



DESCRIPTION OF THE LIFE STAGES OF *SPHENARCHES ANYSODACTYLUS* (WALKER) (PTEROPHORIDAE: LEPIDOPTERA)

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ABSTRACT

Morphological description of egg, larval chaetotaxy, pupa, adult genitalia of plume moth *Sphenarches anysodactylus* (Walker, 1864) (Pterophoridae: Lepidoptera) is presented. The mtCO1 of the Indian population done in this study is provided, revealing maximum similarity with six populations from Africa (97.55 to 98.37 %) and two populations from Australia (97.52 to 97.70) with differences in 10-15 nucleotide sequences.

Key words: *Sphenarches anysodactylus*, *Lablab purpureus*, egg larva, larval chaetotaxy, pupa, genitalia, mtCO1, phylogenetic analysis

Genus *Sphenarches* was erected by Meyrick (1886) with type species *S. synophrys*. *Sphenarches* consists of eight species (Gielis, 2003), of which *S. anysodactylus* (Walker, 1864), *S. zanlistis* (Meyrick, 1905) and *S. caffer* (Zeller, 1852) are present in India (Meyrick, 1886; Lefroy, 1909; Fletcher, 1910; 1914; Narayanan, 1985; Nair, 1995; Gielis, 2003; Kumar, 2015). It had been reported as pest in crops under Fabaceae and Cucurbitaceae (Matthews and Lott, 2005), and *S. anysodactylus* infested predominantly on *Lablab purpureus* in Tamil Nadu during 2021. This species was described from India by Walker (1864). Its morphology of immature and adult has been studied elsewhere (Yano, 1963; Cassani et al., 1990; Gielis, 1993, 2006; Kovtunovich et al., 2014; Gielis and Wangdi, 2018). This study describes the immature stages and adult genitalia of *S. anysodactylus*. In addition mtCO1 and phylogenetic analysis are also added.

MATERIALS AND METHODS

Sphenarches anysodactylus larvae were collected from lablab fields of Tamil Nadu viz., Coimbatore (11.0055°N, 76.9300°E), Salem (77.9236°E, 11.5133°N) and Namakkal (78.1678°E, 11.2194°N) during 2021. These were reared on *Lablab purpureus* pods and young tender leaves till pupation in rearing cages (28±2°C, 75-80% RH) at the Insect Biosystematics Laboratory, Department of Agricultural Entomology, TNAU, Coimbatore, India. On pupation, pupae were transferred to adult emergence cage. Honey solution (10%) was provided as adult food along with lablab pods as the ovipositional substrate. Eggs were maintained on the

pods after oviposition. Spent adult moths were killed with ethyl acetate (80%) and were further examined. Eggs (6 Nos), final instar larvae (13 Nos), pupae (8 Nos) stored in 70% alcohol and adult (19 Nos) were examined for their morphological features under a stereozoom microscope (Leica: M205A) and photographed with an image analyzer (LAS V4.12). Eggs were also studied with scanning electron microscopy (SEM). Egg, larva and pupal terminology is after Peterson (1964), Hinton (1946), Stehr (1987) and Mosher (1916). Adult colour was described as per Ridgway (1912), wing venation as per Comstock and Needham (1898) and Zimmerman (1978). Adult genitalia study methodology and description was followed as per Klots (1970) and Robinson (1976).

The larva was subjected to mtCO1 phylogenetic analysis. Using CTAB method, DNA was isolated from third instar larvae (Hebert et al., 2003; Gawel and Jarret, 1991). The sequence was submitted to GenBank. Using MEGA X, Maximum Likelihood method based on Kimura two-parameter (K2P), a phylogenetic tree was created along with eight other reference sequences of *S. anysodactylus* and outgroup *Pectinophora gossypiella* (retrieved from GenBank) (Kumar et al., 2018; Tamura et al., 2011).

RESULTS AND DISCUSSION

Genus *Sphenarches* Meyrick, 1886

Sphenarches Meyrick, 1886:8 (Type species: *Sphenarches synophrys* Meyrick, 1886).

***Sphenarches anysodactylus* (Walker, 1864)**

Redescription: Egg, larval chaetotaxy, pupa and adult of *S. anysodactylus* are described and discussed. Egg: Length 0.52 mm and diameter 0.33 mm; elongate and oval shaped; pale yellowish green immediately on oviposition and later turned dark green before hatching (Fig.1). Eggs were laid either singly or in small groups on the upper surface of pods, young tender leaves and stems (Fig.2). Egg surface was smooth with indistinct furrows. Primary rosette with 11 to 13 cells (Fig.3). Six aeropyles were present around the primary rosette. The micropyle lies within a triangular depression with shrunken appearance on the margin of the triangle (Fig.4). The number of cells of secondary rosette is very unclear and faint. Cassani et al. (1990) has observed the aeropyles to be hexagonal in shape.

Larva: Body length 10.74 mm; pale yellowish green and laterally lined with reddish brown. Head ochreous with sclerotized cranium. Raised ivory longitudinal ridges with dorsal setae surrounds the mid-dorsum. Body with prominent primary and secondary bifurcate setae (ventral and head setae normal). Primary setae were pale brown. Secondary setae were translucent. Primary setae were arranged on verrucae and were surrounded by sparse bifurcate secondary setae. Larval body texture granulated. Spiracles were present on T1, A1 to A8. Outer circle of spiracle was lined with raised black ring and inner peritreme was yellow. Prolegs present in A3 to A6 and A10 (Fig.5).

Head: Cranium sclerotized, ochreous. Median epicranial suture moderately long, more than half length of lateral adfrontal suture. Epicranial and adfrontal suture well marked. Adfrontal area with no specific colouration. Frontoclypeous long and narrow. Distinct six semicircular stemmata present. Stemmata 1 to 4 were bigger in size. Fifth stemmata present at the base of the antenna and sixth behind fourth stemmata. Frontal group unisetose with F1 and pore Fa. Fa present near median longitudinal line, anteromesad to F1. Clypeal group bisetose with C1 and C2. C1 longer than C2. Adfrontal group bisetose with seta AF1 and AF2 of same length. AF2 dorsad to AF1. Anterior group with setae A1, A2 and A3. A1 ventral to A2. A2 posterior in straight line with A1. A3 behind stemmata two. Postero dorsal group bisetose with P1 and P2. P2 longer than P1. P1 antero dorsad to P2. Lateral group unisetose with L1. L1 posterolaterad to P1 (Fig. 6). Stemmatal area with trisetose. S1 posterolaterad to stemmata 1. S2 behind stemmata two. Setae S3 ventral to stemmata six (Fig.7).

Thorax: T1: Prothoracic shield weakly sclerotized, olive green with reddish brown anterior margin. Prothoracic shield with six setae namely XD1, XD2, D1, D2, SD1 and SD2. XD group present in the anterior margin of the shield. XD1 longer than XD2. XD2 ventral to XD1. XD1 antero lateral to D1. Dorsal group with setae D1 and D2. D1 dorsad to D2. D2 longer than D1. D1 and SD2 spatulate. SD1 longer than SD2. SD1 anterolateral to SD2. Lateral group trisetose with setae L1, L2 and L3. L1>L2>L3 lengthwise. L1 ventral to L2. L2 anterolateral to L3. SV group with SV1 and SV2 setae. SV2 shorter than SV1 (Fig. 8). T2 and T3: Dorsal group bisetose with D1 and D2. D1 spatulate and shorter than D2. Subdorsal group bisetose on the same pinaculum. SD1 longer than SD2. SD2 spatulate and posteriorly laterad to SD1. Lateral group trisetose with L1, L2 and L3 setae on same pinaculum. L3 spatulate and smaller than L2 and L1. L2>L1>L3 lengthwise. Subventral group bisetose, SV1 longer than SV2 (Fig. 8).

Abdomen: A1: Dorsal group bisetose and spatulate with D1 and D2 setae. D1 anterolaterad to D2. D1 shorter than D2. Subdorsal group spatulate with setae SD1 and SD2. SD2 posterolaterad to SD1. SD1 longer than SD2. Lateral group trisetose with L1, L2 on same pinaculum and L3 on separate pinaculum. L2>L3>L1 lengthwise. L1 dorsad to L2 and L3 ventral to L2. SV group bisetose with SV1 and SV2 setae. SV1 longer than SV2. SV1 anterolaterad to SV2 (Fig.9). A2: Setal arrangements similar as previous segment A1. Except subventral group. SV group trisetose with SV1, SV2 and SV3 setae. SV1>SV3>SV2 lengthwise (Fig. 9). A3 to A6: Dorsal group bisetose and spatulate. D1 anterolaterad to D2 on same pinaculum. Subdorsal group spatulate and bisetose with SD1 and SD2 setae on same pinaculum. Lateral group trisetose with setae L1, L2 and L3. L1 spatulate. L1 and L2 on same pinaculum and L3 on separate pinaculum. L2>L3>L1 lengthwise. L2 anterolaterad to L1. L3 ventral to L2. SV group trisetose on same pinaculum. SV1>SV3>SV2 lengthwise. SV1 ventral to L3 (Fig. 10). A7: Setal arrangements similar as previous segment A6. Except dorsal and subventral group. Dorsal group bisetose with D1 spatulate. D2 longer and postero ventrad to D1. Subventral group bisetose with SV1 and SV2 setae. SV1 longer than SV2 (Fig. 11). A8: Dorsal group bisetose with spatulate setae D1 and D2. D2 posterolaterad to D1. D2 longer than D1. SD1 spatulate, unisetose and dorsad to spiracle. Lateral group ventral to spiracle. L1 spatulate and anterolateral to L2. L2>L3>L1 lengthwise. SV group unisetose with SV1 (Fig. 11). A9:



Fig. 1. *Sphenarches anysodactylus* eggs

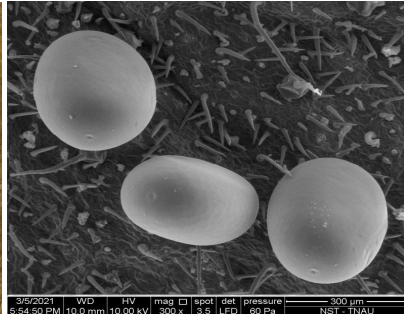


Fig. 2. Scanning electron microscope image showing eggs

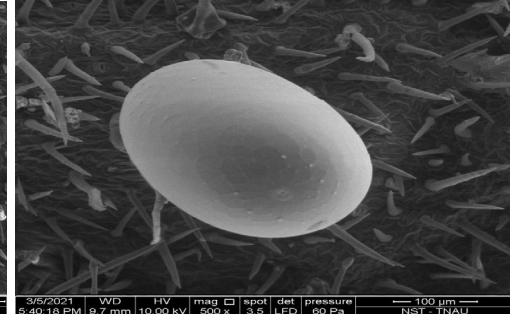


Fig. 3 Scanning electron microscope image showing egg chorion

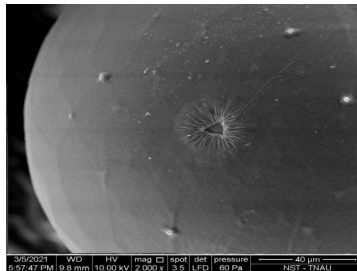


Fig. 4 Scanning electron microscope image showing egg chorion with mycophyle marking



Fig. 5 *S. anysodactylus* larva dorsal view

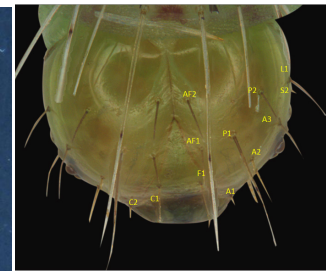


Fig. 6 Head dorsal view

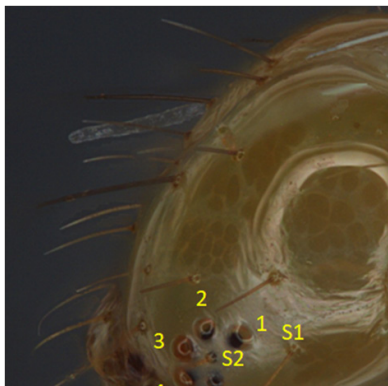


Fig. 7 Head lateral view

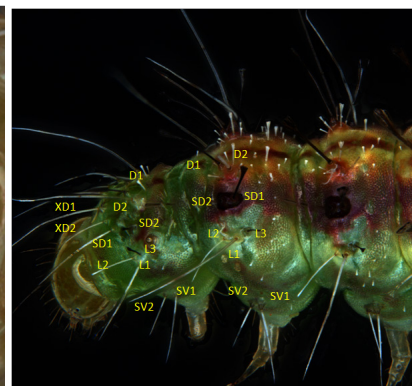


Fig. 8 Thorax lateral view T1, T2 and T3

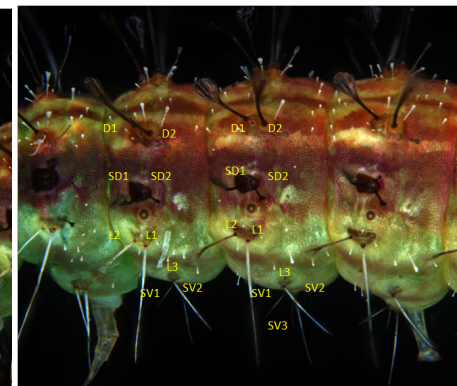


Fig. 9 Abdomen lateral view A1 and A2

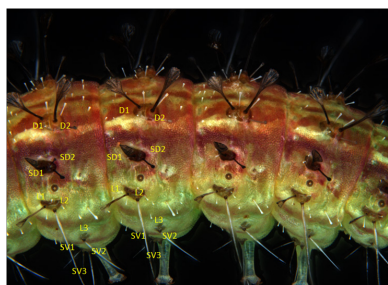


Fig. 10 Abdomen lateral view A3 to A6

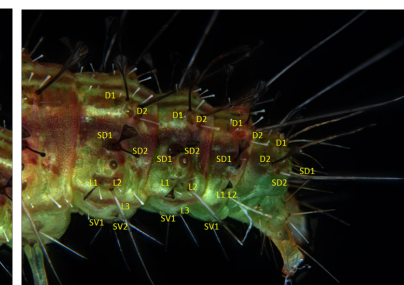


Fig. 11 Abdomen lateral view A7 to A10

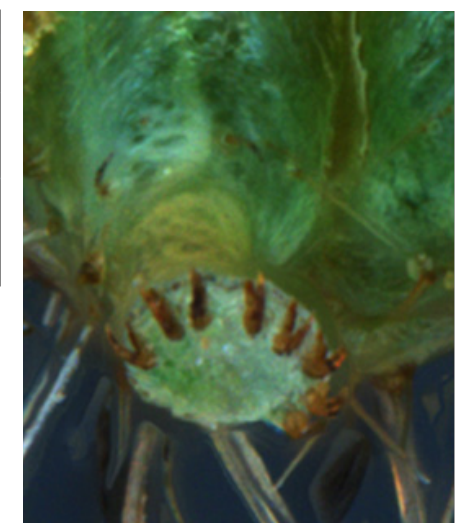


Fig. 12. Proleg crochets

Dorsal group bisetose on same pinaculum. D1 spatulate and shorter than D2. SD group bisetose. SD1 spatulate and ventral to D1. SD2 posterolateral to SD1. Lateral group bisetose with L1 spatulate. L2 longer than L1. Subventral group unisetose with SV1 setae. SV1 ventral to L2 (Fig. 11). A10: dorsal group bisetose with D1 and D2 on anterior margin of mid dorsal line. D1 spatulate

and anterolateral to D2. D2 longer than D1. Subdorsal group bisetose with SD1 and SD2. SD1 spatulate, shorter than SD2 (Fig. 11). Prolegs: Abdominal prolegs present on A3 to A6. Crochets reddish brown in colour. Incomplete uniordinal penellipse with eight crochets pointed outwardly (Fig. 12, 13). Anal prolegs present on A10 with seven to eight crochets. The larval chaetotaxy was in conformation with Cassani et al. (1990) and Yano (1963).

Pupa: Length 9.34 mm. Initially green, turns reddish brown before adult emergence. Body surface with fine hairs. Dorsal view: vertex serrate and pronotum sculptured. Pupa laterally lined with red dorsum. Prothorax semicircular shape with pair of dorsal setae; mesothorax with 12 dorsal seta along three ridges; metathorax M shaped with six long setae; meso thoracic segment larger than meta and prothoracic segments. Dorsal ridges present on the A1 to A8. Abdominal segment A1 with dorsal ridge forming strong dentate processes near anterior margin and minute processes in the middle; A2 and A3 similar in shape; A4 to A10 taper towards end (Fig. 14). Ventral view: frontoclypeal suture indistinct but clypeal area distinct and smooth. Maxillary palpi short. Labial palpi half the length of the prothoracic leg. Fore leg arises behind the lateral margin of eyes. Middle leg situated between lateral margins of foreleg and mesal margin of antenna. Hindleg ended on A5. Antenna ended before the hindleg. Hind wing concealed by forewing. Only A5-A10 segments visible ventrally. Genital opening slit-like, located in postero margin (A8 in female and on A9 in male) and surrounded by elevated tubercles. A10 covered with minute cremaster spines (Fig. 15). Lateral view: Eyes oval; forewing covering most parts of lateral thorax. Elevated dorsal ridges with two or three processes present on A1 to A8. Spiracle visible from A2 to A8. Spiracle round with yellowish brown outer margin and pale yellow peritreme (Fig. 16). The pupae of *S. anysodactylus* are similar to other allied genera *Procapperia pelecynthos* (Meyrick) and *Trichoptilus wahlbergi* (Zeller) (Yano, 1963). *S. anysodactylus* can be identified by the foreleg extending to distal end of antenna, large and small spinous projections on dorsum of abdomen (A3 to A7).

Adult: Male: Body length 8.9 mm and wingspan 12 to 17 mm (Fig. 17, 18). Head 1.3 mm length, 0.9 mm diameter; brown ochreous covered with brown scales; eyes semicircular; greyish black with brown scale. Paraocular area and paraocular suture parallel to eyes. Frontoclypeus subquadrate; separated from vertex by

transfrontal suture. Vertex wider than frontoclypeus and enclosed with pair of antennal sockets. Antenna filiform, brown laterally covered with black scales; 1.94 mm length. Maxillary palpi 0.65 mm length. Labial palpi 1.23 mm length; upwardly curved; three segmented; second and third segment almost equal in length (Fig. 19). Proboscis laterally covered with pale white scales. Thorax covered by brown ochreous scales.

Forewing upper side: two clefted, ochreous brown in color; first lobe basally ochreous brown, irrorated with yellowish white and black scales towards apex, distally falcate; second lobe basally ochreous brown, distally decorated by brown patch, apex distinctly excavate, scale tooth present on before apex. Forewing underside cinnamon brown with irregular pale yellow patch with black cilia. Hindwing upperside: three clefted, first and second lobe greyish brown, third lobe ochreous brown and scale tooth presents on apex, cilia long and greyish brown. Hindwing underside was identical to upperside. Wing venation: FW: Sc arises on basal sclerite; Sc ends before mid costa; R2 originate on apex of discal cell; R4 and R5 stalked on first cleft; M1 and M2 originate anterior and posterior margin of discal cell respectively; M3 and Cu1 stalked; Cu2 arises on anterior margin of discal cell; 1A ended near basal cleft. HW: Sc+R1 and Rs on first cleft. M1 and Cu1 stalked on second cleft. 1A and 2A on third cleft. Leg brown ochreous. Foreleg 3.34 mm length; dorsally covered by brown ochreous scales and ventrally black scales. Middle and hind leg with alternate pale yellow and brown patches. Middle leg 4.41 mm length with a pair of spine on caudal margin of tibia. Hind leg 5.66 mm length with two pairs of spines; one pair at mid tibia while another pair at tibial end; dark brown and white bands encircle the hind tibia, spurs dark brown and equal in length. Abdomen pale yellow with irregular brown ochreous patch on dorsal side.

Male genitalia: Uncus bilobed and rounded. Tegumen elongate and distally pointed. Valva broad, flap-like, proximal end rounded with dense setae. Vinculum sclerotized and well developed. Anellus arm slender and hooked (Fig. 20). Aedeagus slender, elongate, narrowing towards distal end. A curved and moderately sclerotised process with a slightly wider base present. Further, the broad basal end the membranous vesica ends in another weakly structure presumably another cornuti which is not straight rather wavy ending in a whip-like structure (Fig. 21). However, there is no mention of the cornuti in the study by Yano (1963) and Kovtunovich et al. (2014), Gielis and Wangdi (2018)

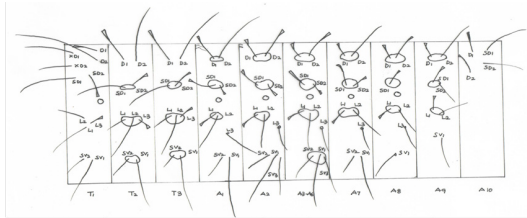
Fig. 13 Setal map of *Sphenarches anysodactylus*

Fig. 16 Pupa lateral view



Fig. 14 Pupa dorsal view



Fig. 15 Pupa ventral view



Fig. 17 Adult dorsal view



Fig. 18 Adult ventral view

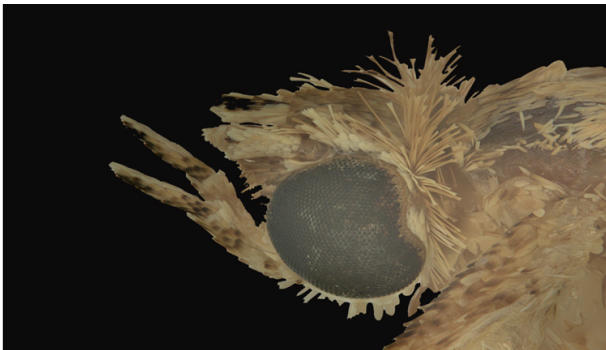


Fig. 19 Labial palpi

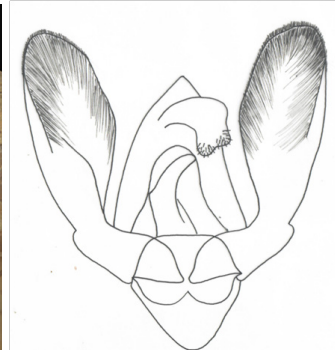


Fig. 20 Male genitalia

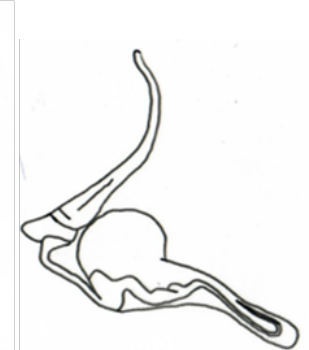


Fig. 21 Aedeagus

while Geils (1993, 2006) has mentioned the absence of cornuti in *S. anysodactylus* though the aforesaid structure is present in the line drawing. Female genitalia: Anal papillae with sclerotized band along anterior margin. Posterior apophysis long. Anterior apophysis absent. Tube-like antrum, anteriorly excavated. Ductus bursae narrow, slender and longer than corpus bursae. Corpus bursae balloon shaped with no distinct signum. However, minute spicules are dispersed throughout the corpus bursae and appeared more dense in a patch at lower part of corpus bursae (Fig. 22). This is in consonance with that of Geils (2006).

The mtCO1 sequence of *S. anysodactylus* from

Coimbatore was compared with eight reference sequences available in the National Center for Biotechnology Information (NCBI). The analysis revealed the presence of two major clusters viz., Africa (Madagascar and Kenya) and Australia. Indian population of *S. anysodactylus* (OP208233) submitted in this study was the first to be DNA barcoded from India; it was found to be similar to the six populations from Africa (97.55 to 98.37%) and two populations from Australia (97.52 to 97.70%) with differences in 10-15 sequences (Fig. 23).

Host records: *Brillantaisia lamium* (Acanthaceae), *Centratherum punctatum*, *Eupatorium betonicaeforme*

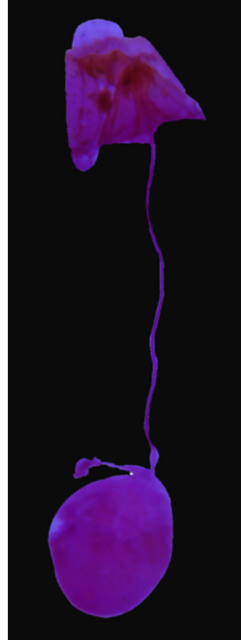


Fig. 22 Female genitalia

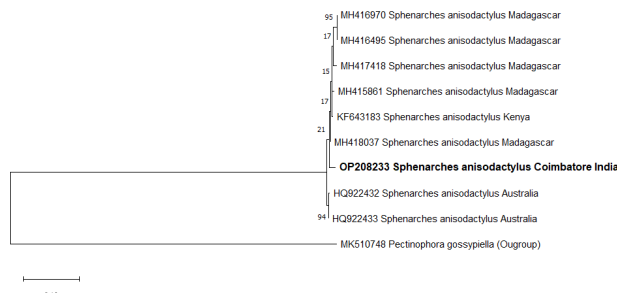


Fig. 23. Phylogenetic tree of *S. anysodactylus*

(Asteraceae), *Cajanus cajan*, *Dolichos labla*, *Mimosa pudica*, *Phaseolus vulgaris* (Fabaceae), *Cucurbita pepo*, *Lagenaria leucantha* var. *clavata*, *L. siceraria*, *L. leucantha* var. *gourda*, *L. vulgaris*, *Luffa aegyptiaca* (Cucurbitaceae), *Caperonia regales*, *C. castaneifolia* (Euphorbiaceae), *Geranium maculatum* (Geraniaceae), *Hibiscus mutabilis*, *Theobroma cacao* (Malvaceae), *Thalia gesniculata* (Marantaceae), *Averrhoa bilimbi*, *Biophytum sensitivum* (Oxalidaceae), *Passiflora foetida* (Passifloraceae), *Antirrhinum majus* (Plantaginaceae), *Lantana camara* (Verbenaceae) (Meyrick, 1886; Lefroy, 1909; Fletcher, 1914; Nickrent et al., 1988; Nair, 1975; Gielis, 1993, 2003; Matthews and Lott, 2005).

Distribution: Brazil, Cameroun, China, Dominica, Ethiopia, Gambia, Ghana, Grenada, Guadeloupe, Guam, Guinea, India, Indonesia, Ivory Coast, Japan, Kenya, Madagascar, Malawi, Malaysia, Nepal, New Caledonia, New Guinea, New Hebrides, The Bismarck Islands, The Bonin Islands, The Fiji Islands, Nigeria, Palau, Panama, Paraguay, Peru, Puerto Rico, Reunion

Island, Seychelles, The Solomon Islands, Sri Lanka, St. Thomas, Swaziland, Taiwan, Tanzania, Thailand, Tonga Islands, U.S.A., Vietnam, Virgin Islands, Zaire (Meyrick, 1886; Lefroy, 1909; Fletcher, 1914; Makhan, 1994; Gielis, 2006; Matthews et al., 2012; Matthews and Lott, 2005).

Materials examined: India. Tamil Nadu, Coimbatore, TNAU, adult 10 ♂ 5 ♀: egg 6: larva 5: pupa 6: 6.iv.2022; Divya, R; Salem, adult 1♂ 1♀: larva 4: pupa 1; 28.iv.2022; Namakkal, adult 1♂ 1♀: larva 4: pupa 1; 23.vi.2022.

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AUTHOR CONTRIBUTION STATEMENT

R.D: Ph.D. undertook the research work: Insect collection, rearing and photographing the *Sphenarches anysodactylus*; drafting the manuscript. N.C: Advisor for the research work and for drafting the manuscript. V.B: Advisor for the research work and review the manuscript. R.A: Advisor for the research work and review the manuscript.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

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