, 2003).

Honda et al. (1999) demonstrated that the genus *Mabuya*, as understood at that time, was paraphyletic (see also Mausfeld and Vrcibradic, 2002; Honda et al., 2003). Mausfeld et al. (2002) argued for the partition of *Mabuya* into four genera (each representing long-separated evolutionary lineages of monophyletic radiations in South American, Asian, Afro-Madagasy and Cape Verdian groups). The Asian species were allocated to *Eutropis* Fitzinger, 1843 (type species: *Gongylus sebae* Duméril and Bibron, 1839, at present synonymous with *Eutropis multifasciata* [Kuhl, 1820]). Recent authors have been divided in the acceptance of this new

taxonomy, because of the limited taxon sampling in the paper by Mausfeld et al. (2002) (see Greer et al., 2004).

There is a relatively long history of studies of the saurofauna of Sri Lanka (formerly Ceylon), starting from Kelaart's (1852; 1854) encyclopaedia of Sri Lankan natural history, Ferguson's (1877) early account of the island's reptiles, and Nevill's (1887) essay on the Scincidae. In the following century, important works include Deraniyagala's (1931) review of the lizards, and his 1953 part-popular guide to the turtles, crocodilians, and lizards, and subsequently Taylor's (1950; 1953) review of the Scincidae and the Sri Lankan lizard families, respectively. However, a number of additional lygosomine species have either been described or recognised in recent years (Greer, 1991; Austin et al., 2004). Within the genus *Eutropis*, six species have been listed in recent works for Sri Lanka (de Silva, 1998; Das and de Silva, 2005).

In this paper, we describe a new species of *Eutropis* from the arid North-Central and Uva Provinces of Sri Lanka. In an earlier publication, we had referred to this species as *Mabuya* species (Das and de Silva, 2005: 118).

## Materials and methods

### *Morphology*

The type series and additional material were collected from localities in the lowlands of Sri Lanka, photographed in life, euthanased using pentobarbitol, fixed in buffered formalin ca. 24 h after collection, and subsequently washed in water and transferred to 70% ethanol about a week after collection. Geographical coordinates for the type localities and some other localities where collections were made by us were taken with a Garmin eTrek™ or Magellan 315™ Global Positioning System (datum: wgs84).

The following measurements were taken with Mitutoyo™ dial vernier callipers (to the nearest 0.1 mm) ca. 52 months after collection: snout-vent length (SVL); tibia length (TBL), distance between surface of knee to surface of heel, with the knee flexed; head length (HL), distance between angle of jaws and snout-tip; head width (HW), measured across distal end of retroarticular process of the mandible; head depth (HD), greatest transverse depth of head, taken posterior of the orbital region; eye diameter (ED), horizontal diameter of the eyes, measured across the anterior and posterior margins of the palpebral margin; interorbital distance (IO), smallest distance between upper eyelids; internarial distance (IN), distance between nostrils; eye to snout distance (E-S), distance between anterior-most commissure of eyelid and tip of snout; eye to nostril distance (E-N), distance between anteriormost point of eyes and posterior edge of nostrils; nostril to snout distance (N-S), distance between anterior-most point of nostril and tip of snout; axilla to groin distance (A-G), distance between posterior edge of fore limb at its insertion to body to anterior edge of hind limb at its insertion to body, with the limbs held at right angle to body; and body width (BW), greatest width of body. Means are given  $\pm$  1 S.E. Nomenclature of head scales follows Taylor (1935: 71), except that the supraciliary scale row is taken to end with the last scale contacted by both the fourth supraocular and the palpebral row, following Greer (1982). Paravertebral counts were made from the anterior-most nuchal to the first scale anterior to an imaginary line along the anterior edge of thighs, held perpendicular to the long axis of the body; ventral counts were from the first postgular to last scale before preanals; subcaudal counts from edge of anal region to the tip of tail; and subdigital lamellae were counted from the first enlarged scale at base of digit, to and including the last scale of the toe. Details of digit scalation were taken on the left limbs. Nomenclature of dorsal striping follows Storr et al. (1999:277). Colour notes were taken of live specimens recorded digitally using Nikon D-70 or D-90 body and a 105 mm Micro-Nikkor f/2.8 D lens, illuminated by Speedlight SB-800 flash. Colour nomenclature follows the swatches of Smithe (1975; 1981). Individuals were sexed by gross examination of gonads and associated reproductive tracts (testes or ovaries and / or presence of oviducal eggs) from a median incision applied to the lower abdominal region. Comparative material examined is in Appendix 1.

Other sources of information on character states of congeneric species of *Eutropis* (as *Mabuya*) include: Boulenger (1887), Das (2002), Das and de Silva (2005), Deraniyagala (1953), Inger et al. (1984), Sharma (1971; 1973), Smith (1935), Talukdar et al. (1978), and Taylor (1950; 1953; 1963). Institutional abbreviations follow Leviton et al. (1985; 1988), RMNP to the zoological collection of the Royal Manas National Park, Gelephu, Bhutan. In addition, ID, AdS, and CCA refer to the authors' field numbers: AMB, that of Aaron M. Bauer. All referred material will be eventually accessioned with CMS.

#### *DNA sequencing and alignment*

Tissue samples preserved in ethanol were used for all genomic lab work. Samples included Sri Lankan *Eutropis*, the new species being described here, four extralimital *Eutropis* species (Borneo, Philippines, Micronesia, and the Andaman Islands), samples from four localities for *E. macularia* from Bhutan and Sri Lanka, *Trachylepis aurata* from Africa (data from GenBank), and outgroup taxa from the scincid genera *Carlia*, *Emoia*, *Eumeces* (GenBank), *Lamprolepis*, and *Sphenomorphus*. Genomic DNA was isolated from muscle and liver tissue samples using the Qiagen DNeasy tissue kit (Valencia, CA, USA). We used the polymerase chain reaction (PCR) to amplify a region of the mitochondrial NADH dehydrogenase subunit 2 (ND2) gene. Amplification of 25  $\mu$ L PCR reactions were done using a MJ Research PTC-200 thermocycler, and PCR products were visualized via electrophoresis in 1% agarose gels. Two primers were used for PCR and sequencing: Metf1.MAB (AAGCTTTCGGGCCCATACC) and CO1r.1 (AGRGTGCCAATGTCTTTGTGRTT) (Macey et al., 1997). Two additional primers were used for internal sequencing: ND2.SKF (GGGGGCTTAAACCAAA-CACA) and ND2.SKR (CTTTTATTTGGGGCTTTGAAGGC). PCR products were sequenced using ABI Big Dye<sup>®</sup> version 3.1 terminator cycle sequencing kit (Applied Biosystems, Foster City, CA, USA) and run on an ABI 3100 automated DNA sequencer. All original DNA sequences are available from GenBank. DNA sequences were aligned using Clustal X (Thompson et al., 1997). Sequences were translated to amino acids with MacClade 4 (Maddison & Maddison, 2000) to confirm open reading frames for all sequences.

#### *Phylogenetic analyses*

Maximum likelihood (ML), maximum parsimony (MP), and Bayesian inference (BI) were the optimality criteria used to assess phylogenetic relationships (Edwards, 1972; Felsenstein, 1981). Phylogenetic analysis were done using PAUP\* 4 (Swofford, 1999) and MrBayes 3.0b4 (Huelsenbeck and Ronquist, 2005). The best-fit model of nucleotide substitution was chosen using Modeltest (Posada and Crandall, 1998). The Akaike Information Criterion (AIC) and hierarchical likelihood Ratio Tests (hLRTs) were used to assess the gamma distribution shape parameter and pick the best model of evolution for the data. All searches in PAUP\* were done using the heuristic search options with 20 random addition sequences, with initial trees obtained by step-wise addition, followed by branch swapping using the tree bisection-reconstruction (TBR) method. For BI analyses searches were initiated with random starting trees and run for 1,000,000 generations. Four chains were used (one 'cold' and three 'heated' chains) and chains were sampled every 100 generations with an initial burn-in of 5,000 generations. Convergence plateaus were checked by plotting likelihood scores against generations. Nodal support for both ML and MP criteria was evaluated by the non-parametric bootstrap resampling method (Felsenstein, 1985; Hillis and Bull, 1993) and BI posterior probabilities were generated for from all post burn-in sampled trees (Huelsenbeck and Ronquist, 2005). The Shimodaira-Hasegawa (SH) test statistic, the difference between the ML scores for the optimal tree and other a priori constraint trees (i.e.  $\delta_T = \ln L_{ML} - \ln L_{CT}$ ), was used to assess a priori hypotheses (Shimodaira and Hasegawa, 1999).

***Eutropis tammanna* sp. nov.**

Figures 1–5

*Mabuya* species I. Das & A. de Silva. 2005. Photogr. Guide. Snakes & Other Rept. Sri Lanka:118.

**Holotype.** Department of National Museums, Colombo (formerly, the Ceylon Museum, CMS), registration number awaited (field number CCA 2365), adult male, from 17 mile post, Buttala (06°40'53"N, 81°16'14"E; altitude 125 m asl), Kataragama Road, Uva Province, Sri Lanka; C. C. Austin and A. de Silva, collectors, 7 November 2002.

**Paratypes.** CMS, registration number awaited (field number CCA 2370), adult female, from Koruppa (07°21'36"N, 80°59'35"E; altitude 100 m asl), Mahiyangana, Uva Province, Sri Lanka; C. C. Austin and A. de Silva, collectors, 9 November 2002; CMS, registration number awaited (field number CCA 2385), adult female, from Rambewa (08°26'59"N, 80°30'32"E; altitude 137 m asl), North Central Province, Sri Lanka; C. C. Austin and A. de Silva collectors, 11 November 2002.

**Other material.** CMS 2007.16.03 (*ex-ID* 8904), CMS 2007.16.04 (*ex-ID* 8903), CMS 2007.16.05 (*ex-ID* 8915), three specimens, from Tammanna Estate (08°00'56.1"N, 79°51'19.5"E; altitude 22 m asl), Puttalam Peninsula, North West Province, Sri Lanka, A. de Silva and I. Das, collectors, 23 October 2004. One adult male and two adult females.

**Morphological diagnosis.** A small (SVL to 52.3 mm) species of *Eutropis*, diagnosable from congeneric species in having the following combination of characters: transparent window-like disk absent on lower eyelids; prefrontals in broad contact; a single pair of nuchals; postnasal absent; ear opening larger than adjacent scales; dorsal scales with 6–7 keels; midbody scale rows 28–29; paravertebral scale rows 37–40; ventral scales 41–48; lamellae under fourth toe 15–16; dark labial bars present in both sexes, which are more distinct in males; dark postocular stripe absent; males brown on dorsum, with dark flanks speckled with cream; females similar to males, the pattern less contrasting; lacking paired series of black markings, pale vertebral stripes or dark longitudinal stripes on dorsum. In addition, the rostral, labials, and gular region of presumed breeding males are flame scarlet.

**Molecular diagnosis.** Eight hundred and thirty four base pairs of the mitochondrial ND2 gene from six species of *Eutropis* show diagnostic characteristics that delimit *E. tammanna* from other *Eutropis*. Site 1 of the aligned data presented here corresponds to site 4076 in the *Eumeces egregius* complete mtDNA genome GenBank sequence (AB016606.1). *Eutropis tammanna* has an uncorrected pair-wise difference of 8.9% from its sister taxa (a population of *E. macularia*; Appendix 2). *Eutropis tammanna* is included in a well supported clade of *Eutropis* from Sri Lanka and *E. macularia* from Bhutan (Fig. 8). The three individuals of *E. tammanna* included in the genetic analyses show seven molecular synapomorphies (node 1, Fig. 8): site 4 is a G (third codon position), site 10 is a G (third codon position), site 259 is a T (third codon position), site 319 is a T (third codon position), site 445 is a G (third codon position), site 461 is a G (first codon position resulting in an amino acid change to valine), and site 569 is a T (first codon position change but not resulting in an amino acid change). The sister taxon to *E. tammanna* is *E. macularia* from Bhutan (RMNP 11, cited by Das and Palden, 2000), and this lineage is united by eight molecular synapomorphies (node 2, Fig. 8): site 57 is a T (second codon position resulting in an amino acid change to isoleucine in *E. macularia* (RMNP 11), and *E. tammanna* (CCA 2385), and a change to valine in *E. tammanna* (CCA 2365 and CCA 2370), site 100 is a T (third codon position), site 118 is a C (third codon position), site 296 is a G (first codon position resulting in an amino acid change to valine), site 425 is a T (first codon position resulting in an amino acid change to serine), site 591 is a C (second codon position resulting in an amino acid change to threonine), site 681 is an A (second codon position resulting in an amino acid change to tyrosine), and site 697 is a C (third codon position). Finally, the well supported monophyletic clade including *E. tammanna* and three distinct *E. macularia* lineages is supported by five synapomorphies (node 3, Fig. 8): site 50 is a T (first codon position resulting in



**FIGURE 1.** Dorsolateral views (A and B) of *Eutropis tammanna* sp. nov. (holotype; CMS uncatalogued; *ex*-CCA 2365), adult male, in life.





**FIGURE 2.** Dorsolateral view of *Eutropis tammanna* sp. nov. (paratype; CMS uncatalogued; ex-CCA 2370), adult female, in life.



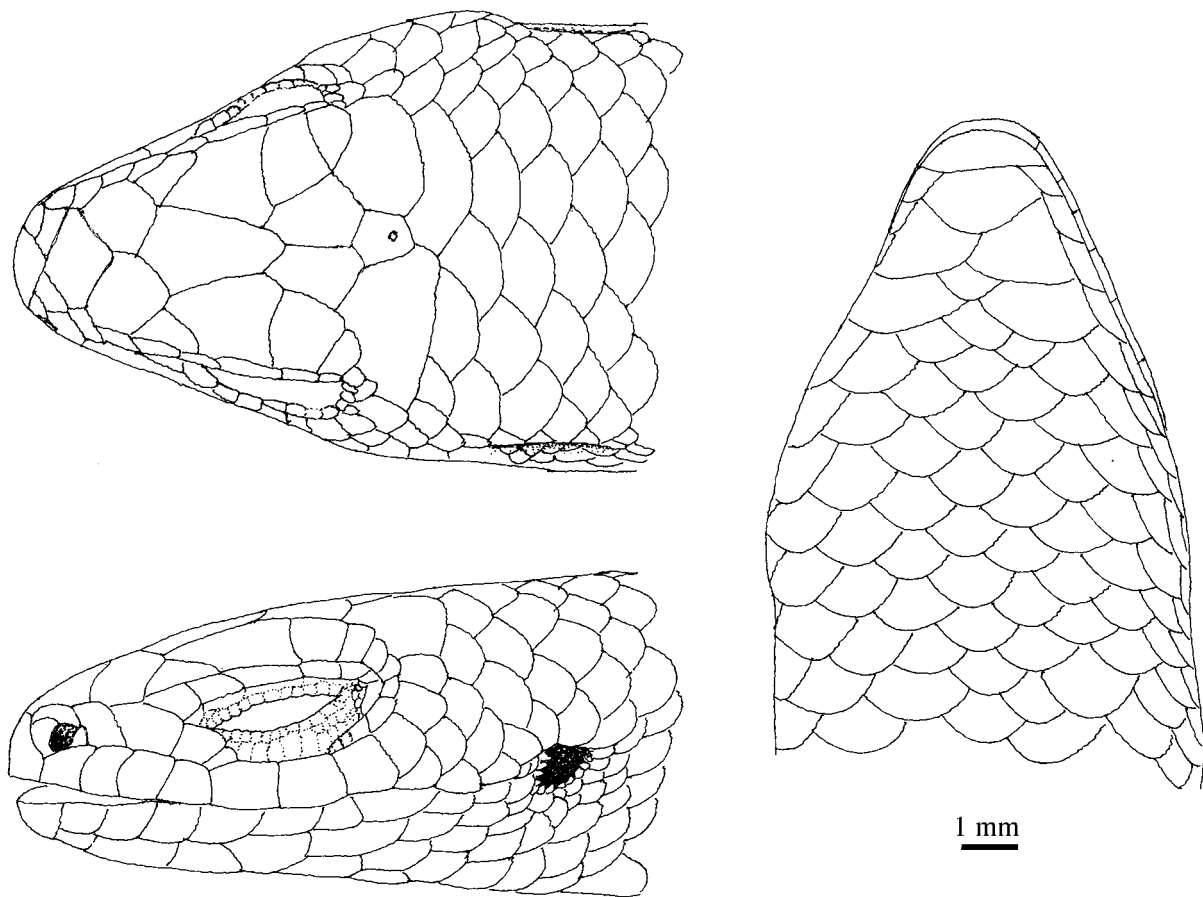
**FIGURE 3.** Dorsolateral view of *Eutropis tammanna* sp. nov. (paratype; CMS uncatalogued; ex-CCA 2385), adult female, in life.

an amino acid change to serine), site 263 is a G (first codon position resulting in an amino acid change to glutamic acid), site 497 is a A (first codon position resulting in an amino acid change to methionine), site 592 is a C (third codon position), site 766 is a third codon position and has either C or T for this clade while all other taxa have either A or G, and site 780 is an A (second codon position resulting in an amino acid change to either lysine or asparagine).



**FIGURE 4.** Head and forebody of male (Top; CMS 2007.16.04) and female (Bottom; CMS 2007.16.03) of *Eutropis tammanna* sp. nov.





**FIGURE 5.** Head scalation in the holotype of *Eutropis tammanna* sp. nov. (CMS uncatalogued, ex-CCA 2365). Top left. Dorsal view; Bottom left. Lateral view; and Right. Ventral view. Scale marker = 1 mm.

**Description of holotype.** A well-preserved adult male, with detached, original tail; SVL 51.9 mm, TL 93.2 mm; snout short (IN/IO ratio 0.57), obtuse, slightly projecting beyond lower jaws; nostril laterally oriented, oval, situated closer to snout-tip than to orbit (E-N/E-S ratio 0.61); head relatively short, slightly longer than wide, HL 8.6 mm, HW 7.6 mm (HL/HW ratio 1.13), slightly flattened, HD 5.0 mm (HL/HD ratio 1.72); rostral broad, projecting well onto snout; posterior border of rostral semicircular; supranasals rectangular, separated from each other, in contact with rostral, frontonasal trapezoid, wider than long; prefrontals large, in broad contact; frontal elongated, arrow-head shaped, wider anteriorly; frontoparietals in broad contact; interparietal single, shorter than frontonasal; parietals separated by interparietal; a pale parietal eye spot situated at posterior half of interparietal; four supraoculars; no contact between supraocular I and frontal; supraocular II most posterior supraocular to contact frontal; six supraciliaries; nostrils located between nasal and anterior loreal; postnasal absent; loreals squarish, two in number; equal in height; anterior loreal higher than long; posterior loreal larger than the anterior; two presuboculars, separating supralabial IV from lower eyelid; seven supralabials (supralabial V contacting orbit of eye); six postsuboculars; two postoculars; all temporals keeled; two primary temporals followed by an upper and lower secondary temporal separated by a well established intervening tertiary temporal (2 + 2 separated pattern of Greer and Broadley, 2000: Fig. 2C); one pair of nuchals; six infralabials; one scale separates second pair of enlarged chin shields; three scales separate third pair of chin shields; enlarged chin shields contact infralabials; external ear opening larger than adjacent scales, oval, with numerous lobules, the most distinct of which is a spinose one on the anterior edge, oriented towards the posterior; pupil rounded; lower eyelid lacking a clear window, supraciliaries five; scales on upper eyelid small, numbering 11; scales on upper row of lower eyelid small, numbering 13; tongue short, with a slight notch anteriorly, teeth small, somewhat obtuse.



Body relatively slender, BW 9.0 mm (BW/SVL ratio 0.17); head indistinct from neck and from body; 40 paravertebral rows; 48 ventrals; skin not fragile; body scales cycloid, with 6–7 distinct keels; 28 transverse scale rows at midbody; 80 subcaudals; on dorsum, keels start from posterior edge of parietals; scales on flanks with weak keels; those on venter smooth; abdominal scales larger than throat and pectoral scales, the median ventral scales also enlarged relative to scales on flanks; preanals enlarged, lateral pair of preanals overlap median preanal; no irregular series of scales covering posterior aspect of thigh; tail relatively long (TL/SVL ratio 1.80), tip acute, tail base not wider than rest of tail, gradually tapering to a point; median row of subcaudals not enlarged relative to adjacent scales.

Limbs relatively short; pentadactyle and clawed; scales on limbs weakly bicarinate; lamellae obtusely tuberculate and enlarged; adpressed limbs reach level of carpals; lamellae under finger I– 4; II– 8; III– 10; IV– 11; V– 6; lamellae under toes I– 5; II– 8; III– 12; IV– 16; V– 8.

**Holotype colouration– adult male.** In preservative, dorsum medium-brown, forehead unicoloured; torso with scattered black blotches; venter, including gular region unpatterned yellowish-ivory; infralabials unbarred; supralabials with dark vertical bars more distinct posteriorly, beyond the level of orbit of eye, forming vertical bars that reach the angle of the jaws and continue as a blackish-brown flank stripe; dark flank stripe five scales wide, comprising scales that are typically bicoloured ivory (on top) and black (on bottom); on sides of tail, the dark stripe breaks up into four dark stripes that traverse the length of the tail; upper surfaces of forelimbs with darker variegations and cream blotches; dorsal surfaces of limbs and tail unbanded pale brown; undersurfaces of limbs and tail ivory; tongue grey.

**Paratype colouration– adult female.** In preservative, based on CMS uncatalogued (*ex*-CCA 2385), dorsum bronze brown, the supralabials, especially the posterior edge with faint grey vertical bars, reminiscent of the pattern of the male, with greater contrast; a dark brown-grey stripe commences from posterior edge of tympanum, broadens on the flanks, and continues along the tail, where it becomes faint at approximately the level of midtail, forming three narrow lines; gular, pectoral and abdominal regions unpigmented yellowish-cream; dorsal surfaces of limbs and tail unbanded pale brown; undersurfaces of limbs and tail ivory; tongue grey.

Colouration (in life). Based on CMS 2007.16.04, adult male and CMS 2007.16.03, adult female. Adult male dorsum Chestnut (#32), flank stripe Dusky Brown (#19) with Sulfur Yellow (#157) speckles; rostral, anterior supralabials, infralabials and gular region Flame Scarlet (#15). Adult female dorsum glossy, iridescent Walnut Brown (#221B); flank stripe Blackish Neutral Gray (#82), the pale flecks Salmon Color (#6). In both sexes, pupil is black and iris is Flesh Color (#5).

**Measurements (in mm).** Holotype with variation shown in type series in parentheses. SVL 51.9 (49.1–51.9, mean  $51.10 \pm 1.01$ ); HL 8.6 (7.2–8.8, mean  $8.20 \pm 0.50$ ); HW 7.6 (6.5–7.6, mean  $6.93 \pm 0.34$ ); HD 5.0 (4.6–5.0, mean  $4.73 \pm 0.13$ ); BW 9.0 (9.0–11.5, mean  $10.07 \pm 0.74$ ); TBL 6.9 (6.2–8.0, mean  $6.43 \pm 0.23$ ); ED 3.2 (2.8–3.2, mean  $2.93 \pm 0.13$ ); IN 2.4 (1.9–2.6, mean  $2.30 \pm 0.21$ ); IO 4.2 (4.0–4.4, mean  $4.20 \pm 0.12$ ); E-S 4.4 (3.4–4.4, mean  $3.87 \pm 0.29$ ); E-N 2.7 (2.2–2.7, mean  $2.37 \pm 0.17$ ); N-S 1.3 (1.0–1.3, mean  $1.10 \pm 0.10$ ); A-G 27.3 (26.0–28.1, mean  $27.13 \pm 0.61$ ); and TL 93.2 (70.3–93.2, mean  $81.30 \pm 6.63$ ).

**Variation in squamation and coloration.** Holotype with variation shown in type series in parentheses. Transverse scale rows at midbody 28 (28–29, mean  $28.33 \pm 0.33$ ); paravertebral rows 40 (37–40, mean  $38.33 \pm 0.88$ ); ventral scale rows 48 (41–48, mean  $45.00 \pm 2.08$ ); supralabials 7 (no variation); infralabials 6 (6–7, mean  $6.33 \pm 0.33$ ); subcaudals 80 (75–85, mean  $80.00 \pm 2.89$ ); and lamellae under toe IV 16 (15–16, mean  $15.67 \pm 0.33$ ). Sexual dichromatism observed includes the flame scarlet rostral, labial and gular colours of the single male described above, in addition to the relatively contrasting flank stripe. In females, the overall colouration of dorsum is comparatively sombre, lacking the bright colours on the lips and throat, and the vertical dark bars near the angle of the jaws are faintly indicated.

**Etymology.** Derived from Pali, a Middle Indo-Aryan dialect, and the source of Sinhala and several east Indian languages, meaning bronze, the overall colour of dorsum of the new species. Tammanna is also the

point where King Vijaya (543–504 B.C.), who founded the first Sinhalese empire, landed on the island, close to the Tammanna Estate, where we collected additional material of the new species.

**Ecological and distributional notes.** CMS 2007.16.03–04 were collected during the day, from under fallen coconuts and discarded thatch material in the vicinity of a coconut and cashew nut plantation, < 50 m from the shore (Fig. 6). The following herpetofaunal species were found in sympatry at Puttalam: (Microhylidae): *Uperodon systoma*; (Agamidae): *Calotes versicolor*, *Sitana ponticeriana*; (Gekkonidae): *Geckoella yakhuna*; *Hemidactylus frenatus*; (Scincidae): *Eutropis carinata*, *Lygosoma punctata*; (Colubridae): *Oligodon arnensis*, and (Elapidae): *Naja naja*. CCA 2370 and CCA 2385 contained two eggs each (measurements not taken due to obvious distortion at preservation).

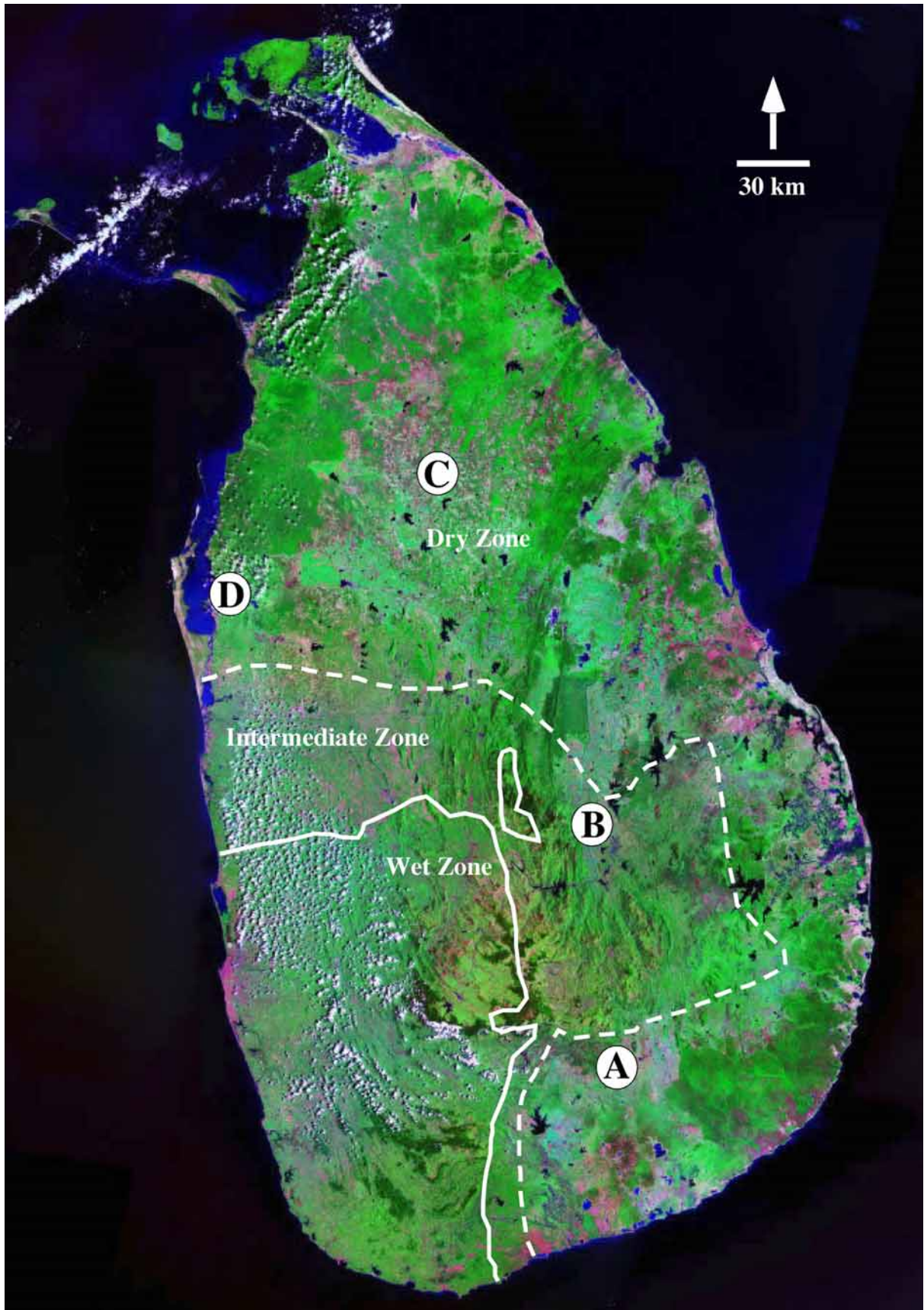
The new species has been collected at the following additional localities: 1 km N Udappuwa, North Western Province, 07°58'24.4"N, 79°47'15.9"E, alt. 12 m asl; vicinity of Kalpitiya, North Western Province, 07°58'23.8"N, 79°47'17"E, alt. 3 m asl; Kandalama, Central Province, 07°20'36"N, 80°51'32"E, alt. 200 m asl, Pothana, Kimbissa (Sigiriya), Central Province, 07°56'37.6"N, 80°42'40.2"E, alt. 190 m asl, and Rajarata University Park, Mihintale, North Central Province, 08°21'11.7"N, 80°30'09.6"E, alt. 108 m asl. The elevational distribution of the new species is thus from sea level to 190 m asl. (Fig. 7).



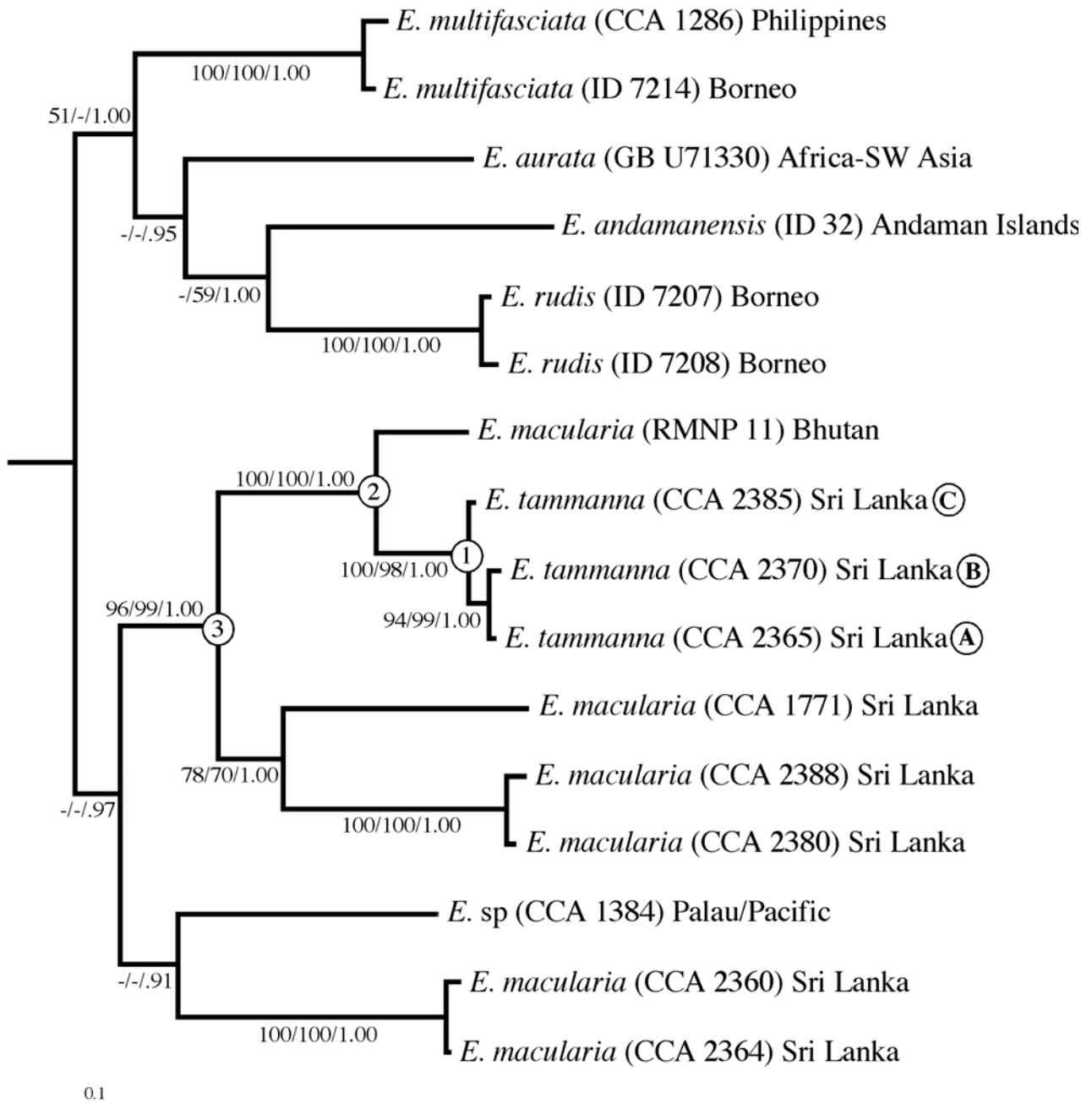
**FIGURE 6.** Habitat of *Eutropis tammanna* sp. nov. at Puttalam, north-western Sri Lanka.

**Comparisons.** Six nominal species of *Eutropis* have been reported from Sri Lanka (de Silva, 1998; Das and de Silva, 2005). In making comparisons, only opposing suite of characters are listed. These are: *beddomei* (Jerdon, 1870: SVL to 55 mm; head narrow; midbody scale rows 30–32; dorsal scales with 3–5 keels; lamellae under toe IV 12–15; dark longitudinal stripes on dorsum and throat of adult males not red; *bibronii* (Gray, 1839: SVL to 50 mm; transparent window on lower eyelids; two pairs of nuchals; a light vertebral stripe present; and throat of adult males not red); *carinata* (Schneider, 1801: SVL to 125 mm; midbody scale rows





**FIGURE 7.** Satellite map of Sri Lanka, showing the collection localities for *Eutropis tammanna* sp. nov. References: A = Buttala, Uva Province; B = Koruppa, Central Province and C = Rambewa, North Western Province. Climate contours redrawn from Panabokke and Kannangara (1996).



**FIGURE 8.** Bayesian phylogram of the phylogenetic relationships of selected species of *Eutropis*. The tree shows Bayesian branch lengths and nodal support is MP bootstraps (left) for 1,000 replicates, ML bootstraps (centre) for 500 replicates, and Bayesian posterior probabilities (right). Outgroups include the Australasian genera *Carlia*, *Emoia*, *Eumeces* (GenBank), *Lamprolepis*, and *Sphenomorphus*. Node 1 is supported by seven molecular synapomorphies, Node 2 is supported by eight molecular synapomorphies, and Node 3 is supported by five molecular synapomorphies (see molecular diagnosis).

30–34; dorsal scales with 3–5 keels; dark labial bars absent; broad postocular stripe present; dark flank stripe lacks pale spots; and males lack flame scarlet areas on labial and gular regions); *floweri* (Taylor, 1950: SVL to 56 mm; dorsal scales tricarinate; midbody scale rows 30–32, dorsum with a paired series of ca. 20 short black



marks from level of axilla to some distance along tail and labial; and gular regions of adult males not flame scarlet); *E. macularia* (Blyth, 1853: SVL to 75 mm; ear opening smaller than adjacent scales on temporal region; throat of adult males not flame scarlet; and at least in the Sri Lankan population [cryptic species have been indicated within this complex- see Ota et al., 2001; Mausfeld and Schmitz, 2003], a narrow [one scale wide], pale dorsal stripe extends from the top of postocular region, across body to the length of tail, adjacent to a broad [three scales wide] laterodorsal stripe); and *madaraszi* (Méhely, 1897: SVL to 77 mm; midbody scale rows 32; a pale dorsolateral stripe from supralabials to midtail; adpressed hind limb reaches axilla; an irregular series of scales covering posterior aspect of thigh; and throat of adult males not flame scarlet).

To the north-west of the arid plains of Sri Lanka lies the tip of the Indian Peninsula, where four of the species of Sri Lankan *Eutropis* also occur: *beddomei*, *bibronii*, *carinata* and *macularia*. The southern hill country of Peninsular India, comprising the Western and Eastern Ghats, is home to four additional congeners (Smith, 1935; Welch et al., 1990; Das, 2002), with which the new Sri Lankan species is here compared: *Eutropis allapallensis* (Schmidt, 1926; distribution: western, central and south-western India, including Goa, Gujarat, Tamil Nadu, Maharashtra and Kerala: SVL to 75 mm; frontoparietals fused; prefrontals not in contact; temporal scales smooth; preanals not enlarged; and gular regions not flame scarlet); *E. clivicola* (Inger, Shaffer, Koshy & Bakde, 1984; distribution: Kerala State: SVL to 55 mm; prefrontals in narrow contact; dorsal scales with five weak keels; lamellae under fourth toe 17–19; a narrow, dark vertebral stripe and labial; and gular regions not flame scarlet); *E. gansi* (Das, 1991: distribution: Tamil Nadu State: SVL to 62.6 mm; prefrontals not in contact; midbody scale rows 30; a two-scale wide dark grey lateral stripe and labial; and gular regions not flame scarlet); and *E. nagarjuni* Sharma, 1969: distribution: Andhra Pradesh: SVL to 51 mm; prefrontals not in contact with each other; three pairs of nuchals and postnasals present and labial; and gular regions not flame scarlet).

Although the island nation of Sri Lanka is generally known to have a distinctive biota, this is localised to regions with high precipitation, specifically, the highlands, which is located around the west-central and south-western portions of the island (Fig. 7; see also Bossuyt et al., 2004). The high endemicity of this region has been attributed in part to the intervening xeric lowlands of northern and eastern Sri Lanka and those of southern India (Das, 1996) and land connection, mediated by sea level lowering, between the now separated landmasses existed as recently as 10,000 years before present (Rohling et al., 1998). The known distribution of the new species of *Eutropis* described lies within the dry and intermediate zones of Sri Lanka (described in Fernando, 1984; Panabokke, 1996), suggesting that herpetological sampling in such areas outside known biodiversity hotspots may yield other herpetological novelties.

## Phylogeny

The general time reversible (GTR) model with an estimated proportion of invariant sites (I) and gamma (G) distributed among-site rate variation for nucleotide evolution was chosen under both the Akaike Information Criterion (AIC) and the hierarchical likelihood Ratio Tests (hLRTs) implemented in Modeltest (Posada and Crandall, 1998). The GTR+I+G model with the gamma shape distribution parameter was estimated to be 0.8057 and the output model criteria were used in resulting ML and BI analyses. All analyses provide robust support for the monophyly of a clade including *E. tammanna* and three distinct lineages of *E. macularia* (node 3, Fig. 8). *Eutropis tammanna* is nested within lineages of *E. macularia*, rendering *E. macularia* paraphyletic. There is weak support for the association of *E. sp.* from Palau with *E. macularia* from central eastern Sri Lanka (CCA 2360 and 2364; Figure 8). We used the SH statistic (Shimodaira and Hasegawa, 1999) to test: (Hypothesis 1) if we can reject the monophyly of *E. macularia* + *E. tammanna*, and (Hypothesis 2) if we can reject the monophyly of *E. macularia*. The constrained tree was not significantly worse than the ML tree for hypothesis 1 demonstrating that we do not have enough evidence with these data to reject the monophyly of *E.*

*macularia* + *E. tammanna*. The tree constraining *E. macularia* as monophyletic to the exclusion of *E. tammanna*, however, was significantly worse than the ML tree demonstrating that these data reject the monophyly of *E. macularia* ( $P < 0.05$ ). Thus, *E. tammanna* appears to be a morphologically differentiated lineage within a larger *E. macularia* species complex. The concordance of the molecular DNA sequence data and morphology in delineating *E. tammanna* from other *Eutropis* provides a strong basis for recognizing this lineage as a distinct species. *Eutropis macularia* has a broad geographic distribution that ranges from southern and eastern (essentially coastal or lowland) Pakistan, through the Indian Peninsula and Sri Lanka, the Himalayan foothills and Indo-China, to the northern Malay Peninsula (Smith, 1935; Welch et al., 1990). Several eastern populations have been treated as subspecies; others have been given species rank (e.g., *Eutropis allapallensis* and *E. gansi*), and our limited data on Sri Lankan populations indicates that there is likely a large cryptic diversity (sensu Bickford et al., 2007) in the *E. macularia* species complex.

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## Appendix 1. List of comparative material examined and/of genetic data

- Eutropis andamanensis* (Smith, 1935): AMS R.153425, from Wandoor, South Andaman Island, India.
- Eutropis aurata* (Linnaeus, 1758): GB U71330, from Turkmenistan.
- Eutropis beddomii* (Jerdon, 1870): ZSI 2356 (holotype of *Euprepes (Tiliqua) septemlineatus* Blanford, 1870), from "Pem Ganga valley, S.E. Berár" (in Madhya Pradesh, central India).
- Eutropis carinata* (Schneider, 1801): AM R 153429–30, Vadanemmeli, Tamil Nadu, India; CMS R.SK6A (holotype of *Mabuya carinata lankae* Deraniyagala, 1953), from "Hambegamuwa" (06° 32'N; 80° 57'E, Southern Province, Sri Lanka); CCA 2364, from 17 mile post, Buttala, Kotragama Road, Uva Province, Sri Lanka; AMS R.153429–30, from Vadanemmeli, Tamil Nadu, south India; USNM 306652–53, Gan Island, Addu Atoll, Maldives.
- Eutropis clivicola* (Inger, Shaffer, Koshy & Bakde, 1984): FMNH 216580–81 (two paratypes), FMNH 216603–18 (16 paratypes), from "Ponmudi, Trivandrum District, Kerala at 260 m above sea level" (in south-western India).
- Eutropis floweri* (Taylor, 1950): CMS uncatalogued, ex-AMB 8494, from N Trincomalee, Eastern Province, Sri Lanka.
- Eutropis gansi* (Das, 1991): ZSI 24826 (holotype of *Mabuya gansi* Das, 1991), ZSI 24827–28 (paratypes of *Mabuya gansi*), from "...circa 2 km NW Muthalar Road Cross off Sengaltheri-Thalayani road (towards Moolakasam), Kalakkad Tiger Reserve, Tirunelveli district, Tamil Nadu State, India".
- Eutropis macularia* (Blyth, 1853): ZSI 2344 (holotype of *Euprepes macularius* Blyth, 1853), from "Rungpore ?" (restricted to Rangpur, Bengal [at present in Bangladesh] by Taylor and Elbel, 1958); ZSI 16170 (lectotype of *Lygosoma dawsonii* Annandale, 1909), from "Maddathorai" (Kerala State, south-western India), lectotype designation by Das et al., 1998); CCA 2360 and CCA 2363, from Pidenipitiya, Sri Lanka; CCA 2380, from Ritigala, North Central Province, Sri Lanka; CCA 2388 from Poonewa, nr. Medawachchiya, North Central Province, Sri Lanka; AdS 13A, from Nilgala Fire Savannah, Uva Province, Sri Lanka; USDZ 2.5231, from Ton Sai Falls, Phuket, Thailand; RMNP 11, Gelephu, Bhutan.
- Eutropis multifasciata* (Kuhl, 1820): ID 7214, from Samajaya Nature Reserve, Kuching, Sarawak, Malaysia.
- Eutropis nagarjuni* (Sharma, 1969): ZSI 21170 (syntype of *Mabuya nagarjuni* Sharma, 1969), from "Vijaypuri South, near right-bank of R. Krishna, lat. 16°35'N., long. 79°28'E., alt. 500 ft." (in Andhra Pradesh, south-eastern India).
- Eutropis rudis* (Boulenger, 1887): ID 7207–08, from 12th mile, Crocker Range Park, Sabah, Malaysia.

## Appendix 2. Summary of uncorrected p-distances in representative species of *Eutropis* examined

Abbreviations: *E.* = *Eutropis*; *T.* = *Trachylepis*.

Species	1	2	3	4	5	6	7	8
1 <i>T. aurata</i> (GenBank U71330) -								
2 <i>E. multifasciata</i> (CCA 1286)	0.22341	-						
3 <i>E. rudis</i> (ID 7207)	0.21384	0.19013	-					
4 <i>E. rudis</i> (ID 7208)	0.21386	0.19134	0.00722	-				
5 <i>E. sp.</i> (CCA 1384)	0.22839	0.22744	0.22022	0.21901	-			
6 <i>E. andamanensis</i> (ID 32)	0.23686	0.21901	0.20217	0.20818	0.22383	-		
7 <i>E. macularia</i> (CCA 2388)	0.25242	0.22984	0.23105	0.23345	0.22744	0.26835	-	
8 <i>E. macularia</i> (RMNP 11)	0.24884	0.23225	0.22503	0.22623	0.22022	0.25150	0.19735	-
9 <i>E. macularia</i> (CCA 2380)	0.24999	0.22744	0.22744	0.22984	0.22623	0.26474	0.00963	0.19735
10 <i>E. tammanna</i> (CCA 2385)	0.24299	0.23353	0.23116	0.23236	0.22389	0.25164	0.19144	0.08304
11 <i>E. tammanna</i> (CCA 2370)	0.24889	0.23947	0.23225	0.23105	0.21901	0.25391	0.19976	0.09266
12 <i>E. tammanna</i> (CCA 2365)	0.24527	0.23827	0.23105	0.22984	0.22279	0.25150	0.19624	0.09148
13 <i>E. macularia</i> (CCA 2360)	0.22142	0.22768	0.22405	0.22768	0.21206	0.23981	0.23622	0.23138
14 <i>E. multifasciata</i> (ID 7214)	0.21616	0.01324	0.19254	0.19374	0.22623	0.22262	0.22503	0.22984
15 <i>E. macularia</i> (CCA 1771)	0.26583	0.23706	0.23466	0.23706	0.23706	0.25993	0.19735	0.20818
16 <i>E. macularia</i> (CCA 2364)	0.21866	0.22142	0.21781	0.22142	0.21059	0.23706	0.23105	0.22744

to be continued.

**Appendix 2.** (continued)

	Species	9	10	11	12	13	14	15	16
1	<i>T. aurata</i> (GenBank U71330)								
2	<i>E. multifasciata</i> (CCA 1286)								
3	<i>E. rudis</i> (ID 7207)								
4	<i>E. rudis</i> (ID 7208)								
5	<i>E. sp.</i> (CCA 1384)								
6	<i>E. andamanensis</i> (ID 32)								
7	<i>E. macularia</i> (CCA 2388)								
8	<i>E. macularia</i> (RMNP 11)								
9	<i>E. macularia</i> (CCA 2380)	-							
10	<i>E. tammanna</i> (CCA 2385)	0.19023	-						
11	<i>E. tammanna</i> (CCA 2370)	0.19856	0.01444	-					
12	<i>E. tammanna</i> (CCA 2365)	0.19503	0.01084	0.00602	-				
13	<i>E. macularia</i> (CCA 2360)	0.23018	0.22784	0.23138	0.22777	-			
14	<i>E. multifasciata</i> (ID 7214)	0.22262	0.22992	0.23586	0.23466	0.22527	-		
15	<i>E. macularia</i> (CCA 1771)	0.19495	0.21068	0.21300	0.21059	0.23947	0.23706	-	
16	<i>E. macularia</i> (CCA 2364)	0.22503	0.22393	0.22744	0.22383	0.00604	0.21901	0.23345	-