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A new Andean element in the lepidopterous fauna of the Guiana Shield:
the day-flying genus *Erateina* DOUBLEDAY, with the description of two
new species from Roraima, Tramen and Auyán Tepui
(Geometridae: Larentiinae)

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ABSTRACT. Two new species of diurnal moths of the genus *Erateina* (Geometridae, Larentiinae) are described from the table mountains of the Guiana Shield in the SE Venezuela. The genus is species rich, with 85 described and over 200 recognized species, but was so far known only from the Andes and the mountains of Costa Rica and Panama. This report extends considerably its range and is another contribution to the knowledge of the fauna of Guiana Shield, one of the most important mountainous areas for biodiversity conservation on the global scale because of its isolation and endemism.

Key words: entomology, taxonomy, Andes, *Erateina puellaastuta* n. sp., *Erateina kuczynskii* n. sp., faunal affinities, geometrid moths, male and female genitalia, new species, Venezuela

INTRODUCTION

GUIANA HIGHLANDS BIOGEOGRAPHICAL AREA

The Guiana Shield is an area of tabletop mountains, called *tepui* in the Pemón language, extending on about 1.2 million km² in southern Venezuela and the adjacent border regions of Brazil and the Guyana, comprising the world's oldest pre-Cambrian formation. Its most impressive features are the numerous, more or less eroded, vertical cliffs of pink sandstones rising abruptly above the surrounding plains and reaching an elevation of 2800 m above sea level. The tertiary was a period of violent rock erosion, leaving a characteristic steepness of the tepuis (MAYR & PHELPS 1967).

The fauna and flora of the Pantepui (a term proposed by MAYR and PHELPS in 1955) has been of high interest to biologists, and biogeographers in particular, for over a hundred years because of its geological origins, geographic isolation and the presence of a number of endemic taxa. Within the Pantepui, 60% of the vascular plant species and 87% of the frog species are endemics, often to a single tepui summit (BERRY & RIINA 2005; McDIARMID & DONNELLY 2005). The origins of the cloud forest faunas of the Guiana Shield is a long debated issue confronting the vicarianists and the dispersalists. The former argue that the endemic faunas of Pantepui are old relict elements proving of distant, sometimes intercontinental Gondwanian or pre-Andean common origins, and the long dated speciation in isolation (GIVNISH *et al.* 2004; DE MARMELS *et al.* 2007). It is called the “Lost World” hypothesis (RULL 2004), after the novel “The Lost World” by Arthur Conan Doyle. Many studies have suggested that vicariance alone cannot explain the current distribution of highland vascular plants (HUBER 1988; GIVNISH *et al.* 1997), birds (MAYR & PHELPS 1967) nor ants (JAFFE *et al.* 1993). The dispersalists point out the similarities of the Pantepui endemics with other neotropical species and suggest they migrated to the mountainous areas of the Pantepui through dispersal during the Pleistocene. Many endemic montane bird species of the Pantepui are closely related to species occurring in the lowlands of the Amazon basin (MAYR & PHELPS 1967). They evolved in the process of vertical habitat shifts and subsequent adaptations to higher elevation ecological conditions and local radiation (BRAUN *et al.* 2005). Following the theories of island biogeography, dispersalist biogeographers interpret the affinities of isolated continental mountain areas as a result of biotic exchange of faunal elements, e.g., overcoming ecological and topographical barriers by long distance dispersal (WHITTAKER & FERNÁNDEZ-PALACIOS 2007).

Some butterfly species occurring in the cloud forests of the Pantepui show morphological similarities with the species inhabiting other mountainous area of South America and in particular the Andes (VILORIA & PYRCZ 1994, 1999; PYRCZ & NEILD 1996; PYRCZ & FRATELLO 2005; PYRCZ 2010). Particular emphasis has been put on the strictly montane tribe Pronophilini with over 500 described species and further 100 identified, including two genera and 10 species endemic to the Pantepui.

THE GENUS *ERATEINA*

The genus *Erateina* DOUBLEDAY (1848) was described for five species, three of which from Venezuela and two from Bolivia, including *Erateina zoraida* DOUBLEDAY (type species, by original designation). The original description was extremely detailed but did not emphasize any distinctive characters of *Erateina* which made it very difficult to recognize from other genera of Geometridae known at the time. However, it is obvious that DOUBLEDAY identified *Erateina* as distinct first of all because of its peculiar wing shape characterized by the anal lobe of the males, and more or less elongated, caudate, hindwings. The genus has been little studied since FORBES (1917) who additionally underlined its lack of a frenulum (in both sexes). So far there has been no generic revision nor in the recent times, the genus was an object of phylogenetical analysis based either on morphology or molecular data. The systematic rank position

and hierarchical rank of *Erateina* is unstable. At some stage it was considered as a separate subfamily (GUENÉE 1858). In the most recent catalogue of Geometridae it is treated as a member of the subfamily Larentiinae (SCOBLE 1999).

VIIIDALEPP (2011) reviewed the Larentiinae and pointed out several typical characters of *Erateina*. He characterized the male genitalia of *Erateina punsaria* GUENÉE as having cidariine (meaning typical of the tribe Cidariini) genital capsule with the uncus finger-shaped, tegumen more slender than the vinculum, valva with large costa bordered against valvula by lacinia costalis, and a slightly projecting sacculus; a broad juxta between bases of sacculi, with sclerotized connections between juxta and hemitransstilla and short membranous papillae at base of hemitransstilla (*op. cit.*). Accordingly, the female genitalia are characteristically small sized with ostium sclerotized, ring-shaped, apophyses long and ovipositor papillae conical and strong. VIIIDALEPP (*op. cit.*) did not propose any position for the genus *Erateina* within the phylogeny of Larentiinae. Also, the relations between *Erateina* and the morphologically similar *Heterusia* HÜBNER are not resolved. Although *Heterusia* does not possess the hindwing anal fold, some species morphologically close to the type species of *Erateina* do not have it either. As stated by VIIIDALEPP (*op. cit.*), *Erateina* is most likely an aggregate of genera, and its monophyly lacks solid support. The type species of the genus, *Erateina zoraida* DOUBLEDAY, shares a number morphological characters with the new species described here, so that their placement appears to be unambiguous.

The genus is typically montane and is found in Neotropical cloud forests. It contains 85 described species (SCOBLE 1999) and well over 150 more identified as new but so far undescribed (PYRCZ, in prep.), which makes it by far the most diverse among day-flying moths in the world. Hitherto, *Erateina* was known almost exclusively from the Andes, apart from a couple of species occurring in the highlands of Mesoamerica in Costa Rica and Panama, all others were known from tropical Venezuela, Colombia, Ecuador, Peru and Bolivia. No species of *Erateina* was reported from other tropical mountainous regions of South America.

MATERIAL AND METHODS

Field work in the Guiana Shield and in the Andes of Venezuela was carried out by the first and second authors. Collecting of *Erateina* day-flying moths was carried out with standard entomological nets and with Van Someren – Rydon traps baited with carnivorous animal dung and carrion which proves to be an efficient bait attracting the males of this genus. Specimens were labelled in situ and georeferenced with GPS and these data were crossed checked with Google Earth.

Male and female genitalia were dissected according to standard procedures by soaking in a warm 10% KOH solution for 35 min., scales and internal organs were removed in distilled water; genital organs were stained with chlorazole black. Genital organs were preserved in glycerol vials, and examined, alongside other morphological microstructures, under an Olympus SZX9 stereomicroscope equipped with a Nikon DS-Fi1 digital camera. Adults were photographed with an Olympus E-500 digital camera, and colour plates were composed using Adobe PhotoShop 8.0 and

Combine Z. The following abbreviations were used: FW: forewing; HW: hindwing; V: ventral surface; D: dorsal surface.

Type and comparison material was examined in the following collections:

- BMNH: Natural History Museum (London, U.K.);
MIZA: Museo de Zoología de la Facultad de Agronomía, Universidad Central de Venezuela (Maracay, Venezuela);
MZUJ: Muzeum Zoologiczne Uniwersytetu Jagiellońskiego (Kraków, Poland);
MCC: collection of Mauro Costa (Caracas, Venezuela);
ZMHB: Zoologisches Museum, Humboldt Universität (Berlin, Germany);
ZSBS: Zoologisches Staatssammlung München (München, Germany).

RESULTS

Erateina puellaastuta PYRCZ & STACHOWICZ, n. sp.

(Figs. 1, 2, 7, 8)

MATERIAL EXAMINED

HOLOTYPE (female): Venezuela, Edo. Bolívar, Gran Sabana, Tramen Tepui, Third Plateau, 1860 m, 01.II.2012, I. Stachowicz leg., MZUJ (to be deposited in MIZA).

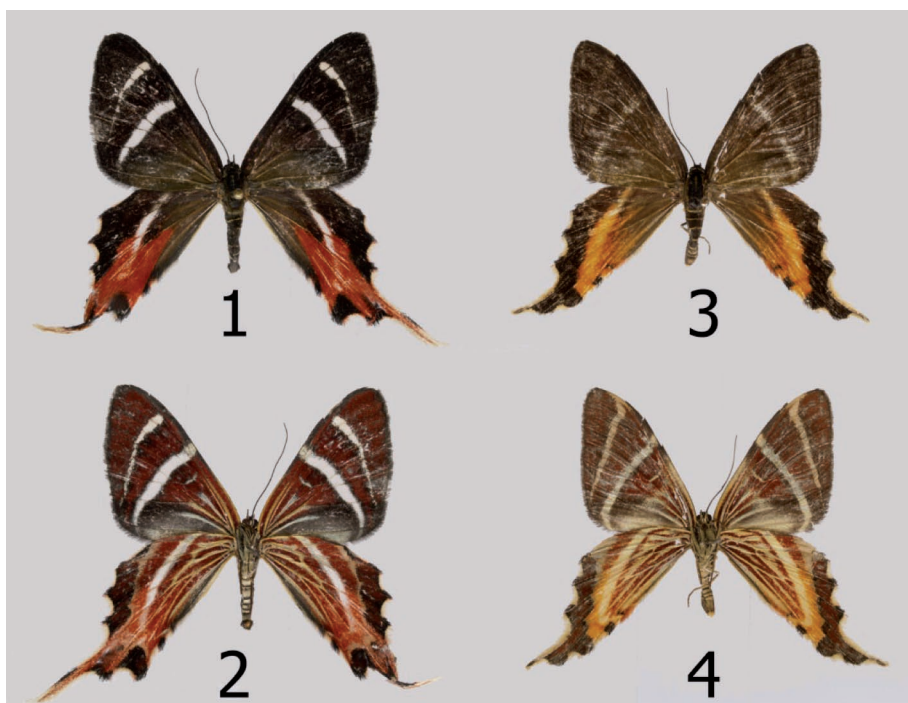
DIAGNOSIS

Recognized immediately from any other, invariably one-banded congeners, by two parallel FW whitish, semi-transparent bands.

DESCRIPTION

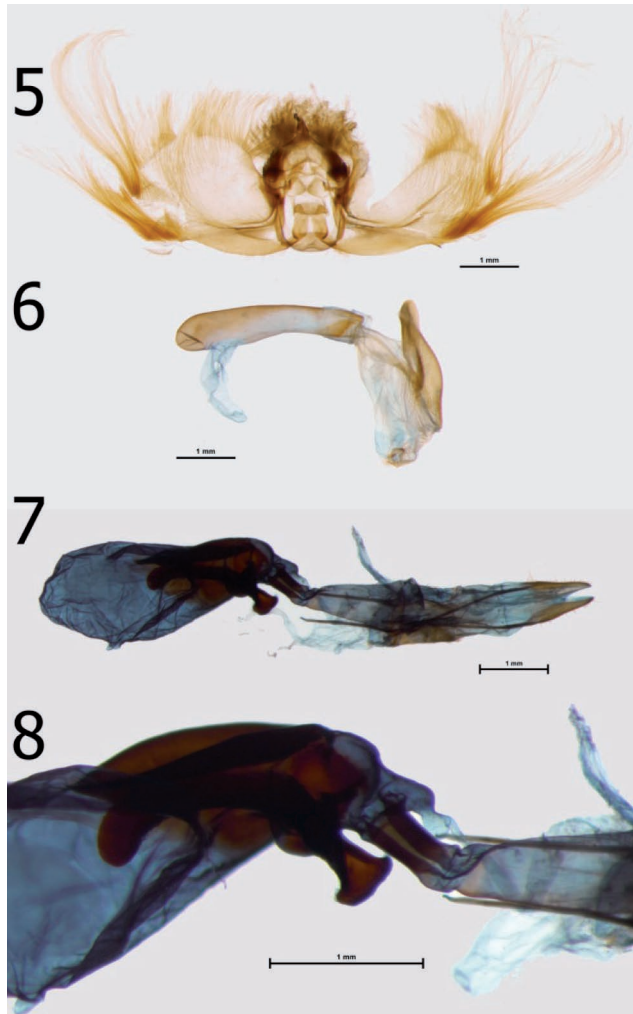
Female (Figs. 1, 2): Head: Eyes brown, lustrous, naked; frons black, bordered with white scales; antennae filamentous, black, hairy, some white scales on basal flagellomeres; a crest of dark grey and white scales at dorsal base of antennae; labial palpi porrect, first palpal segment densely covered with white scales, second and third laterally white, dorsally black; collar snow white, milky white and grey. Thorax: black with a mid-dorsal milky white oblong line; tegulae covered with long brown and milky white hair extending to base of abdomen; legs tibiae and femora covered with white scales and black, tarsi with brown scales; epiphysis on 1st leg reaching distal end of femur; two double spurs on 2nd and 3rd leg tibiae approximately 1/8 the length of tibiae each. Abdomen: dorsally and laterally covered with grey scales, with milky white thin ring at distal end of each segment, ventrally milky white. Wings: FW (length 22 mm) with a subacute apex, a straight outer margin, and a gently rounded tornus. HW elongated, with a scalloped outer margin, an anal notch at tornus, and an approximately 5 mm long, sharply ended tail-like extension along vein CuA₂. FWD: dark grey, a shade lighter in basal one-fourth; two roughly parallel white, semi-transparent bands, median and submarginal, the former nearly straight, extending from subcosta to tornal area without reaching outer margin, approximately the same width throughout, some 2 mm

wide, except beyond CuA_2 where constricted; the latter band narrower, gently arched, approximately 1 mm wide in subapical area, gradually narrowing towards tornus, and fading away in CuA_1 - CuA_2 ; fringes mostly white, short. HWD dark grey in basal half, gradually turning black distally; a straight, whitish semi-transparent median band approximately 1 mm wide extending from costa to postdiscal area where overcast by a carmine red patch, which gradually widens from median area and spreads over most of outer half from CuA_1 to anal margin, leaving free a large black tornal patch and a smaller one at tail-like extension base; tail-like extension red in basal half, milky white in distal half, with some sparse black marginal scales; fringes milky white, considerably longer than on the FW. FWV ground colour dark grey with a heavy burgundy red overcast; two semi-transparent bands shaped as on the dorsal surface but slightly wider and longer, particularly the median band which extends from costa to tornus; a series of intravenal basal to post-basal white stripes; a light grey cross discal line. HWV predominantly burgundy red from costa to median area and along outer margin and crimson red from median area to anal margin; a series of sandy yellow; a series of intravenal stripes extending from base to submedian area where joining an irregular band of same colour extending from post-basal area on costa to median area at CuA_1 base; a median semi-transparent band shaped as on the dorsal surface but wider;



1-4. *Erateina* adults. 1 – *Erateina puellaastuta* female (holotype) dorsum; 2 – *Erateina puellaastuta* female (holotype) venter; 3 – *Erateina kuczynskii* male (holotype) dorsum; 4 – *Erateina kuczynskii* male (holotype) venter

distally, a wide red band, burgundy red from costa to median area where gradually turning crimson red, extending to anal margin, edged distally with sandy yellow and black; submarginal and marginal are from apex to vein CuA_1 burgundy red; a black patch at tornus; tail-like extension mostly crimson red, except for milky white towards its end, and some sparse marginal black scales. Female genitalia (Figs. 7, 8): Body of genital apparatus elongated; papillae anales slender, elongated and tapering; posterior and anterior apophyses stout, the latter reaching to base of ductus bursae, the former 1.5 longer; lamella antevaginalis gently sclerotized; ductus bursae short, strongly scler-



5-8. *Erateina* genitalia: 5 – *Erateina kuczynskii* male (holotype) ventral view; 6 – *Erateina kuczynskii* male (holotype) aedeagus in lateral view; 7 – *Erateina puellaastuta* female, (holotype) lateral view; 8 – *Erateina puellaastuta* female (holotype) ductus bursae and digitabulum amplified

rotized with outcurved edges; a strong sclerotization from base of bursa to a heavily sclerotized, prominent, appendix bursae (digitabulum) prominent, clubbed, oriented parallelly to ductus bursae; bursa without apparent signa. Roughly similar to the genus *Hydriomena* HÜBNER [1825].

Male: So far unknown.

ETYMOLOGY

This specific epithet means “smart girl” in Latin and refers to the collector of the only known specimen, Izabela STACHOWICZ. The specific epithet was proposed by Alicja ZDOBYŁAK, the winner of the National Geographic Poland contest for the taxonomic name of this new species in 2012.

***Erateina kuczynskii* PYRCZ & GARLACZ, n. sp.**

(Figs. 3, 4, 5, 6)

MATERIAL EXAMINED

HOLOTYPE (male): Venezuela, Edo. Bolívar, Gran Sabana, Roraima Tepuy, *talud cumbre*, 2500-2550 m, 22.XII.2010, M. Costa leg., MZUJ (to be deposited in MIZA); **PARATYPE** (male): Venezuela, Edo. Bolívar, Gran Sabana, Auyán Tepui, M. Costa leg., MCC (to be deposited in MIZA).

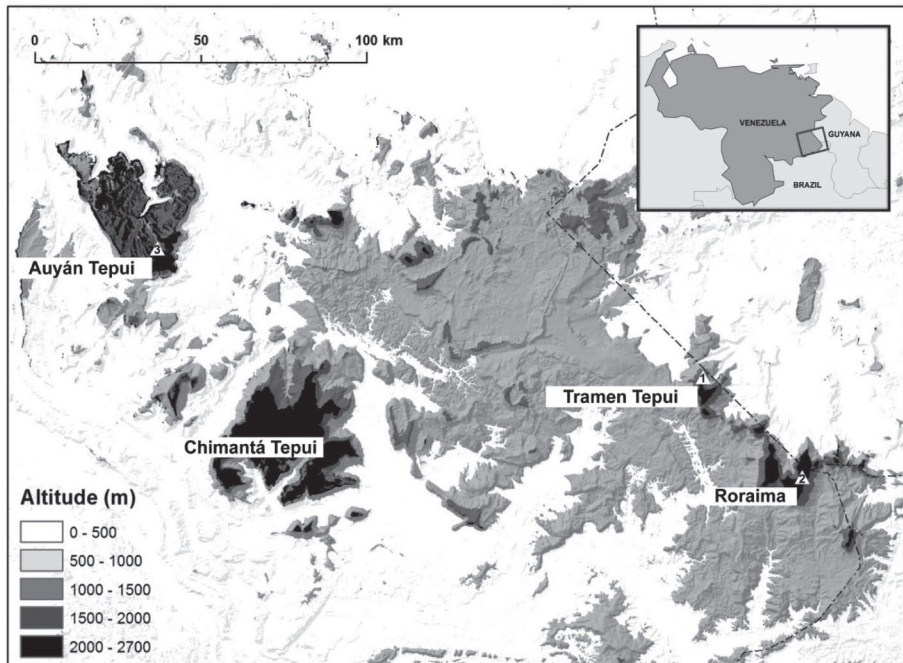
DIAGNOSIS

Wing shape, in particularly the length and shape of the HW tail-like extension, and HW colour most similar to *E. zoraida* DOUBLEDAY, 1848, *E. julia* DOUBLEDAY, 1848, and to a number of other species from which it can be immediately distinguished by the faint, barely visible FW median transverse lighter band, sharp and neat in all other comparable species.

DESCRIPTION

Male (Figs. 3, 4): Head: Eyes brown, lustrous, naked; frons black, bordered with sandy yellow scales; antennae filamentous, black, hairy, some white scales on basal segments; a crest of dark grey and sandy yellow scales at dorsal base of antennae; labial palpi porrect, first palpal segment densely covered with white scales, second and third laterally sandy yellow, dorsally black; collar sandy yellow, brown and grey. Thorax: black with a mid-dorsal sandy yellow oblong line; tegulae covered with long brown and sandy yellow hair extending to base of abdomen; legs tibiae and femora covered with sandy yellow and black, tarsi with brown scales; epiphysis on 1st leg reaching distal end of femur; two double spurs on 2nd and 3rd leg tibiae approximately 1/8 the length of tibiae each. Abdomen: dorsally and laterally covered with grey scales, with sandy yellow thin ring at distal end of each segment, ventrally sandy yellow. Wings: FW (length 21 mm) with a subacute apex, a straight outer margin, and a gently rounded tornus. HW elongated, with a scalloped outer margin, and an approximately 2 mm long, sharply ended tail-like extension along vein CuA₂. FWD: uniform dull grey; a faint, nearly straight white median band extending from mid-costa to tornus, reaching outer

margin, approximately the same width throughout, some 2 mm wide; fringes grey. HWD dull grey in basal half; an orange median-postmedian band gradually widening from mid-costa where 1.5 mm wide, to anal margin near tornus where some 4 mm wide, enclosing a small black anal dot, with a diffuse inner margin gradually intergrading with basal grey, except from costa to vein M_2 where edged basally with dark grey; distally from orange band blackish; fringes creamy, including tail-like extension along vein CuA_2 , considerably longer and more conspicuous than on the FW. FWV ground colour dark grey with a heavy burgundy red overcast; two, roughly parallel semi-transparent bands, median one shaped as on the dorsal surface but considerably wider and conspicuous curved basally near tornus, and a submarginal straight band extending from costa to outer margin near tornus, and gradually narrowing; basal to postbasal area creamy white with a series of intravenal basal to postbasal burgundy stripes; a diffuse mid-discal cell burgundy patch. HWV predominantly burgundy red; a series of sandy yellow intravenal stripes extending from base to submedian area; a 3 mm wide sandy white postmedian band extending from mid-costa to anal margin near tornus; distally a burgundy band of approximately the same width and shape, turning from burgundy to orange at vein M_2 ; a wide marginal black band with a strong burgundy overcast except at apex where distinctively pale yellow; fringes sandy yellow, same as on dorsum. Male genitalia (5, 6): Uncus two and half the length of tegumen shoulder with a swollen basal one-third and slender distal two-thirds with the apex slightly pointed downwards;



9. Map of the south-eastern portion of the Guiana Shield with the collecting localities on Tramen Tepui (1), Roraima (2) and Auyán Tepui (3)

tegumen broad, distinctly swollen along lateral edges; vinculum strongly sclerotized with rather even edges fused to tegument, with a distinctive, crest of brush hair; saccus broad but shallow, moderately sclerotized, hooked upwards; fultura inferiores broad and moderately sclerotized; valva broad, with a moderately sclerotized and swollen basal lobe, with a small spine-like projection at $\frac{1}{2}$ of ventral edge, medial and saccular area lightly sclerotized, striated at base, with long and dense hair pencils anchored along distal edge; aedeagus simple, tubular, approximately the length of valva, with smooth edges, vesica expanded basally, forming a wide, striated lobe. Roughly similar to the cidariine genus *Eulithis* HÜBNER, 1821, from the Holarctic.

Female: so far unknown.

ETYMOLOGY

This species is dedicated to Maciej KUCZYŃSKI, a Polish geologist and speleologist who explored for the first time the caves of the Sarisarañama Tepuy in the Guiana Shield in 1976, an achievement described in the book "*Tajemniczy płaskowyż*" ("The mysterious plateau") published in 1981.

DISCUSSION

The status of the two newly described species within the genus *Erateina* has strong basis as they both are morphologically similar to the type species of the genus, *E. zoraida*. *E. puellaastuta* is described from the unique specimen because it presents exclusive colour pattern characters which enable its immediate recognition from all other congeners. Considered the extreme inaccessibility of the collecting site and the rarity of *Erateina* in the Guiana Shield, the collecting of further individuals is highly unlikely within a foreseen perspective.

Our findings extend considerably the known range of the genus *Erateina*. The centre of diversity are the tropical Andes, and only are known from the mountain of Central America. No species has been reported from the Brazilian Serra do Mar. It also constitutes a new, important element for the lepidopterous fauna of the Guiana Shield. So far, the few Andean elements in this mountainous region of South America included four species of Satyrinae of the genera *Pedaliodes* BUTLER, *Eretris* C. FELDER & R. FELDER, *Oxeoschistus* BUTLER and *Forsterinaria* GRAY (PYRCZ & FRATELLO 2005), one species of *Perisama* (Nymphalidae, Biblidinae), one species of *Catasticta* (Pieridae) and a couple of species belonging predominantly yet not exclusively to Andean Ithomiini, Acraeini and other Nymphalidae, including the genus *Memphis* HÜBNER, *M. viloriae* PYRCZ & NEILD and *M. montesino* PYRCZ (PYRCZ & NEILD 1995; NEILD 2008).

E. kuczynskii is known from two individuals found on widely separated tepuis, Roraima and Auyán. A similar pattern was detected for *Protopedaliodes ridouti* VILORIA and PYRCZ. This species was described from Roraima and until recently was considered to be an endemic of this table mountain. However, morphologically identical specimens were found on top of Chimantá Tepui by M. Costa (PYRCZ, in prep.). These two findings indicate that the current isolation of higher strata of cloud forests of these two tepuis is less complete than generally considered and/or short lasting.

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