Additional note on the genus *Archaeoattacus* Watson [*in* Packard], 1914: Description of a fourth species (Lepidoptera: Saturniidae, Saturniinae, Attacini)

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Abstract: A new species of the genus *Archaeoattacus* is described from Southern Vietnam: *Arch. **vietnamensis*** **n. sp.** The male holotype will be deposited in the collections of Museum für Naturkunde, Berlin, Germany; both holoytpe and female paratype ("allotype") are figured in colour. The nearest relative of this Southern Vietnamese endemic is shown to be the Himalayan *Arch. edwardsii* (White, 1859).

Key words: *Archaeoattacus*, new species, Southern Vietnam, DNA barcoding, endemic species.

Ergänzende Anmerkung zur Gattung *Archaeoattacus* Watson [*in* Packard], 1914: Beschreibung einer vierten Art (Lepidoptera: Saturniidae, Saturniinae, Attacini)

Zusammenfassung: Eine neue Art der Gattung *Archaeoattacus* wird aus dem südlichen Vietnam beschrieben: *Arch. **vietnamensis*** **n. sp.** Der männliche Holotypus wird in die Sammlung des Museums für Naturkunde, Berlin, Deutschland, gelangen; Holotypus und weiblicher Paratypus („Allotypus") werden in Farbe abgebildet. Als nächster Verwandter dieses südvietnamesischen Endemiten wird *Arch. edwardsii* (White, 1859) aus dem Himalya erkannt.

Introduction

The genus *Archaeoattacus* Watson [*in* Packard], 1914 contains some of the largest moths in the world, which are distributed from the Himalaya over all tropical parts of continental South East Asia, with one species also occuring on the Indonesian islands of Sumatra, Java and Borneo. It was extensively revised in a recent paper by Nässig et al. (2010), the same team of authors as here, with illustrations of all types of the genus as well as a literature overview. Since this publication, we obtained additional material and in particular a series of specimens from Southern Vietnam. The study of these specimens revealed constant morphological differences and consistent genetic divergence between these and representatives of *Arch. malayanus* Kurosawa & Kishida, 1984, a species whose populations encircle the Southern Vietnamese population.

In our 2010 study, we had proposed several consistent characters separating the Himalayan *Arch. edwardsii* (White, 1859) from *Arch. malayanus* (and of course, also from the externally very distinct *Arch. staudingeri* (Rothschild, 1895)); these are consistently supported by the addition of new material made available to us in the meantime. Because details of the other species in the genus were thoroughly presented in our earlier work, we focus here on the description of a new species for the Southern Vietnamese population, for which we provide a detailed account of differences to its nearest relatives.

Abbreviations

CSLL	Collection Swen Löffler, Lichtenstein/Sachsen, Germany.
CSNB	Collection Stefan Naumann, Berlin, Germany; part of the Rainer Seegers Foundation, to be incorporated in the collections of ZMHU.
CWAN	Collection Wolfgang A. Nässig, incorporated in SMFL.
MNHN	Muséum national d'Histoire naturelle, Paris, France.
SMFL	Senckenberg-Museum, Lepidoptera collection, Frankfurt am Main, Germany.
ZMHU	Museum für Naturkunde, Berlin (formerly Zoologisches Museum der Humboldt-Universität), Germany.

The new species

*Archaeoattacus **vietnamensis*** n. sp.

Holotype ♂ (Figs. 1, 2): Vietnam (S), Lam Dong Prov., Di Linh, iv. 2015, leg. Dang Ngoc Van (CSNB). – A red holotype label will be added accordingly. The holotype will be deposited within the Rainer Seegers Foundation in the collections of ZMHU.

Paratypes (in total 24 ♂♂, 5 ♀♀ with following data) (Figs. 3, 4: ♀ paratype ["allotype"]), all S. Vietnam: **Lam Dong Prov.:** 4 ♂♂, 1 ♀ [♀ "allotype"], same data as holotype, 1 ♂ with genitalia no. 2494/16 SNB (CSNB). 1 ♀, Dalat env., Bidoup, v. 2013, leg. Nguyen; barcode SNB 5166 (CSNB). 2 ♂♂, 1 ♀, same locality and collector, v. 2014 (CSNB). 1 ♂, 1 ♀, Da Lat, iii. 2016, leg. Van (CSNB). 2 ♂♂, Bidoup Nui Ba Nat. Park, Lac Duong, 10. + 15. ii. 2015, leg. Nhon (CSNB). 4 ♂♂, Bidoup Nui Ba Nat. Park, 1× 25. ii. 2016, 3× 8. iii. 2016, leg. Nhon (CSNB). 1 ♂, Bhu Son, Lam Ha, 1320 m, Regenwald, 11°55.079′ N, 108°10.711′ E, 10./11. vii. 2002, leg. M. Hoffmann & S. Löffler (CSLL). 1 ♂, Gebirgspaß Phu Mi, Bhu Son, Lam Ha, 27.–29. iv. 2003, leg. Hoa Binh Nguyen (CSLL). – **Khanh Hoa Prov.:** 1 ♂, Nui Ba N.P., Bidoup Mt., 1600 m, iv. 2014, leg. Le Luong Thanh, barcode SNB 5473 (CSNB). – **Quang Ngai Prov.:** 3 ♂♂, 1 ♀, Bato Mt., 950 m, iv. 2014, leg. Le Luong Thanh, 1 ♂ with barcode SNB 5726

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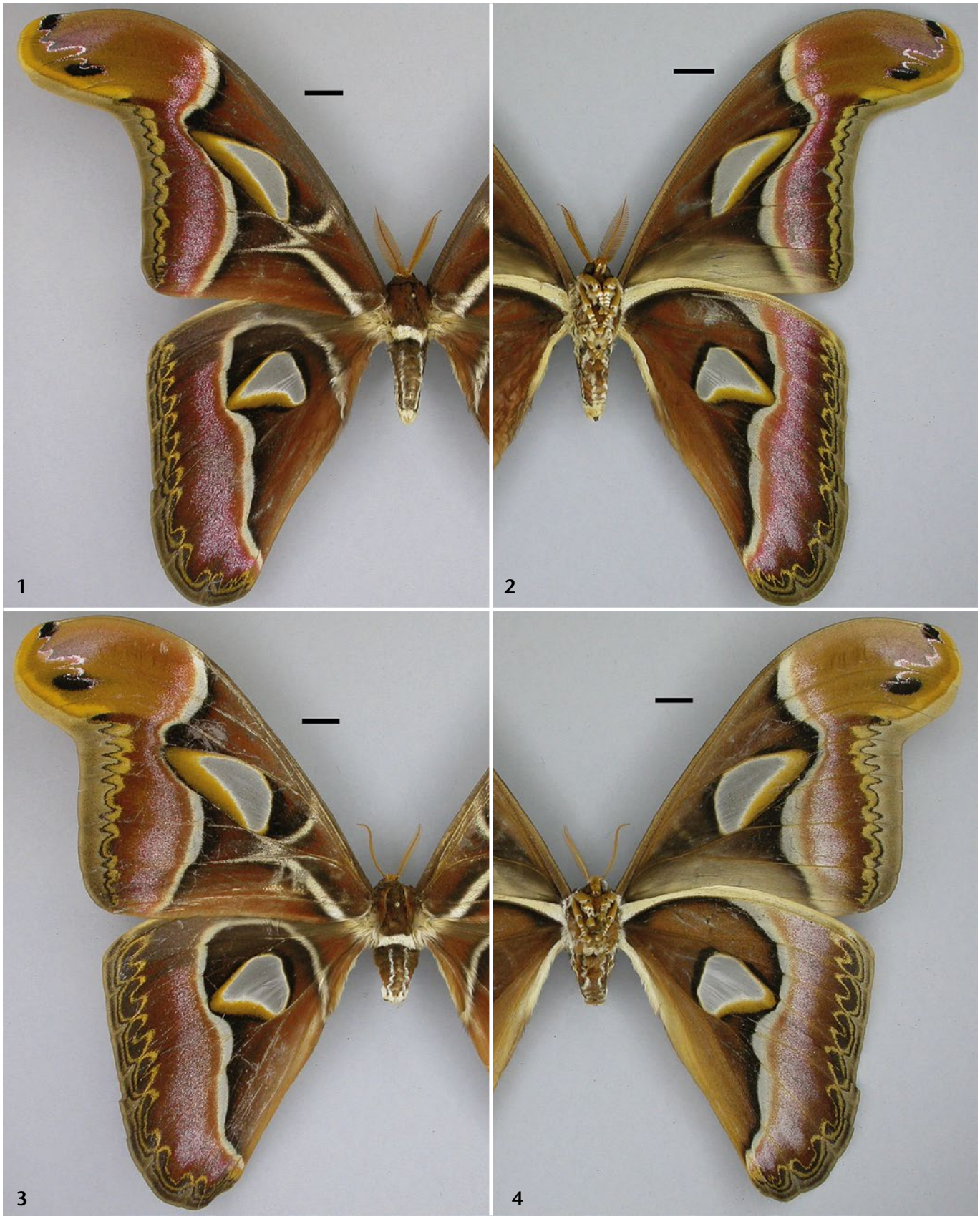
[2] 87th contribution to the knowledge of the Saturniidae. (86th contribution: Nässig, W. A., Naumann, S., & Oberprieler, R. O. (2015): Notes on the Saturniidae of the Arabian Peninsula, with description of a new species (Lepidoptera: Saturniidae). – Nachrichten des Entomologischen Vereins Apollo, Frankfurt am Main, N.F. **36** (1): 31–38.)

and genitalia no. 2495/16 SNB (CSNB). 1 ♂, same locality and collector, IX. 2014 (CSNB). 1 ♂, same locality and collector, II. 2015 (CSNB). 1 ♂, same locality and collector, III. 2015 (CSNB). – **Quang Nam Prov.:** 1 ♂, Plato Tay Nguyen, Mt. Ngoc Linh, 15°2′ N, 107°59′ E, 900–1400 m, 10.–25. VIII. 1996, leg. SINIAEV & AFONIN (CWAN in SMFL). – Vietnam (C), **Da Nang Prov.:** 1 ♂, Ba Na Mt., 850 m, III. 2014, leg. Le Luong THANH; barcode SNB 5474 (CSNB). – Blue paratype labels wil be added accordingly. Some of the paratypes ex CSNB will be deposited in SMFL and MNHN.



Figs. 1–4: Specimens of *Archaeoattacus vietnamensis* n. sp. **Figs. 1–2:** ♂ holotype, (**1**) dorsal view, (**2**) ventral view, Vietnam (S), Lam Dong prov., Di Linh. **Figs. 3–4:** ♀ paratype ("allotype"), (**3**) dorsal view, (**4**) ventral view, dorsal view, Vietnam (S), Lam Dong prov., Dalat env. – Scale bar = 1 cm, i.e., approx. 70% natural size. – All photos S.N.

Derivatio nominis: The endemic species is named for its geographical origin, the country of Vietnam.

Diagnosis and description

Diagnosis: *Arch. vietnamensis* n. sp. is defined by the combination of its intense chestnut brown colouration, the long rounded forewing fenestra, and details in male genitalia morphology. Its distinction as a separate species is also well-supported by the analysis of mtDNA barcode sequences.

Male (Figs. 1–2, holotype): Ground colour on dorsal side chestnut brown. Antennae quadripectinate, 18–18.5 mm long, longest rami 2.9 mm. Head, dorsal parts of thorax and abdomen in ground colour, thorax and abdomen separated by white band of long hair, abdomen with 2 dorsolateral longitudinal white lines and intersegmental white stripes. Anal tuft white. Forewing length, measured from base to tip of apex, 105–115 mm (holotype 110 mm). Costa dark grey, antemedian area in ground colour, suffused with black scales to the broad white antemedian line in the lower parts. The median area completely in ground colour, with a triangular fenestra of 21–26 mm in its maximum dimension, slightly rounded on its costal margin, surrounded with black mainly in the proximal and lower parts of the wing. The hyaline part is bordered by thin white line and broader yellow margin, broadest to the marginal area. Postmedian line S-shaped, white, in the costal half almost connected with the tip of the fenestra. It is followed by a violet portion suffused with white scales in the centre, and in the lower marginal area by a creamy yellow band, separated by a black zigzag line from the ochreous marginal area. The apex very elongated, rounded, of creamy orange and pink colour, with a black apical and a black subapical dot, both connected by a thin white line. Marginal area yellow. Hindwing 78–85 mm (holotype 85 mm) maximum length, of same colouration as forewing, but both antemedian and postmedian lines connected in one curvature, median area covered densely with black scales. Fenestrae triangular, drop-like, 14–17 mm maximum length. A row of black dots in the postmedian area, just in front of the marginal line. Marginal area with a dark grey to black submarginal line and fainted yellow outer margin.

Ventral side with same ornamentation and colour, except for missing antemedian lines on both the fore- and hindwings; hindwing costal margin and central anal margin broad white. Thorax and abdomen in ground colour, but legs of greyish ochreous colour.

Male genitalia (Fig. 5): Uncus with broad base, two long lateral processes. Apex of the valve rounded, elongated, ventral process of the valve knob-like, short. The saccus long and slender, juxta broad, round, with medial curvature. The vesica emerges on left lateral side from the 6.0 to 6.5 mm long phallus, vesica about 2.8 mm long, almost one bulb with a very small dorsal projection near to the distal margin of the phallus.

Female (Figs. 3, 4 paratype [“allotype”]): Aside from typical saturniid sexual dimorphism in size and shape, female specimens closely resemble the males. Antennae quadripectinate with shorter rami, 16–17.5 mm long, longest rami 1.9 mm. Wings much broader and of larger surface, forewing length, measured from base to tip of apex, 112–117 mm, hindwing length 86–93 mm. In accordance to the larger wing surface, the fenestrae are also larger and more rounded.

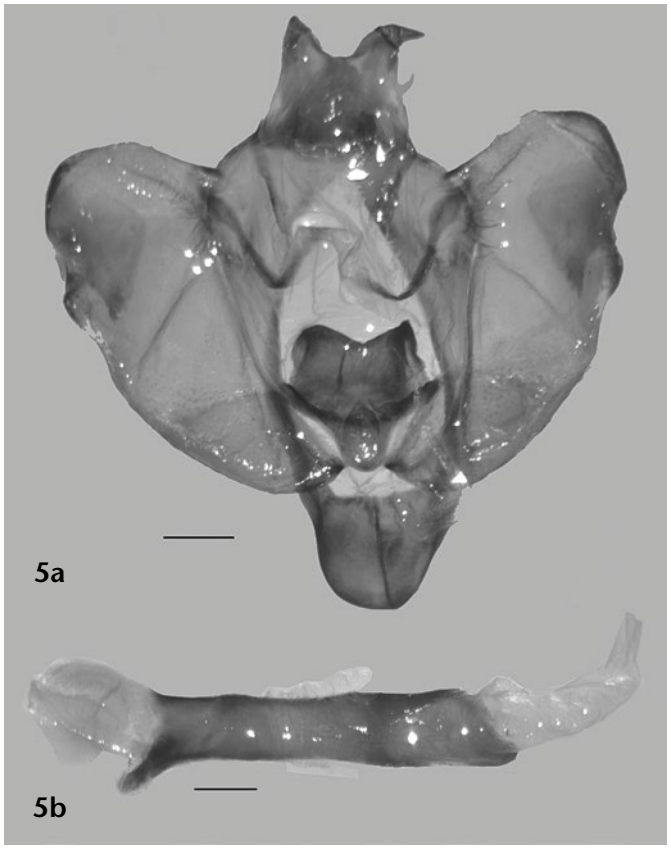


Fig. 5: ♂ genitalia of *Arch. vietnam*ensis n. sp., paratype, genitalia no. 2495/16 Naumann. **5a:** genitalia, **5b:** phallus. — Scale bars = 1 mm, not exactly to the same scale.

Morphological evidence

Arch. vietnamensis n. sp. shows many similarities with Himalayan specimens of *Arch. edwardsii,* but generally is more colourful contrasting and always has a rounded costal margin of the forewing fenestra. As pointed out by Nässig et al. (2010), differences in male genitalia morphology between species in the genus are generally subtle. It is not surprising then that *Arch. vietnamensis* only shows slight differences as well in male genitalia structures when compared to its congeners. As expected, genitalia are most similar to those of *Arch. edwardsii,* but they can easily be separated from those of *Arch. malayanus* and *Arch. staudingeri* by the larger size, broad-based uncus, the more rounded valve apex, the reduced, knob-like ventral process of the valve, and finally the longer phallus with a slender vesica and almost no dorso-proximal expansion. The structures of *Arch. edwardsii* are somewhat larger and the valves are more rounded than in *Arch. vietnamensis*.

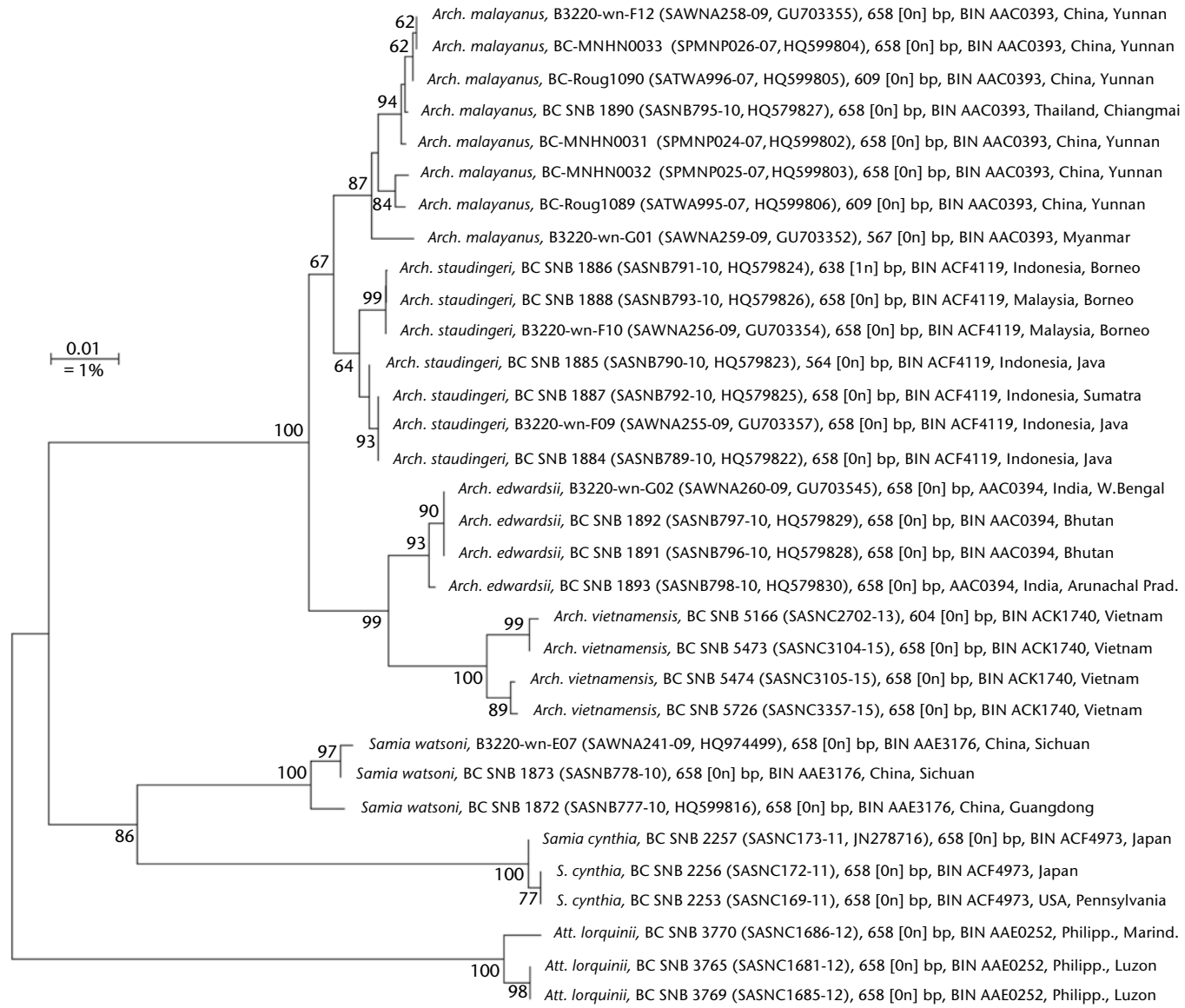


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Fig. 6: NJ-Tree (cf. Saitou & Nei 1987) of the 4 species of *Archaeoattacus* in SE Asia; as an outgroup we used 6 specimens of two species of the closely related genus *Samia* and 3 specimens of *Attacus,* which is a genus more distantly related within Attacini. In total, 32 nucleotid sequences = specimens were used. For details, see Table 1. The optimal tree with the sum of branch length = 0.31872756 was computed with Mega5 (Tamura et al. 2011). The percentage of replicate trees in which the associated taxa clustered together in the bootstrap test (1000 replicates) are shown next to the branches (Felsenstein 1985); only values above 60% are shown. Evolutionary distances were computed using the Maximum Composite Likelihood method (Tamura et al. 2004).

Results of DNA barcode analysis

In our previous study of the genus *Archaeoattacus* (Näss ig et al. 2010), the analysis of DNA barcodes (a short fragment of mitochondrial DNA used as standard marker for species identification in animals) consistently supported the distinction of the three species also delineated through a traditional comparative morphology study. Here, the newly described fourth species *Arch. vietnamensis* is also unequivocally distinguished from all other species within the genus by its DNA barcodes (see Fig. 6). These were obtained using standard laboratory protocols (see Decaëns & Rougerie 2008) for four specimens of the new species. Their comparison with sequences from our previous study revealed an average and maximum genetic distance (uncorrected p-distance) within the species of 0.74% and 1.17%, respectively; distance to nearest neighbour (*Arch. edwardsii*) is 2.57%. All sequences and specimen data are publicly available within dataset DS-ARCH01 on BOLD (www. boldsystems. org); sequences are also deposited in GenBank (accession numbers not yet completely available at the time of publication). For the specimens used in the barcode comparison, see Fig. 6 and Table 1.

Discussion

The distribution pattern (Fig. 7) of the genus *Archaeoattacus* is somewhat surprising, compared with the morphological and molecular aspects found during our studies. While the two most morphologically different species, *Arch. staudingeri* and *Arch. malayanus*, revealed a sur-

Table 1: Data of the specimens used for the DNA barcoding; specimens arranged from top to bottom in the order of the NJ-tree graph (Fig. 6). — Abbreviations: GBAC = GenBank Access Code; PT = paratype; SL = Sequence Length (data from BOLD); — = GBAC not yet available. BIN = Barcode Index Number; an automatically assigned identifier for genetic clusters within BOLD, see RATNASINGHAM & HEBERT (2013).

Sample ID	Process ID	GBAC	Species/BOLD BIN-Code	Deposit.	SL	Sex	Origin
B3220-wn-F12	SAWNA258-09	GU703355	*Arch. malayanus*/AAC0393	SMFL	658[0n]bp	♂	China, Yunnan
BC-MNHN0033	SPMNP026-07	HQ599804	*Arch. malayanus*/AAC0393	MNHN	658[0n]bp	♂	China, Yunnan
BC-Roug1090	SATWA996-07	HQ599805	*Arch. malayanus*/AAC0393	MNHN	609[0n]bp	♂	China, Yunnan
BC SNB 1890	SASNB795-10	HQ579827	*Arch. malayanus*/AAC0393	CSNB	658[0n]bp	♂	Thailand, Chiangmai
BC-MNHN0031	SPMNP024-07	HQ599802	*Arch. malayanus*/AAC0393	MNHN	658[0n]bp	♂	China, Yunnan
BC-MNHN0032	SPMNP025-07	HQ599803	*Arch. malayanus*/AAC0393	MNHN	658[0n]bp	♂	China, Yunnan
BC-Roug1089	SATWA995-07	HQ599806	*Arch. malayanus*/AAC0393	MNHN	609[0n]bp	♀	China, Yunnan
B3220-wn-G01	SAWNA259-09	GU703352	*Arch. malayanus*/AAC0393	SMFL	567[0n]bp	♂	Myanmar, Kachin
BC SNB 1886	SASNB791-10	HQ579824	*Arch. staudingeri*/ACF4119	CSNB	638[1n]bp	♂	Indonesia, Borneo (Kalimantan Tengah)
BC SNB 1888	SASNB793-10	HQ579826	*Arch. staudingeri*/ACF4119	CSNB	658[0n]bp	♀	Malaysia, Borneo (Sabah)
B3220-wn-F10	SAWNA256-09	GU703354	*Arch. staudingeri*/ACF4119	SMFL	658[0n]bp	♂	Malaysia, Borneo (Sabah)
BC SNB 1885	SASNB790-10	HQ579823	*Arch. staudingeri*/ACF4119	CSNB	564[0n]bp	♂	Indonesia, East Java
BC SNB 1887	SASNB792-10	HQ579825	*Arch. staudingeri*/ACF4119	CSNB	658[0n]bp	♂	Indonesia, Sumatera Barat
B3220-wn-F09	SAWNA255-09	GU703357	*Arch. staudingeri*/ACF4119	SMFL	658[0n]bp	♂	Indonesia, Java
BC SNB 1884	SASNB789-10	HQ579822	*Arch. staudingeri*/ACF4119	CSNB	658[0n]bp	♀	Indonesia, East Java
B3220-wn-G02	SAWNA260-09	GU703545	*Arch. edwardsii*/AAC0394	SMFL	658[0n]bp	♂	India, West Bengal
BC SNB 1892	SASNB797-10	HQ579829	*Arch. edwardsii*/AAC0394	CSNB	658[0n]bp	♀	Bhutan
BC SNB 1891	SASNB796-10	HQ579828	*Arch. edwardsii*/AAC0394	CSNB	658[0n]bp	♂	Bhutan
BC SNB 1893	SASNB798-10	HQ579830	*Arch. edwardsii*/AAC0394	CSNB	658[0n]bp	♂	India, Arunachal Pradesh
BC SNB 5166	SASNC2702-13	–	*Arch. vietnamensis*/ACK1740 (**PT**)	CSNB	604[0n]bp	♀	Vietnam, Lam Dong
BC SNB 5473	SASNC3104-15	–	*Arch. vietnamensis*/ACK1740 (**PT**)	CSNB	658[0n]bp	♂	Vietnam, Khanh Hoa
BC SNB 5474	SASNC3105-15	–	*Arch. vietnamensis*/ACK1740 (**PT**)	CSNB	658[0n]bp	♂	Vietnam, Da Nang
BC SNB 5726	SASNC3357-15	–	*Arch. vietnamensis*/ACK1740 (**PT**)	CSNB	658[0n]bp	♂	Vietnam, Quang Ngai
B3220-wn-E07	SAWNA241-09	HQ974499	*Samia watsoni*/AAE3176	SMFL	658[0n]bp	♂	China, Sichuan
BC SNB 1873	SASNB778-10	–	*Samia watsoni*/AAE3176	CSNB	658[0n]bp	♂	China, Sichuan
BC SNB 1872	SASNB777-10	HQ599816	*Samia watsoni*/AAE3176	CSNB	658[0n]bp	♂	China, Guangdong
BC SNB 2257	SASNC173-11	JN278716	*Samia cynthia*/ACF4973	CSNB	658[0n]bp	♂	Japan
BC SNB 2256	SASNC172-11	–	*Samia cynthia*/ACF4973	CSNB	658[0n]bp	♀	Japan, Hokkaido
BC SNB 2253	SASNC169-11	–	*Samia cynthia*/ACF4973	CSNB	658[0n]bp	♀	USA, Pennsylvania [*sic*]
BC SNB 3770	SASNC1686-12	–	*Attacus lorquinii*/AAE0252	CSNB	658[0n]bp	♂	Philippines, Marinduque
BC SNB 3765	SASNC1681-12	–	*Attacus lorquinii*/AAE0252	CSNB	658[0n]bp	♂	Philippines, Luzon
BC SNB 3769	SASNC1685-12	–	*Attacus lorquinii*/AAE0252	CSNB	658[0n]bp	♂	Philippines, Luzon

prisingly low level of genetic divergence (as low as 1.4%, see NÄSSIG et al. 2010) between them, we report here a higher genetic distance (more than 2.5%) between *Arch. edwardsii* and *Arch. vietnamensis,* two species widely separated by their geographical distribution, but hardly distinguishable by their morphology. Interestingly, we note that there is some morphological variation in series of *Arch. malayanus,* with specimens resembling more *Arch. edwardsii* and *Arch. vietnamensis* in populations further away from the Himalaya or Southern Vietnam. Specimens of *Arch. malayanus* from Northern Vietnam look quite distinct to their Southern Vietnamese relatives, being of much darker, sometimes blackish colour, and there, in the North, they have slender, almost triangular forewing fenestrae with a typical angle on the costal margin (compared to rounded, broad ones in *Arch. vietnamensis*). A similar situation is found with specimens of *Arch. malayanus* from South Laos. Furthermore, we note that the white streaks of the fenestrae, proposed by KUROSAWA & KISHIDA (1984) as a diagnostic character for *Arch. malayanus* when not reaching the postmedian line, proved inconsistent when examined in series of specimens for the species, and thus cannot be considered a diagnostic character for *Arch. malayanus.*

The situation with occurence of two different species in Himalayan and in continental South East Asia was observed now in some other Saturniidae genera as well, e.g. for *Saturnia (Rinaca) zuleika* HOPE, 1843 with its counterpart *S. (R.) lesoudieri* LE MOULT, 1933 (NAUMANN & NÄSSIG 2010) or for *Antheraea compta* ROTHSCHILD, 1899 with its Himalayan counterpart *A. discata* NAUMANN & LÖFFLER, 2015.

In the description of another Southern Vietnamese Attacini representative, *Samia vuvanlieni* NAUMANN et al.,

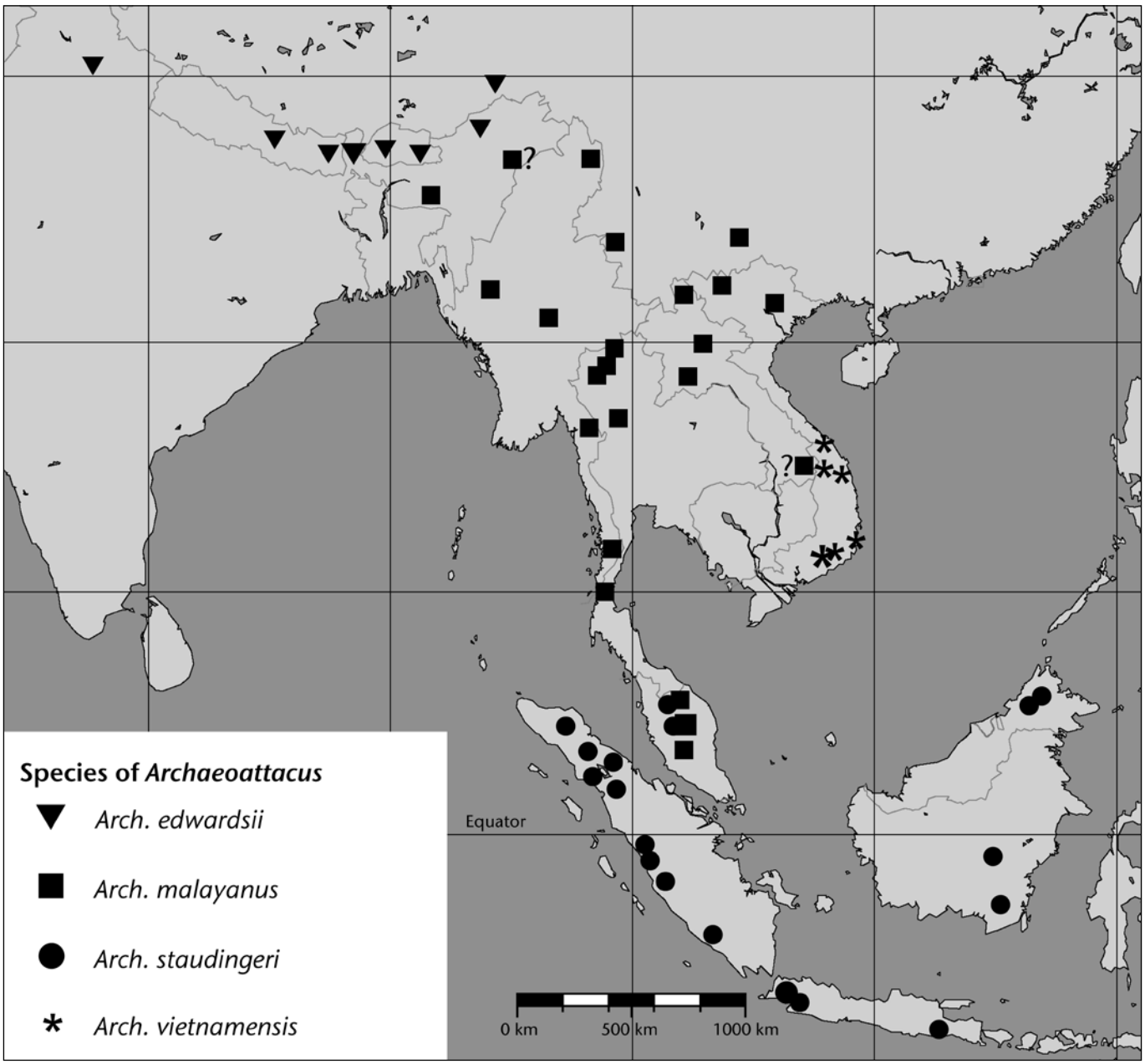

Fig. 7: Distribution data of the 4 species of *Archaeoattacus* in SE Asia; from Nässig et al. (2010), modified. Symbols may represent more than one locality in close proximity; not all places were located on maps. Symbols of type localities enlarged. Localities with "**?**" mean that the specimens have not yet been successfully identified by barcode analysis or the locality is based on a photograph only (*Ar. malayanus* in southern Arunachal Pradesh); two dubious localities of *Arch. malayanus* and *Arch. staudingeri* illustrated for Borneo in 2010 have been omitted because they could not be positively reconfirmed. Data compilation mainly like in 2010, except for new material from C. and S. Vietnam. — Map base from OMC, Martin Weinelt (www.aquarius.geomar.de/omc/, downloaded on 23. v. 2006; this address is no longer in existence).

2014, the authors gave some notes on the distribution of this taxon in Southern and Central Vietnam; there are some similarities with the species described here, although, in *Archaeoattacus,* specimens from Southern Laos habitually belong to *Arch. malayanus,* not to the new species; a successful barcode was not yet achieved of this population.

The distribution map shown in our first work on *Archaeoattacus* (Nässig et al. 2010: 42) still shows a black square for the then single record from Southern Vietnam, which by now has to be corrected. So far no further specimens in museum collections are known to us, and also in older literature (e.g., de Joannis 1929) no data were mentioned which could be allied to the here described taxon.

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