



Description of *Emeryus* Zacca, Mielke & Casagrande gen. nov. (Lepidoptera: Nymphalidae) to accommodate three species formerly placed in *Paryphthimoides* Forster, 1964

Thamara Zacca,^{1*}  Mirna M Casagrande,² Olaf H H Mielke,² Blanca Huertas,³ Eduardo P Barbosa,¹  André V L Freitas¹ and Keith R Willmott⁴

¹Department of Animal Biology and Museum of Zoology, Biology Institute, Laboratório de Ecologia e Sistemática de Borboletas, Universidade Estadual de Campinas, Campinas, São Paulo Brazil.

²Department of Zoology, Laboratório de Estudos de Lepidoptera Neotropical, Universidade Federal do Paraná, Curitiba, Paraná Brazil.

³Department of Life Sciences, Natural History Museum, London, UK.

⁴McGuire Center for Lepidoptera and Biodiversity, Florida Museum of Natural History, University of Florida, Gainesville, Florida, USA.

Thamara Zacca: <http://zoobank.org/urn:lsid:zoobank.org:author:EBE99273-B02D-4A17-AD52-5BB3DFBA6C85>

Mirna M Casagrande: <http://zoobank.org/urn:lsid:zoobank.org:author:241FC1DB-F7FF-4480-A648-D72644538822>

Olaf H H Mielke: <http://zoobank.org/urn:lsid:zoobank.org:author:4E0FFE51-850C-4E51-AC9A-6B5552377C0B>

<http://zoobank.org/urn:lsid:zoobank.org:pub:3D9FBA40-DC58-42BC-B2C1-DB207D878850>

Abstract

A new genus of Euptychiina, *Emeryus* Zacca, Casagrande & Mielke, **gen. nov.**, is herein described using an integrative taxonomic approach to accommodate three species previously placed in *Paryphthimoides* Forster, 1964: *Emeryus argulus argulus* (Godart, [1824]), **comb. nov.** (type species), *Emeryus difficilis* (Forster, 1964), **comb. nov.** and *Emeryus numeria* (C. Felder & R. Felder, 1867), **comb. nov.** Additionally, a new taxon *Emeryus argulus magnum* Zacca, Casagrande & Mielke, **ssp. nov.** from Venezuela (Aragua and Bolívar) and Brazil (Roraima), is described. A neotype is designated for *Satyrus argulus* Godart, [1824], and lectotypes are designated for *Euptychia huebneri* Butler, 1867, *Euptychia ambigua* Butler, 1867 and *Neonympha numeria* C. Felder & R. Felder, 1867. Female genitalia are described and illustrated for the first time for all of the above taxa. A Maximum Likelihood analysis using combined nuclear and mitochondrial genes supports the monophyly of the new genus. No DNA sequences could be obtained for *E. numeria*, but its inclusion in the genus is supported by morphological evidence. The genitalic morphology of both sexes of *Emeryus* species is helpful in distinguishing this genus from the other Euptychiina, although the male genitalia structures are highly conserved among congeners.

Key words

Euptychiina, integrative taxonomy, Neotropical region, new subspecies, phylogeny, Satyrini, South America, systematics.

INTRODUCTION

Satyrinae are one of the most diverse subfamilies of nymphalid butterflies in terms of habitat, ecology and morphology with more than 200 genera and 2400 species distributed in all continents (except Antarctica) from sea level up to 4000 m (Ackery *et al.* 1999; Lamas 2004; Wahlberg *et al.* 2009; Peña *et al.* 2010). Adults of Satyrinae are characterised by having the discal cell closed by tubular veins in both wings, and the bases of the subcostal, cubitus and anal veins are inflated (Weymer 1910–1913; Ackery 1998), while the larvae have bifid anal projections and feed mostly on Poaceae and Cyperaceae (Poales), except for a few groups on Marantaceae, Arecaceae, Selaginellaceae and Lycopodiaceae (DeVries 1987; Freitas *et al.* 2019).

Among the satyrines, Euptychiina has been considered one of the most taxonomically challenging subtribes due to the drab wing colour patterns of many species and their small size, which has led this group to be historically neglected. However, collaborative efforts of researchers around the world have resulted in a number of publications during the last five years on the taxonomy and systematics of this subtribe, and as a result, the group is now much better understood. The subtribe now comprises 56 genera and 428 described species, mainly distributed in the lowlands across the Neotropical region, with only a few species in the Nearctic and Palearctic regions (e.g. Lamas 2004; Brévignon 2005; Peña & Lamas 2005; Peña *et al.* 2010, 2011; Freitas *et al.* 2011, 2012, 2013, 2015, 2016, 2018; Brévignon & Benmesbah 2012; Matos-Maravi *et al.* 2013; Zacca *et al.* 2013, 2014, 2017; Nakahara *et al.* 2015a, 2015b, 2016a, 2016b, 2018, 2019; Barbosa *et al.* 2015, 2016; Costa *et al.* 2016; Henao-Bañol & Meneses 2017; Andrade-C *et al.* 2019;

*zacca.butterfly@gmail.com

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Henao-Bañol 2019; Nakahara *et al.* 2019a, 2019b). It is estimated that many new genera and species still need to be described, which should further increase the current known diversity of Euptychiina species by up to 20% (Nakahara *et al.* 2018; Espeland *et al.* 2019).

A detailed study by Zacca *et al.* (2020) on the systematics of the genus *Paryphthimoides* Forster 1964 using data from morphology, mitochondrial and nuclear DNA, and geographic distribution has demonstrated that the genus, as previously circumscribed by Lamas (2004) is polyphyletic. As result, a new taxonomic arrangement was proposed, which excluded nine species from *Paryphthimoides*. The current study uses a similar integrative taxonomic approach including morphological, distributional, mitochondrial and nuclear genes data to erect a new genus for three of the species previous placed in *Paryphthimoides*.

MATERIALS AND METHODS

Morphological data

Selected male and female specimens had their abdomen detached and soaked in a heated test tube with 10% potassium hydroxide solution (KOH) for about five minutes to facilitate the dissection of the genitalia. Dissected specimens are marked with an asterisk after the voucher number in the 'Material examined' sections. Images of genitalia were obtained in Leica LAS 3D view and LAS montage version 4.7 with the aid of a video camera Leica DFC500 attached to a stereoscopic microscope Leica MZ16. Illustrations were prepared with the aid of a camera lucida attached to a stereoscopic microscope and subsequently vectorised by using the software GIMP version 2.8.10 (GIMP Team 2019).

Terminology of the genitalia follows mostly Klots (1970), but the term 'gnathos' (= brachia) is applied *sensu* Pierce (1914), 'fultura superior' and 'fultura inferior' (= juxta) *sensu* Petersen (1904) and 'combination of ventral arm of tegumen and dorsal arm of saccus' (= vinculum) *sensu* Austin and Mielke (2008). The nomenclature of the wing venation mostly follows Comstock and Needham (1898–1899) and Comstock (1918), and for broad regions of the wing, we follow Neild (1996). The following abbreviations are used throughout the text: VW – ventral wings, DFW – dorsal forewings, VFW – ventral forewings, VHW – ventral hindwings and 'n' – number of examined specimens.

Distributional data

Locality data were obtained from specimens deposited in collections and publications and were used to produce a distribution map using QGIS software (QGIS Development Team 2016). Information inferred from abbreviations on specimens labels is enclosed in square brackets. We treated allopatric taxa with no consistent differences in genitalia but consistent differences in wing pattern as subspecies (see Mallet 1995, 2001; Braby *et al.* 2012).

Molecular data

DNA was extracted from two legs of adults using Quiagen's DNeasy Blood & Tissue Kit following the manufacturer's protocol. DNA was stored in TE buffer at -20°C . The mitochondrial gene cytochrome *c* oxidase I (COI – 1498 bp) (for all specimens), and the nuclear genes glyceraldehyde 3-phosphate dehydrogenase (GAPDH – 691 bp) and ribosomal protein S5 (RpS5 – 610 bp) (for some specimens of *Emeryus argulus*) were amplified, purified and sequenced using standard techniques (see Silva-Brandão *et al.* 2005; Wahlberg and Wheat 2008; Barbosa *et al.* 2015), and the 13 new resulting sequences were deposited in GenBank (Benson *et al.* 2013) (see Table 1 for accession numbers). Attempts to sequence several older specimens of *Emeryus numeria* and *E. argulus magnum* ssp. nov. from the DZUP collection were unsuccessful.

New sequences were viewed and edited with FinchTV v. 1.4.0 software (Geospiza, PerkinElmer Inc., Waltham, MA, USA). Sequences obtained from GenBank and new ones provided in the present study were aligned using the ClustalW algorithm (Thompson *et al.*, 1994) in Mega X (Kumar *et al.* 2018). The final concatenated matrix comprised 55 specimens from species of 19 genera, including 15 specimens of *Emeryus* gen. nov. (see Table 1 for the voucher numbers and accession codes), with a total of 2799 base pairs. A Maximum Likelihood (ML) tree was inferred in IQ-Tree v1.6.9 software (Nguyen *et al.* 2015), using the edge-linked partition (-spp) (Chernomor *et al.* 2016), with 1000 likelihood searches in each of the 10 runs performed. Three partitions were used in our study, as follows: COI (1-1448 sites), GAPDH (1449-2188) and RpS5 (2189-2799). ModelFinder (-m MFP) was used to find the best-fit model for each partition (Kalyaanamoorthy *et al.* 2017), which resulted in GTR+F+I+G4 for COI and SYM+I+G4 for both GAPDH and RpS5. To estimate branch support, we used 1000 ultrafast bootstrap searches, optimised by the nearest neighbour interchange (-bnni) to reduce the risk of overestimating branch supports (Hoang *et al.* 2018), and 1000 SH-aRLT replications (Guindon *et al.* 2010). The unrooted tree with the lowest negative log likelihood was selected as the best tree and is used to discuss results.

Genetic distances among the species of *Emeryus* gen. nov. were determined based on COI using the program MEGA v. 6.0 (Tamura *et al.* 2013) under the Kimura-2-parameters (K2P) model of nucleotide substitution (Kimura 1980).

Sources of material examined

We examined 202 specimens, including types, from several public and private collections cited throughout the text by the following acronyms:

DZUP	Pe. Jesus de Santiago Moure collection, Universidade Federal do Paraná, Paraná, Brazil
FLMNH	McGuire Center for Lepidoptera and Biodiversity, Florida Museum of Natural History, University of Florida, Gainesville, Florida, USA

Table 1 Species of Euptychiina used in the phylogenetic analysis, specimen voucher codes, sampling site data and GenBank accession numbers for sequenced genes

Species	Voucher	Locality	COI	GAPDH	RpS5
<i>Oressinoma sorata</i>	CP06-89	Peru, Pasco, Oxapampa	GQ357209	GQ357440	GQ357570
<i>Atlanteuptychia ernestina</i>	YPH-0191	Brazil, São Paulo, Serra do Japi	KP994863	KU340904	KU340937
<i>Cyllopsis pertepida</i>	NW165-3	Mexico, Guanajuato, Mpio. San Felipe/León 8 km NE El Zuaco	GQ357204	GQ357428	GQ357557
<i>Paramacera xicaque</i>	CP15-08	Mexico, D.F., Magdalena Contreras, Cañada de los Dinamos	GQ357210	GQ357442	GQ357571
<i>Euptychia bouletti</i>	PM17-01	Brazil, Rio de Janeiro, Itatiaia	JQ639284	JQ639286	JQ639287
<i>Euptychia mollina</i>	YPH-0154	Brazil, Pará, Tapajós	KP890210	KU340902	KU340935
<i>Euptychia mollina</i>	YPH-0155	Brazil, Pará, Tapajós	MT246303	MT258823	—
<i>Cissia proba</i>	CP01-30	Peru, Madre de Dios, Tambopata Research Center	GQ864751	GQ864945	GQ865416
<i>Cissia pompilia</i>	MAL-02577	Mexico, Yucatán, Valladolid, carretera a Xocén	GU659737	—	—
<i>Cissia rubricata</i>	LEP-19315	USA, Arizona, Southwestern Research Station, Portal	MG209757	MG546314	MG546327
<i>Cissia penelope</i>	CP07-58	Peru, Junín, La Solitaria-Quebrada Siete Jeringas	GU205833	GU205945	GU206005
<i>Cissia phronius</i>	NW126-7	Brazil, São Paulo, Atibaia	DQ338807	GU205973	GU206034
<i>Cissia eous</i>	YPH-0422	Brazil, Rio Grande do Sul, Alegrete	KU340872	KU340920	KU340955
' <i>Cissia</i> ' <i>confusa</i>	DHJ-02	Costa Rica, Area de Conservación Guanacaste, Sector Pitilla, SenderoTierra Blanca	JQ526869	—	—
' <i>Cissia</i> ' <i>myncea</i>	NW108-6	Brazil, São Paulo, Ubatuba, Picinguaba	DQ338581	GQ357427	GQ357556
<i>Godartiana muscosa</i>	NW127-8	Brazil, São Paulo, Jundiá, Serra do Japi	DQ338582	GQ864974	GQ865443
<i>Godartiana armilla</i>	PM04-02	Brazil, Brasília, Parque Nacional de Brasília	JQ392582	JQ392816	JQ392921
<i>Pindis squamistriga</i>	NW165-5	Mexico, Penjamo, 9 km W Penjamo, Mpio. Penjamo	GQ357211	GQ357445	GQ357574
<i>Paryphthimoides poltys</i>	CP02-19	Peru, Madre de Dios, Tambopata Research Center	GU205861	GU205972	GU206033
<i>Paryphthimoides vestigiata</i>	YPH-0779	Brazil, São Paulo, São Luís do Paraitinga	MH581137	MH581140	MH581145
<i>Sepona punctata</i>	YPH-0240	Brazil, Rondônia, Porto Velho, Abunã	KR349480	KR349476	—
<i>Sepona punctata</i>	CP23-21	Peru, La Convención	JQ392607	JQ392838	JQ392943
<i>Taygetis virgilia</i>	PM02-03	Colombia, Antioquia, Porcé, Amalfi	JQ392700	JQ392912	JQ393021
<i>Taygetis laches</i>	PM04-13	Brazil, Para, Xingu	JQ392659	JQ392878	JQ392988
<i>Posttaygetis penelea</i>	CP01-06	Peru, Madre de Dios, Tambopata Research Center	JQ392620	—	JQ392955
<i>Forsterinaria necys</i>	NW126-10	Brazil, São Paulo, Campinas, Ribeirão das Pedras	GU205837	GU205950	JQ392927
<i>Forsterinaria boliviana</i>	CP04-88	Peru, Junín, Quebrada Siete Jeringas	DQ338799	GQ357435	GQ357564
<i>Capromieria galesus</i>	NW167-5	Brazil, Santa Catarina, Apiúna, Parque Nacional da Serra do Itajai	GU205826	GU205938	GU205998
<i>Erichthodes narapa</i>	YPH-0233	Brazil, Minas Gerais, Santana do Riacho, Serra do Cipó	MK260016	MK260030	MK260038
<i>Erichthodes narapa</i>	YPH-0274	Brazil, Minas Gerais, Santana do Riacho, Serra do Cipó	MK260017	MK260031	—
<i>Nhambikuara mima</i>	MGCL-LOAN-175	Brazil, Alagoas, Ibataguara	MF489993	—	—
<i>Nhambikuara mima</i>	MGCL-LOAN-550	Brazil, Rondônia, Porto Velho	MF489994	MF490009	MF490025
<i>Nhambikuara cerradensis</i>	YPH-0573	Brazil, Minas Gerais, Santana do Riacho	MF489985	MF490005	MF490018
<i>Nhambikuara cerradensis</i>	YPH-0574	Brazil, Minas Gerais, Santana do Riacho	MF489986	MF490006	MF490019
<i>Magneuptychia modesta</i>	LEP-08985	Ecuador, Morona-Santiago, Wachirpas airfield	MT246304	—	—
<i>Magneuptychia fugitiva</i>	CP01-18	Peru, Madre de Dios	GU205845	GU205958	GU206017
<i>Yphthimoides mimula</i>	YPH-00095	Brazil, Mato Grosso do Sul, Três Lagoas	KR349477	KR349473	KR349471
<i>Yphthimoides mimula</i>	YPH-00098	Brazil, Mato Grosso do Sul, Três Lagoas	KT880200	KT880209	KT880214
<i>Yphthimoides affinis</i>	YPH-00080	Brazil, São Paulo, Luís Antônio, Reserva Jataí	MN264766	MN264880	MN311531
<i>Yphthimoides affinis</i>	YPH-00082	Brazil, São Paulo, Luís Antônio, Reserva Jataí	MF489978	MF489998	MF490011
<i>Emeryus difficilis</i>	MGCL-LOAN-288*	Brazil, Mato Grosso, Cachoeira Sete Quedas, Rio Teles Pires	MK659558	MN414201	—
<i>Emeryus difficilis</i>	PM01-28	Brazil, Tocantins, Xambiá, Rio Araguaia	MF084835	—	—
<i>Emeryus difficilis</i>	YPH-0652*	Brazil, Rondônia, Pimenta Bueno	MK260018	—	—
<i>Emeryus difficilis</i>	YPH-0653*	Brazil, Mato Grosso, Jangada	MK260019	—	—
<i>Emeryus difficilis</i>	YPH-0654*	Brazil, Rondônia, Pimenta Bueno	MK260020	—	—
<i>Emeryus difficilis</i>	YPH-0655*	Brazil, Mato Grosso, Jangada	MK260021	—	—
<i>Emeryus difficilis</i>	YPH-0659*	Brazil, Mato Grosso, Jangada	MK260022	—	—
<i>Emeryus argulus</i>	YPH-0591*	Brazil, Roraima, Caracará, Parque Nacional Viruá	MK260023	MK260032	MK260039
<i>Emeryus argulus</i>	YPH-0592*	Brazil, Roraima, Caracará, Parque Nacional Viruá	MK260024	MK260033	MK260040
<i>Emeryus argulus</i>	YPH-0614*	Brazil, Minas Gerais, Santana do Riacho, Serra do Cipó	MK260025	—	—
<i>Emeryus argulus</i>	YPH-0625*	Brazil, Amazonas, Manaus	MK260026	MK260034	—
<i>Emeryus argulus</i>	YPH-0627*	Brazil, Amazonas, Presidente Figueiredo	MK260027	MK260035	—
<i>Emeryus argulus</i>	YPH-0684*	Brazil, Border Mato Grosso-Pará, Fazenda Cristalina, BR-163	MK260028	MK260036	MK260041
<i>Emeryus argulus</i>	YPH-0685*		MK260029	MK260037	MK260042

(Continues)

Table 1 (Continued)

Species	Voucher	Locality	COI	GAPDH	RpS5
<i>Emeryus argulus</i>	PM01-26	Brazil, Border Mato Grosso-Pará, Fazenda Cristalina, BR-163 Brazil, Tocantins, Santa Fé do Araguaia, Ilha Barreira Branca	MF084836	—	—

—, missing data; *, new sequences obtained for the present study.

LBCB	Lalita & Christian Brévignon collection, Matoury, Guyane, France
MNHN	Muséum national d'Histoire naturelle, Paris, France
MUSM	Museo de Historia Natural, Universidad Nacional Mayor de San Marcos, Lima, Peru
NHMKUK	Natural History Museum, London, United Kingdom
OM	Olaf H. H. Mielke collection, Paraná, Brazil
RBINS	Royal Belgian Institute of Natural Sciences, Brussels, Belgium
ZSMS	Zoologische Staatssammlung München, Munich, Germany
USNM	Smithsonian National Museum of Natural History, Washington D. C., USA
ZUEC	Museu de Zoologia da Universidade Estadual de Campinas, São Paulo, Brazil
ZUEC-AVLF	André V. L. Freitas collection, Museu de Zoologia da Universidade Estadual de Campinas, São Paulo, Brazil

RESULTS

Molecular data

A Maximum Likelihood analysis (ML) using combined nuclear and mitochondrial genes strongly supported the monophyly of *Emeryus* gen. nov. (ultrafast bootstrap support [ubs] = 100; SH-aLRT support: 100) (Fig. 1), which appeared as a member of the ‘*Splendeuptychia* clade’ *sensu* Espeland *et al.* (2019). *E. argulus* (ubs = 99.7; SH-aLRT = 100) and *Emeryus difficilis* (ubs = 96.6; SH-aLRT = 99) are also reciprocally monophyletic with high support (Fig. 1).

Interspecific genetic distance ranged from 7.8% to 10.4% between individuals of *E. argulus* and *E. difficilis* (Table 2; Fig. 11). Intraspecific genetic distances among eight individuals of *E. argulus* ranged from 0.0% to 6.8% and varied from 0.0% to 6.2% among six individuals of *E. difficilis* (Table 2).

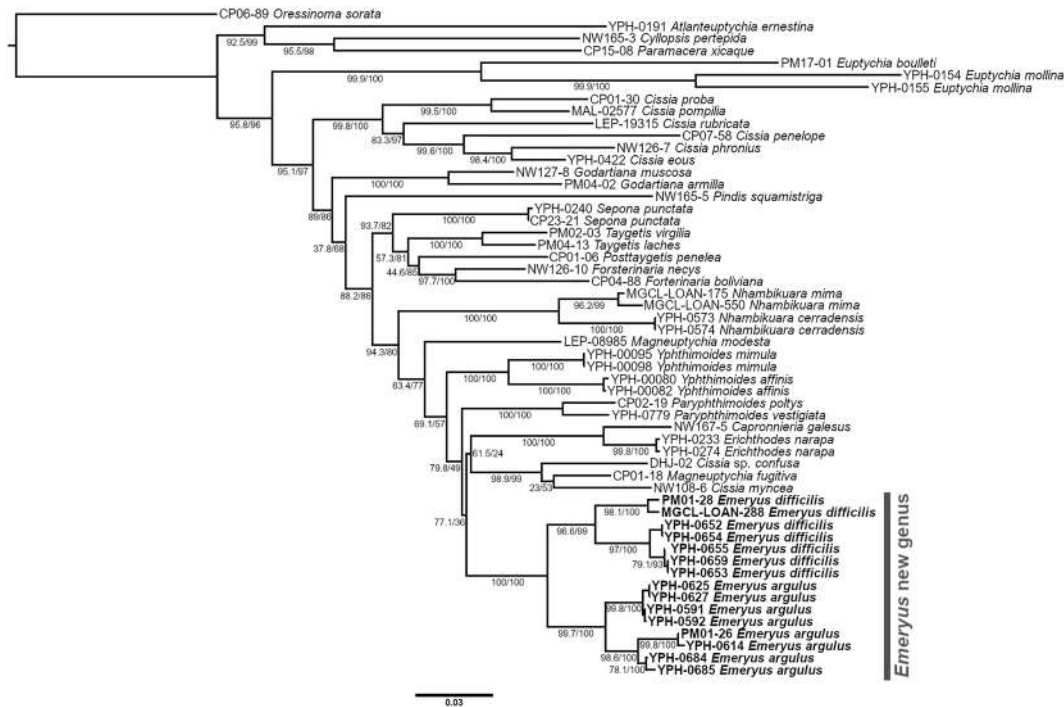


Fig. 1. Maximum likelihood tree (log-likelihood: -21957.9648) showing the genetic relationships among *Emeryus* gen. nov. and other species of Euptychiina based on COI, GAPDH and RpS5 genes. Numbers below the branches indicate SH-aLRT and ultrafast bootstrap support values.

Table 2 Pairwise genetic distances (%) for COI sequences among species of *Emeryus* gen. nov.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1. PM01-28 <i>Emeryus difficilis</i> (sprinkled VW phenotype)														
2. YPH-0654 <i>Emeryus difficilis</i> (sprinkled VW phenotype)	5.8													
3. YPH-0652 <i>Emeryus difficilis</i> (sprinkled VW phenotype)	5.80.0													
4. YPH-0655 <i>Emeryus difficilis</i>	6.21.41.4													
5. YPH-0659 <i>Emeryus difficilis</i>	5.81.41.4	0.4												
6. YPH-0653 <i>Emeryus difficilis</i> (sprinkled VW phenotype)	5.81.41.4	0.40.0												
7. YPH-0627 <i>Emeryus argulus</i>	9.49.89.8	9.89.49.4												
8. YPH-0625 <i>Emeryus argulus</i>	9.49.89.8	9.89.49.40.0												
9. YPH-0591 <i>Emeryus argulus</i>	9.09.49.4	9.49.09.00.70.7												
10. YPH-0592 <i>Emeryus argulus</i>	9.29.69.6	9.69.29.20.90.90.2												
11. YPH-0684 <i>Emeryus argulus</i>	8.07.87.8	8.27.87.85.85.85.45.6												
12. YPH-0685 <i>Emeryus argulus</i>	8.68.28.2	8.88.48.46.06.05.65.80.5												
13. PM01-26 <i>Emeryus argulus</i>	10.09.49.4	9.89.49.46.46.46.26.42.72.9												
14. YPH-0614 <i>Emeryus argulus</i>	10.49.89.810.29.89.86.86.86.66.83.13.30.4													

TAXONOMY***Emeryus* Zacca, Casagrande & Mielke, gen. nov.**

<http://zoobank.org/urn:lsid:zoobank.org:act:7FCF24D1-338F-4484-BD15-F84A6E9772A8>

Type species: *Satyrus argulus* Godart, [1824] (designated by authors)

Diagnosis

Among the genera of Euptychiina, species of *Emeryus* resemble species of *Paryphthimoides* in their wing pattern elements, coloration (Fig. 2) and venation (Fig. 3a,b), but they can be easily distinguished by the following characters: (1) glabrous eyes (hairy in *Paryphthimoides*), (2) male genitalia with thin and elongated appendices angularis (short and broad at the base in *Paryphthimoides*), trapezoidal valva with apex elongated, without dorsal projection (dorsal projection developed in *Paryphthimoides*) and vesica without cornuti (present in



Fig. 2. Species of *Emeryus* gen. nov. dorsal and ventral. (a–d) *Emeryus argulus argulus*: (a,b) male neotype of *Satyrus argulus* (DZ 35.230), (c,d) female (DZ 34.524). (e–h) *Emeryus argulus magnum* spp. nov.: (e,f) male holotype, dorsal (DZ 35.260), (g) female (DZ 25.666). (i–p) *Emeryus difficilis*: (i,j) male (DZ 31.211), (k,l) female (DZ 30.023), (m,n) male (DZ 28.448), (o,p) female (DZ 35.581). (q–t) *Emeryus numeria*: (q,r) male (DZ 31.182), (s,t) female (DZ 28.431). Scale bar = 1 cm.

Paryphthimoides) and (3) female genitalia with wrinkled and sclerotised lamella antevaginalis and papilla anales with posterior apophysis (absent in *Paryphthimoides*).

Description

Wings. Forewings sub-triangular, costa slightly convex, apex rounded, external margin slightly convex without indentations and inner margin straight. Ground colour brown without ocelli on dorsal wings. Ventral forewings with four narrow lines (median, submedian, marginal and submarginal), submarginal line well-crenulated, three to five small ocelli between M_1 - CuA_1 , M_1 - CuA_2 and M_1 -2A. Hindwings sub-oval, somewhat longer than wide, costa convex, apex rounded, external margin convex with indentations, inner margin straight. Ventral hindwings with five to six ocelli from Rs - CuA_2 or Rs -2A, ocelli in Rs - M_1 , M_1 - M_2 and CuA_1 - CuA_2 with black ocellar spot surrounded by yellowish ocellar ring and two tiny silver pupils inside, ocelli in M_2 - CuA_2 with lighter ocellar spot and large silver pupils inside.

Venation. Forewings with veins Sc, CuA and 2A swollen at base, discal cell half-length of entire length of wing. Hindwings with discal cell half-length of entire length of wing, humeral vein developed and m_1 - m_2 slightly convex (Fig. 4).

Male genitalia. Tegumen convex in dorsal view, laterally sub-triangular. Uncus sinuous, about 2/3 length of tegumen, apex curved downwards and truncated in dorsal view. Gnathos curved upwards, sinuous, 2/3 length of uncus, larger at base and tapering at apex. Combination of ventral arms of tegumen and dorsal arms of saccus sinuous. Appendices angularis present. Anterior projection of saccus cylindrical with variable size. Fultura inferior sclerotised in V-shape. Fultura superior absent. Valva elongated and rectangular and covered by long hair-like scales latero-ventrally and short hair-like scales at inner side; costa developed and sub-squared; dorsal margin sinuous with apical third slightly serrated; ventral margin slightly projected at median region; apex variable. Aedeagus straight and of variable size; anterior region oblong; posterior region with variable size; distal margin dorsally truncated, with an inner sclerotised triangular projection in lateral view, which is bipartite in ventral view; distal ventral opening almost same length as proximal opening; vesica without cornuti.

Female genitalia. Eighth tergite rectangular. Papilla anales elliptical, varying in size, covered with long hair-like scales at distal region; posterior apophysis present. Lateral plate (probably derived from eighth sternite) separated from eighth tergite and lamella antevaginalis. Lamella antevaginalis sclerotised, varying in shape, with a wrinkled appearance. Lamella postvaginalis absent. Ductus bursae membranous; corpus bursae about same length as ductus bursae, with paired signa of variable location.

Etymology

The generic name is in honour of the deceased Brazilian lepidopterist Eduardo Oliveira Emery (05 February 1972 to 25 August

2017), who made a number of contributions to the knowledge of the butterflies and moths of the Brazilian Cerrado biome. It is a masculine Latin noun in the nominative case.

Systematics checklist

Emeryus Zacca, Casagrande & Mielke gen. nov.

Emeryus argulus (Godart, [1824] comb. nov.

Emeryus argulus argulus (Godart, 1824) comb. nov.

= *Euptychia huebneri* Butler, 1867.

Emeryus argulus magnum Zacca, Casagrande & Mielke ssp. nov.

Emeryus difficilis (Forster, 1964) comb. nov.

Emeryus numeria (C. Felder & R. Felder, 1867) comb. nov.

= *Euptychia ambigua* Butler, 1867.

= *Euptychia historie* Weymer, 1911 [nom. nud.]

Diagnosis

Emeryus argulus is the only species in *Emeryus* with submedian and median lines wider than the submarginal and marginal lines on both VFW and VHW (they have the same width in the other species of the genus). Furthermore, the outer margin of the HW is crenulated, and the submarginal ocelli are all well marked and developed compared to the other species of *Emeryus*.

Emeryus argulus argulus (Godart, [1824]), comb. nov.

(Figs 2a-d, 3a, 4a-b, 5a-l, 8a-b, 9-10)

Papilio argante Cramer, 1779: 19, pl. 204, figs C, D; syntypes: Surinam [preocc. Fabricius, 1775].

Megisto argante; Hübner [1819]: 54.

Euptychia argante; Westwood 1851 in Doubleday: 374. – Butler 1867: 472. – Butler 1868: 21. – Butler 1869: 13; syn. *perfuscata*. – Kirby 1871: 49. – Butler 1877: 118. – Sharpe, 1890: 568. – Weymer, 1911: 202. – Gaede 1931: 438. – Hall 1939: 34.

Satyryus argulus Godart, [1824]: 463, 488; syntype: Suriname. Neotype here designated: Brazil, Pará, Santa Bárbara do Pará; DZUP.

Paryphthimoides argulus; Lamas 2004: 221. – Barlow et al. 2008: 1099, 1102. – Brévignon 2008: 79, figs 61a–61c (male: adult, genitalia).

Euptychia huebneri Butler, 1867: 473, pl. 39, fig. 11; syntypes: Brazil, Pará. Lectotype here designated: Brazil, Pará; NHMUK. – Sharpe, 1890: 568.

Material examined

22♂, 22♀ (4 specimens dissected). GUYANA – *no specific locality*: 1♂, 2♀, no data, Parish leg., Joicey Bequest Brits. Mus. 1934-120, BMNH(E) 1422121, BMNH(E) 1422128, BMNH(E) 1422345 (NHMUK); *Essequibo*: Demerara river, 2♂, no data, Bates leg., Godman-Salvin Coll. 1904-1, BMNH(E) 1422158, BMNH(E) 1422189 (NHMUK); *Potaro-Siparuni*: Ireng River, Cipo, [4°48'59"N 60°1'30"W], 610 m, 2♂, IX. [no year], S. Fratello leg., FLMNH-MGCL-297366, FLMNH-MGCL-297367 (FLMNH); *Upper Demerara-Berbice*: Essequibo River,

35 mi SW of Georgetown, Shanklands Resort, [6°28'44"N 58°34'54"W], 20 m, 1♀, 20-28 IX.2006, M. G. Douglas leg., FLMNH-MGCL-297368 (FLMNH); *Upper Takutu-Upper Essequibo*: E. Kanuku Mountains, Two Hat Mountain, [3°8'48"N 59°6'54"W], 244 m, 1♀, 17.IX-2.X.2000, S. Fratello et al leg. (FLMNH). SURINAME – no specific locality: 1♂, no data, BMNH(E) 1422127 (NHMUK), 3 females, ex-coll. Fruhstorfer, BMNH(E) 1422159, BMNH(E) 1422097, BMNH(E) 1422035 (NHMUK); *Berg en Daal*: 1♀, IV.1892, C. W. Ellacombe leg., Godman-Salvin Coll. 1904-1, BMNH(E) 1422066 (NHMUK). FRENCH GUIANA – *Cayenne*: Malmanoury, [5°19'02"N 52°52'16"W], 1♂, 19.X.1999, C. Faynel leg. (LBCB). BRAZIL – *Amazonas*: Barcelos, Rio Aracá, Foz do Rio Curuduri, 0°05'50"S 63°17'22"W, 1♂, 15-19.VI.2010, Mielke & Casagrande leg., DZ 22.288* (DZUP), Barcelos, Campina Tucano, 0°22'5.46"S 62°55'21.96"W, 1♀, 27.V.2017, M. Marín leg., DNA voucher YPH-0625, ZUEC-LEP 10658 (ZUEC), Boca do Aracá, 0°25'1.51"S 62°54'25.72"W, 1♂, 24.V.2017, A. Rosa leg., DNA voucher YPH-0627, ZUEC-LEP 10656* (ZUEC); *Roraima*: Caracará, Parque Nacional de Viruá, 2♂, 2♀, 20.V-19.VI.2015, M. B. Graça leg., DNA voucher YPH-0592, ZUEC-LEP 10657, DNA voucher YPH-0591, ZUEC-LEP 10655*, ZUEC-LEP 10654, ZUEC-LEP 10653 (ZUEC); *Pará*: no specific locality, 1♂, no data, Hewitson coll. 79-69, BMNH(E) 1422283 (NHMUK), 1♂, 1♀, no data, H. W. Bates leg., Godman-Salvin Coll. 1904-1, BMNH(E) 1422252, BMNH(E) 1422067 (NHMUK), Belém, Utinga, 3♀, 25.XI.1959, H. Ebert leg., DZ 35.180, DZ 35.220, DZ 35.270 (DZUP), Faro, Companhia Mineradora Santarém, 1♂, 19.VII.1973, K. Brown leg., ZUEC-LEP 10652 (ZUEC), Santa Bárbara do Pará, 3♂, 4♀, 2-3.II.2010, Carneiro, Dolibaina, Dias & Moreira leg., DZ 33.894*, DZ 33.895* (with first instar cephalic capsule inside), DZ 33.896*, DZ 35.133, DZ 35.200, DZ 35.230, DZ 35.240 (DZUP), Santarém, 2♂, 2♀, no data, H. H. Smith leg., Godman-Salvin Coll. 1904-1, BMNH(E) 1422314, BMNH(E) 1422221, BMNH(E) 1422190, BMNH(E) 1422098 (NHMUK); *Pará-Mato Grosso*: Fazenda Cristalina, 1♂, 2.XI.2016, R. Rogner leg., DNA voucher YPH-0685, ZUEC-LEP 10660* (ZUEC), 1♂, 5.XI.2016, no collector, DNA voucher YPH-0684, ZUEC-LEP 10659* (ZUEC); *Tocantins*: Ilha Barreira Branca, Santa Fé do Araguaia, 6°43'S 48°48'W, 1♂, 19.VI.2009, no collector, DNA Voucher PM 01-26 (ZUEC – AVLF); *Maranhão*: Imperatriz, 2♀, 17.VII.1974, Exc. Dept. Zoologia, DZ 34.234, DZ 34.524 (DZUP).

Diagnosis

This subspecies differs from *Emeryus argulus magnum* ssp. nov. by its darker ground colour and reduced ocelli (well-developed in *E. argulus magnum* ssp. nov.) on the VW.

Remarks

Satyryus argulus Godart, [1824] was described based on an unstated number of specimens from Suriname. The description of this species is vague, not precisely defining *S. argulus*, as is the case with many other Euptychiina species described by Jean Baptiste Godart (1775-1825). However, Godart stated that his

name *Satyryus argulus* also applied to the specimen illustrated by Cramer (1779: pl. 204, fig C–D) as *Papilio argante*, which we had no success in locating at NHMUK and which name is preoccupied by *Papilio argante* Fabricius, 1775 (currently *Phoebis argante*, Pieridae). The syntypes of *S. argulus* were not found at the MNHN by OHHM and AVLF and the curator (R. Rougerie, pers. comm.), nor at NHMUK, where part of Godart's collection is deposited (except those taxa described from the Dufresne collection that are deposited in the Royal Museum Edinburgh, Scotland, UK – see Grimshaw 1897). Considering that the identity of this name is important for Euptychiina taxonomy, mainly because its wing pattern resembles many species in this subtribe, we herein designate a neotype for *Satyryus argulus*. The designated neotype (Fig. 2a,b) agrees with Godart's original description and Cramer's illustration and is deposited in the DZUP; it has the following labels: /Neotypus/2-3-II-2010 Sta [Santa] Barbara do Pará, Pará, [Brazil], [coordinates: –1.224; –48.294], Carneiro, Dolibaina, Dias & Moreira leg./DZ 35.230/Neotypus *Satyryus argulus* Godart [1824]. T. Zacca, det. 2016/. DZUP.

Hübner ([1819]) treated *Satyryus argulus* in *Megisto* Hübner [1819] together with *M. cymela* (Cramer, 1777), *M. eurydice* (Fabricius, 1775) (currently a synonym of *M. cymela*) and '*M. acmenis*' (Hübner, 1823) (currently in *Ypthimoides* Forster 1964). However, *Satyryus argulus* differs in several morphological respects from other currently recognised *Megisto*, including having hairy eyes (glabrous in *Megisto*), the HW with a crenulated outer margin (not crenulated in *Megisto*) and male genitalia characters. Butler (1869) regarded his name *Euptychia perfuscata* Butler 1868 (currently in *Ypthimoides*) as a synonym of *Papilio argante* Cramer, thereby implying that this name should be treated in *Emeryus*. Cardé et al. (1970) did not examine the type of *E. perfuscata*, and Lee D. Miller (*in litt.* in Cardé et al. 1970) suggested that it was closely related to *Satyryus grimon* Godart [1824]. Lamas (2004), however, correctly treated it as *Ypthimoides maepius perfuscata* (Butler 1868), and synonymised *E. huebneri* Butler 1867 with *Parypthimoides argulus* (Godart 1824).

Euptychia huebneri Butler, 1867 was described based on an unstated number of specimens from Pará, Brazil. Two syntypes, one male and one female, were found at the NHMUK collection; the male specimen (Fig. 4a) agrees with the illustration provided by Butler (1867: pl. 39, fig. 11), and this specimen is herein designated as the lectotype of *Euptychia huebneri* to fix the identity of the name, since its wing pattern resembles that of other Euptychiina species. The male lectotype has the following labels: /Type H. T./Type of species/Para, L.[over] Amazons, H. W. Bates/B. M. Type No Rh 3220 *Euptychia hubneri* [sic] ♂ Butl[er]/Godman-Salvin Coll. 1904. – 1. *Euptychia hubneri* [sic] Butl[er]/*huebneri* [handwritten]/*Euptychia huebneri* Butler Monog[raph] [handwritten]/BMNH(E) 1204751/; two others will be added later: /Lectotypus/Lectotypus *Euptychia huebneri* Butler 1867. T. Zacca, det. 2016/. NHMUK.

Male genitalia. Only differs from characteristics listed in description section of *Emeryus* by the uncus being slightly sinuous and valva with apex pointed (Fig.5).

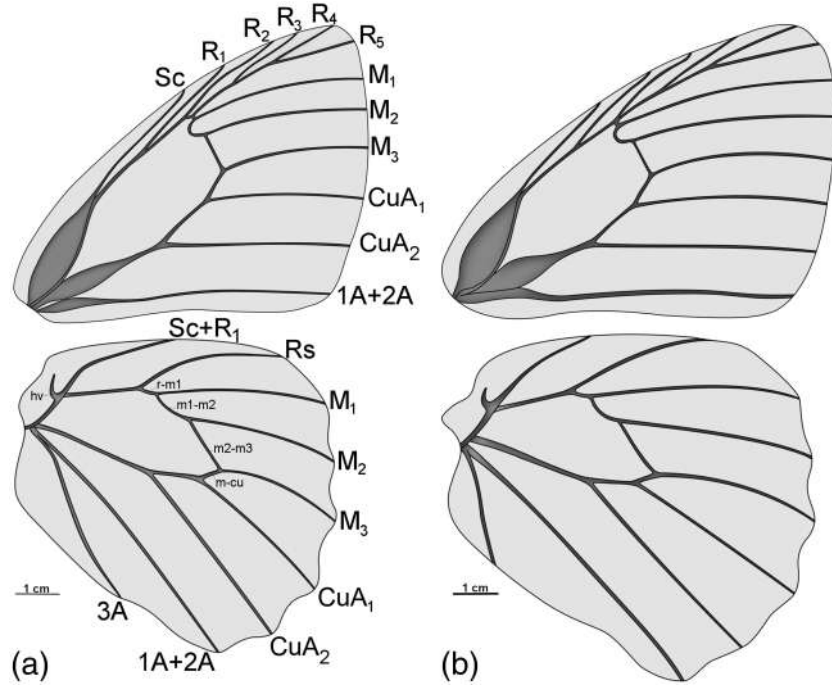


Fig. 3. Wing venation of *Emeryus argulus argulus* showing the venation pattern typical of *Emeryus* species. (a) Male, (b) female. Abbreviations: hv = humeral vein, Sc = subcostal vein, R = radial vein, M = medial vein, CuA = cubital anterior vein, A = anal vein.

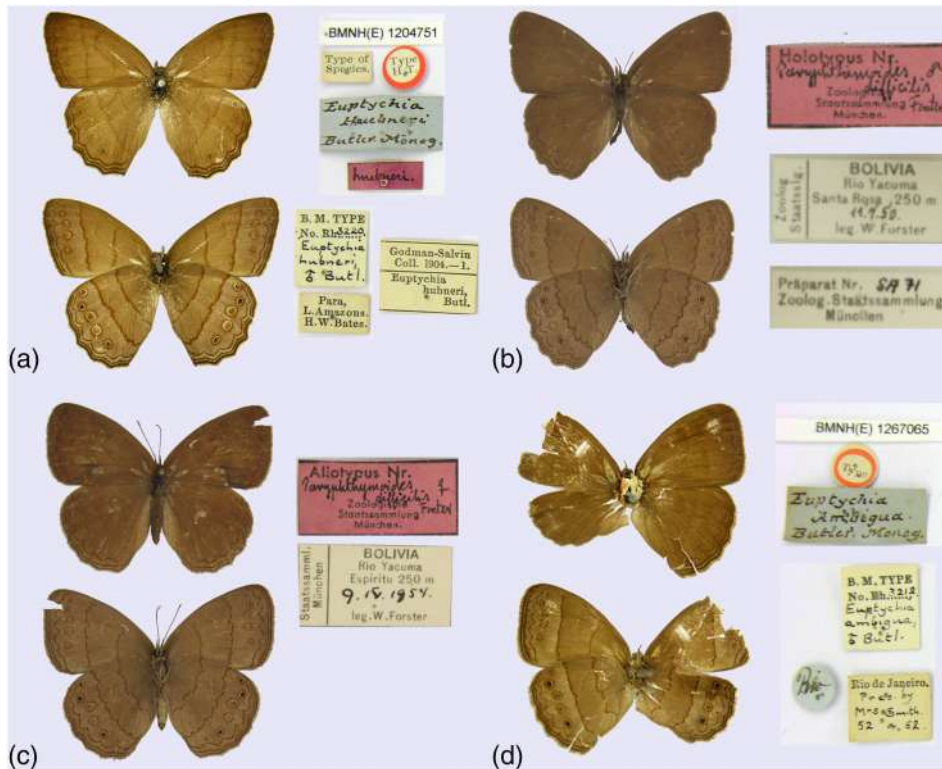


Fig. 4. Type specimens and respective labels. (a) lectotype male of *Euptychia huebneri*; (b) holotype male of *Paryphthimoides difficilis*; (c) allotype female of *Paryphthimoides difficilis*; (d) lectotype male of *Euptychia ambigua*.

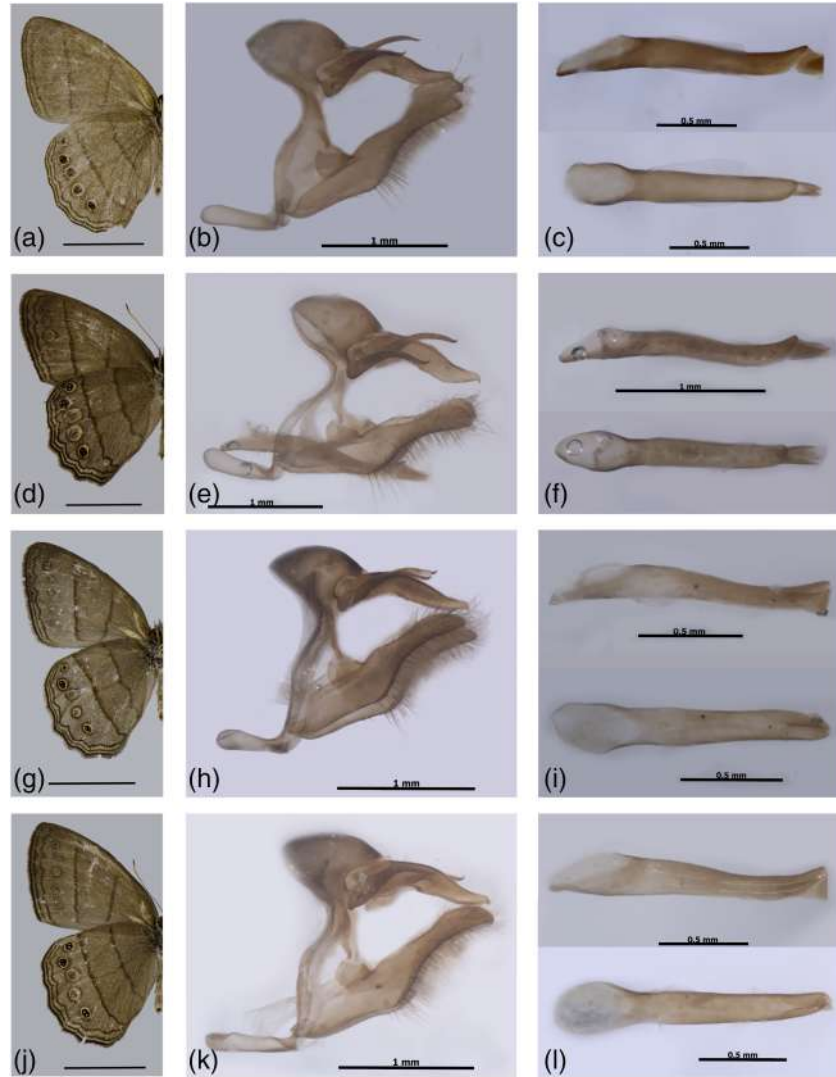


Fig. 5. Wing pattern and male genitalia variation in *Emeryus argulus*. (a–c) Amazonas, Brazil (DNA voucher YPH-0627). (d–f) Roraima, Brazil (DNA voucher YPH-0591), (g–i) Mato Grosso, Brazil (DNA voucher YPH-0684), (j–l) Mato Grosso, Brazil (DNA voucher YPH-0685). Scale bar = 1 cm.

Female genitalia. Only differs from characteristics listed in description section of *Emeryus* by papilla anales being broad at mid-ventral region, with a reduced ventral projection, posterior apophysis reduced and lamella antevaginalis ovoid and with lateral expansion at apical third in ventral view (Fig 8a,b).

Variation

In general, females are larger (FW length: 21–22 mm, $n = 10$) than males (FW length: 20–21 mm, $n = 10$; NT: 20 mm). A small incomplete ocellus can be present in CuA_2-2A on VHW, and the pupils of the ocellus in $Rs-M_1$ can be very close to each other giving the impression of only one pupil.

Ecology and distribution

This subspecies is restricted to South America, being found in Venezuela (Amazonas), Guyana (Essequibo), Suriname (Berg en Daal), French Guiana (Cayenne) and Brazil (Amazonas, Roraima, Pará, Tocantins and Maranhão) at altitudes below

150 m (Fig. 9 and Suppl. Mat. S1). It is also expected to occur in Colombia. According to the data gathered from specimens deposited in collections and reported in the literature, this species flies between February and November. It occurs in secondary forests (Brévignon 2008) and white-sand savanna with ‘campina’ vegetation (Fig. 10), although it was also reported as abundant at fruit baits in *Eucalyptus* plantation forests in Pará (Barlow *et al.* 2008). Hostplant and immature stages are unknown.

Emeryus argulus magnum Zacca, Casagrande & Mielke, ssp. nov.

(Figs 2e–h, 9)

<http://zoobank.org/urn:lsid:zoobank.org:act:62E4F4F8-AFAD-4AF0-8225-855CBC053659>

Ypthimoides argyrosipila (Butler 1867) [misidentification]; Mielke and Casagrande 1992: 180. – Mielke and Casagrande 1998: 469, appendix 6.

Material examined**Holotype**

Male with the following labels: /Holotypus/23-28.II.1988, [coordinates 3.416°–61.666°], Ilha de Maracá, Alto Alegre, RR [Roraima], Mielke & Casagrande leg./*Ypthimoides argyrospila* (Butler 1867), Mielke & Casagrande det. 1989/DZ 25.626/ Holotypus *Emeryus argulus magnum* Zacca, Casagrande & Mielke det. 2018/. DZUP.

Paratypes

– 8♂, 7♀ (3 specimens dissected). VENEZUELA – *Aragua*: Parque Nacional Henri Pittier, Rancho Grande, [10°20'58"N 67°41'3"W], 1125 m, 2♀, 21.VII.1979, J. B. Sullivan leg., FLMNH-MGCL-297369, FLMNH-MGCL-297370 (FLMNH); *Bolívar*: Santa Elena do Uairen, 850 m, 1♀, 18.VII.2009, Mielke & Casagrande leg., DZ 33.897* (DZUP). BRAZIL – *Roraima*: Ilha do Maracá, Alto Alegre, 2♂, 24-31.VIII.1987, Mielke & Casagrande leg., DZ 35.260, DZ 5.545* (DZUP), 5♂, 5♀, 23-28.II.1988, DZ 35.143, DZ 25.616, DZ 25.646, DZ 25.676, DZ 25.706, DZ 25.686, DZ 25.696, DZ 25.666 (DZUP), Serra dos Surucucus, 1♀, 16.XI.1979, Gifford leg., DZ 25.656 (DZUP), Amajari, Tepequén, 620 m, 1♀, 14-16.VII.2009, Mielke & Casagrande leg., DZ 35.210 (DZUP), Pacaraima, 800 m, 2♂, 1♀, 28-30.V.1988, Mielke & Casagrande leg., DZ 35.190, DZ 35.250, DZ 5.544* (DZUP).

Diagnosis

This subspecies differs from *Emeryus argulus argulus* by the paler VW and well-developed (occupying the entire cell) ventral ocelli on both wings (Fig. 2f,h).

Variation

Females are slightly larger (FW length: 21–23 mm, $n = 7$; AT: 21 mm) than males (FW length: 18–20 mm, $n = 7$; HT: 20 mm). A small incomplete ocellus may be present in CuA₂-2A on VHW, and the pupils of the ocellus in Rs-M₁ can be very close to each other, giving the impression of only one pupil.

Ecology and distribution

This subspecies is only known to occur in Venezuela (Aragua and Bolívar) and Brazil (Roraima) (Fig. 9 and Suppl. Mat. S1). It occurs in association with forested areas and dry savannas, at altitudes up to 1125 m. Data from specimens in collections and literature suggest that this taxon flies throughout the year. Hostplant and immature stages are unknown.

***Emeryus difficilis* (Forster, 1964), comb. nov.**

(Figs 2i-p, 3b-c, 6, 8c-d, 9)

Parypthimoides difficilis Forster, 1964: 107, fig. 108 (male genitalia), pl. 30, figs 11-12 (male); holotype: Rio Yacuma, Santa Rosa, Bolivia; ZSM. – Lamas 2004: 221.

Material examined

57♂, 46♀ (14 specimens dissected). BOLIVIA – *El Beni*: Paraparau, [13°49'29"S, 64°26'15"W], 147 m, 1♂, 1♀, 10.V.2004, W. Aliaga leg., MUSM-LEP-104126, MUSM-LEP-104129 (MUSM), 1♀, 16.V.2004, MUSM-LEP-104127 (MUSM), 1♀, 8.V.2004, MUSM-LEP-104128 (MUSM). BRAZIL – *Rondonia*: Pimenta Bueno, 1♂, 1♀, no data, M. P. Guimarães leg., DNA voucher YPH-0652, ZUEC-LEP 10675, DNA voucher YPH-0654, ZUEC-LEP 10676* (ZUEC); *Tocantins*: Rio Araguaia, Xambioá, 6°26'S, 48°34'W, 1♂, 30.VII.2009, no collector, DNA voucher PM 01-28 (ZUEC-AVLF); *Maranhão*: Imperatriz, 1♂, 9.VII.1974, Ex[pedition] Dept. Zoologia, DZ 24.429 (DZUP), 1♀, 18.VII.1974, DZ 28.430* (DZUP), 1♂, 29.VII.1974, DZ 28.432* (DZUP). *Mato Grosso*: Alta Floresta, Cachoeira Sete Quedas, 1♂, 21.IV.2009, no collector, MGCL-LOAN-288 (ZUEC), Alto Araguaia, 1♀, 11.XII.2009, R. Dell'Erba & E. D. Zillmer leg., ZUEC-LEP 8556 (ZUEC), Alto Araguaia, 35 Km NW, Alto Garças road, 4♂, 1♀, 28.VI.1971, K. Brown leg., ZUEC-LEP 10674, ZUEC-LEP 10670, ZUEC-LEP 10669, ZUEC-LEP 10667, ZUEC-LEP 10665 (ZUEC), Alto Rio Paraguai, Barra do Bugres, 150 m, 1♂, 26-29.VII.1974, H. & H. D. Ebert leg., DZ 28.455* (DZUP), Chapada dos Guimarães, Buriti, 700 m, 1♂, 1♀, 27.VIII.1978, ex-coll. H. Ebert, DZ 28.449, DZ 28.450 (DZUP), 1♀, 26.V.1969, K. Brown leg., ZUEC-LEP 10673 (ZUEC), Cárceres, 1♂, 1♀, 9-11.XI.1984, Buzzi, Mielke, Elias & Casagrande leg., DZ 28.426*, DZ 38.023* (with first instar cephalic capsule inside) (DZUP), Diamantino, Fazenda São João, 1♀, 16.I.1978, Mielke & Furtado leg., DZ 36.902 (DZUP), 1♂, 28.IV.1978, H. & H. D. Ebert leg., DZ 28.428 (DZUP), 1♀, 5.V.1978, H. & H. D. Ebert leg., DZ 28.438 (DZUP), 300-400 m, 1♂, 2♀, 1-8.VIII.1974, H. Ebert leg., DZ 28.446, DZ 28.452, DZ 28.446 (DZUP), 1♂, 1♀, 24.VII.1975, DZ 28.442, DZ 28.441 (DZUP), 3♂, 27.VII.1975, DZ 28.451*, DZ 25.705, DZ 28.437 (DZUP), 1♂, 5.X.1975, E. Furtado leg., DZ 28.436 (DZUP), 1♂, 1♀, 28.IV.1978, DZ 28.439*, DZ 28.435 (DZUP), 1♂, 4.V.1978, E. Furtado leg., DZ 28.445 (DZUP), 2♂, 11.VIII.1978, H. Ebert leg., DZ 28.457, DZ 28.443 (DZUP), 1♀, 14.VIII.1978, DZ 28.453 (DZUP), 3♂, 3♀, 17.VIII.1978, DZ 28.434, DZ 28.454, DZ 28.444, DZ 28.447, DZ 28.440, DZ 28.434 (DZUP), Jangada, 4♂, 2♀, 8.I.2010, G. Both & G. Noletto leg., ZUEC-LEP 8602, ZUEC-LEP 8627, ZUEC-LEP 8642, ZUEC-LEP 8599, ZUEC-LEP 8669, ZUEC-LEP 8718 (ZUEC), 3♂, 3♀, 09.I.2010, G. Both & G. Noletto leg., ZUEC-LEP 8662, ZUEC-LEP 8600, ZUEC-LEP 8589, ZUEC-LEP 8665, ZUEC-LEP 8666, ZUEC-LEP 8672 (ZUEC), 2♂, 3♀, 10.I.2010, G. Both & G. Noletto leg., DNA voucher YPH-0659, ZUEC-LEP 10661*, ZUEC-LEP 8667, DNA voucher YPH-0656, ZUEC-LEP 10678, ZUEC-LEP 8611, ZUEC-LEP 8656 (ZUEC), 2♂, 4♀, 11.I.2010, G. Both & G. Noletto leg., DNA voucher YPH-0657, ZUEC-LEP 10664, DNA voucher YPH-0658, ZUEC-LEP 10663, DNA voucher YPH-0655, ZUEC-LEP 10662*, ZUEC-LEP 8593, ZUEC-LEP 8614, ZUEC-LEP 8652 (ZUEC), 3♂, 3♀, 12.I.2010, G. Both & G. Noletto leg., ZUEC-LEP 8644, ZUEC-LEP 8605, ZUEC-LEP

8606, ZUEC-LEP 8668, ZUEC-LEP 8620, ZUEC-LEP 8659 (ZUEC), 1♂, 18.VIII.2010, G. R. Soares *leg.*, DNA voucher YPH-0653, ZUEC-LEP 10677* (ZUEC), Nova Xavantina, Bacaba, UNIMAT, 1♀, 17–19.VIII.1997, Mielke *leg.*, DZ 35.581 (DZUP), Xavantina, 2♂, 11.I.1977, ex-coll. Gifford, DZ 31.151, DZ 31.211 (DZUP); *Mato Grosso do Sul*: Três Lagoas, 1♂, 9.XI.2007, A. Freitas *leg.* (ZUEC), 20°45'S 51°40'W, 2♂, 17.VIII.2007, M. Uehara-Prado *leg.*, ZUEC-LEP 5264, ZUEC-LEP 5262 (ZUEC), 1♂, 1♀, 18.VIII.2007, M. Uehara-Prado *leg.*, ZUEC-LEP 5273, ZUEC-LEP 5274 (ZUEC); *Goiás*: Goiás Velho, 1♂, 15.VI.1976, D. Gifford *leg.*, DZ 31.201 (DZUP), Iporá, 22 km W, 420 m, 1♀, 21.VI.1972, Mielke & Brown *leg.*, DZ 28.456* (DZUP), 3♀, K. Brown *leg.*, ZUEC-LEP 10671, ZUEC-LEP 10668, ZUEC-LEP 10666 (ZUEC), 26 km W, 420 m, 1♂, 21.VI.1972, Mielke & Brown *leg.*, DZ 28.427 (DZUP), Alto Araguaia, Jataí, Mineiros road Km 123, 17°23'23.50"S 52°38'53.74"W, 1♀, 19.V.1969, K. Brown *leg.*, ZUEC-LEP 10672 (ZUEC), Serra Dourada, [14°40'S 49°16'W], 4♂, 4♀, no date, C. J. Callaghan *leg.*, FLMNH-MGCL-297357, FLMNH-MGCL-297358, FLMNH-MGCL-297359, FLMNH-MGCL-297360, FLMNH-MGCL-297361, FLMNH-MGCL-297362, FLMNH-MGCL-297364, FLMNH-MGCL-297365 (FLMNH); *Minas Gerais*: Corinto, 1♂, 10.X.1979, C. Elias *leg.*, BC-DZ Unicamp 2017, DZ 28.448 (DZUP). PERU – *Madre de Dios*: Río Heath, Pampas del Heath, [12°30'S 68°39'W], 200 m, 1♂, 28.XI–14.XII.2011, J. Cerdeña *leg.*, MUSM-LEP-104125 (MUSM).

Diagnosis

This species resembles *E. numeria* but differs from it by the VW having a darker ground colour, the median and submarginal lines being more crenulated and the lateral expansion of the lamella antevaginalis being broader and reaching the eighth tergite (Fig. 8c,d). The wing pattern of *E. difficilis* resembles that of some species of *Hermeuptychia* (see Seraphim *et al.* 2013), but the species can be distinguished by the absence of a male androconial patch on the DFW in *E. difficilis* (also absent in some *Hermeuptychia*), the dark line on the lower disco cellular vein on both VW (present in *Hermeuptychia*), absence of the ocellus at CuA₂-2A on the VHW (present in *Hermeuptychia*), and the submedian, median and marginal lines being crenulated on the VHW, as well as the outer margin (straight in *Hermeuptychia*).

Remarks

Forster (1964) described *Paryphthimoides difficilis* based on a male holotype from Santa Rosa, Beni, Bolivia (Fig. 4b). A female specimen labelled as the allotype of *P. difficilis* from Rio Yacuma, Espirito, Beni (Fig. 4c), was also found at the ZSMS (where Forster's types are deposited); this specimen was not mentioned in the original description, but it is possible Forster missed including this information, since the handwritten label is similar to that of other specimens described by Forster (i.e. *Euptychia hannemanni* Forster, 1964, *Euptychoides pseudosaturanus* Forster 1964). Lamas (2004) followed Forster's

taxonomy for this species, and no taxonomic changes have been proposed until the present study. *Emeryus difficilis* seems to be rare in collections, and it has not been mentioned in inventories or lists compiled in localities where the species is very likely to occur (Brown and Mielke 1967; Motta 2002; Emery *et al.* 2006; Pinheiro and Emery 2006; Silva *et al.* 2010; Queiroz-Santos *et al.* 2016).

Male genitalia. Only differs from characteristics listed in description section of *Emeryus* by uncus about 2/3 length of tegumen and dorsally elliptical, appendix angularis curved inwards, anterior projection of saccus short valva with apex pointed and aedeagus same length as valva (Fig. 6).

Female genitalia. Only differs from characteristics listed in description section of *Emeryus* by papilla anales narrow at mid-ventral region, posterior apophysis reduced and curved upwards, lamella antevaginalis trapezoidal corpus bursae with paired signa latero-ventrally (Fig. 8c,d).

Variation

There is slight sexual dimorphism with females (FW length: 20–23 mm, $n = 5$) being larger than males (FW length: 17–20 mm, $n = 5$). The wing phenotype can vary among individuals collected in dry and wet seasons throughout the distribution; in the former, ventral wings are covered by lighter flecked scales which gives a 'sprinkled pattern' to the wing (Figs 2m–p and 6a,d). However, in transitional months (August to October), individuals can be observed displaying both wing phenotypes. The male and female genitalia can exhibit some variation in their morphology (Fig. 6). The combination of the ventral arms of tegumen and dorsal arms of saccus can vary in the degree of sinuosity, and the aedeagus can be smaller than the valva in some observed individuals. In the female genitalia, the apophysis posterior of the papilla anales can vary in size, and the corpus bursae can be longer than the ductus bursae.

Ecology and distribution

This species has been found in the province of Beni (Bolivia) and in the states of Rondônia, Tocantins, Maranhão, Mato Grosso, Mato Grosso do Sul, Goiás and Minas Gerais (Brazil) in association with open savannah, primary and secondary growth vegetation and riparian areas (Fig. 9 and Suppl. Mat. S1). This species apparently flies throughout the year. Hostplant and immature stages are unknown.

Emeryus numeria (C. Felder & R. Felder, 1867), comb. nov.

(Figs 2q–t, 3d, 7, 8e,f, 9)

Neonympha numeria C. Felder & R. Felder, 1867: 478; syntypes: [Brazil] Bahia; Lectotype here designated: [Brazil] Bahia; NHMUK.

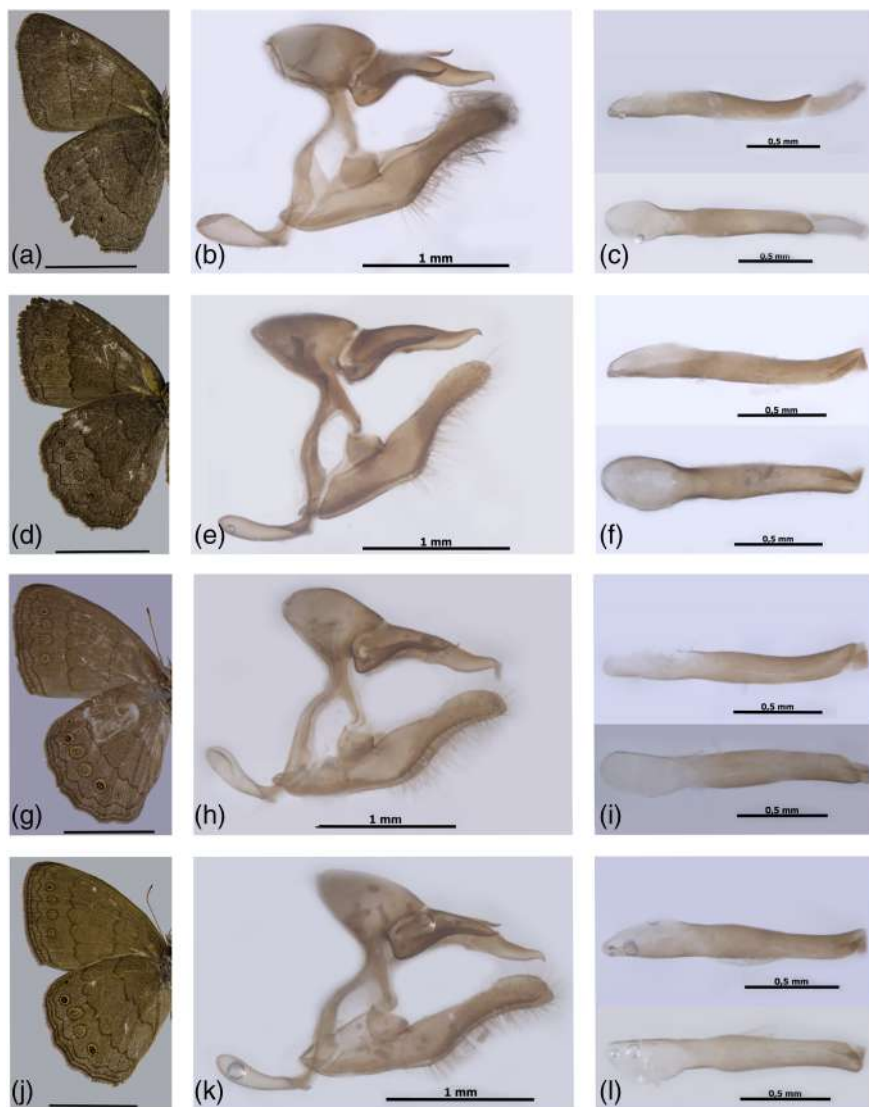


Fig. 6. Wing pattern and male genitalia variation in *Emeryus difficilis*. (a–c) Mato Grosso, Brazil (DNA voucher YPH-0653), (d–f) Rondônia, Brazil (DNA voucher YPH-0654), (g–i) Mato Grosso, Brazil (DNA voucher YPH-0655), (j–l) Mato Grosso, Brazil (DNA voucher YPH-0659). Scale bar = 1 cm.

Euptychia ambigua Butler, 1867: 472, fig. 10; syntypes: [Brazil] Rio de Janeiro; Lectotype here designated: [Brazil] Rio de Janeiro; NHMUK. – Butler 1877: 123. – Bryk 1953: 61.

Material examined

13♂, 10♀ (3 specimens dissected). BRAZIL – *Piauí*: Piracuruca, Parque Nacional Sete Cidades, 2♂, 18–21.IV.2012, O. Mielke & Casagrande leg., DZ 31.181, DZ 31.191 (DZUP); *Pernambuco*: Camaragibe, 1♀, 4.VIII.1957, ex-coll. H. Ebert, DZ 31.162* (DZUP), 1♂, 3.X.1957, DZ 31.202 (DZUP), 1♂, 7.IX.1959, DZ 31.183 (DZUP), Igarassu, 1♀, no data, Rothschild Bequest B. M. 1939-1, BMNH(E) 1422088 (NHMUK), Recife, Várzea, 25 m, 2♀, 25.IX.1957, ex-coll. H. Ebert, DZ 34.795, DZ 31.163 (DZUP), 1♂, 6.X.1957, ex-coll. H. Ebert, DZ 31.161* (DZUP), 1♂, 27.VIII.1960, DZ 31.172 (DZUP), 1♂, 13.X.1960, DZ 31.173 (DZUP), 1♀, 7.X.1961, Ebert leg., DZ

31.171* (DZUP), 1♂, 7.X.1961, DZ 31.203 (DZUP), 1♂, 7.X.1969, Ebert leg., DZ 31.193 (DZUP), São Lourenço da Mata, 1♂, 1♀, 15.VII.1973, Mielke & Kesselring leg., DZ 28.431, DZ 31.182 (DZUP), Tiama, 100 m, 1♂, 3.VIII.1958, H. Ebert leg., DZ 34.805 (DZUP), 1♀, 20.VII.1958, DZ 25.636 (DZUP), 1♀, 8.XI.1958, DZ 31.212 (DZUP), 1♂, 27.VII.1959, Ebert leg., DZ 31.200 (DZUP), 1♀, 26.V.1960, DZ 31.152 (DZUP), 1♂, 15.II.1969, DZ 31.153 (DZUP), 1♀, 5.VIII.1969, DZ 31.213 (DZUP).

Diagnosis

This species resembles *Emeryus difficilis* in its wings pattern, but it can be distinguished from that species by the larger ocelli on VHW and the less crenulated (almost straight) median line on the VFW and VHW.

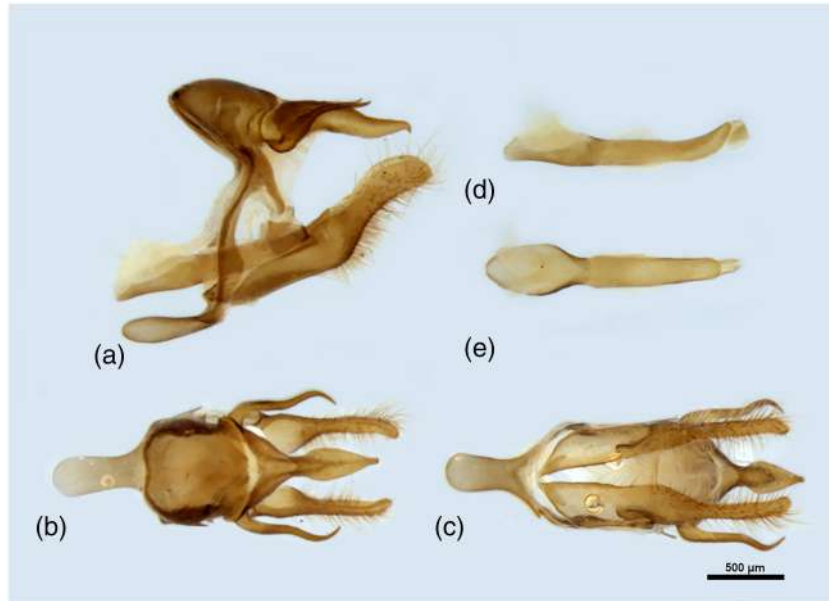


Fig. 7. Male genitalia of *Emeryus numeria* (DZ 31.183): (a) lateral, (b) dorsal, (c) ventral, (d) aedeagus, lateral, (e) aedeagus, dorsal.

Remarks

Neonympha numeria was described based on an unstated number of specimens from Bahia, Brazil. One male syntype was found at NHMUK, and it is herein designated as the lectotype of *Neonympha numeria* (Fig. 4d) to fix the identity of the name, since its wing pattern resembles that of other Euptychiina species. This male lectotype has the following labels: /Felder Coll [ectio]n/Bahia, Luschnath type/numerica Feld[er]/Rothschild Bequest B.M. 1939-1/ /Type ♂ *N. numeria* Feld. = ♂ of *E. ambigua* Butl[er]. comp[ared]. w[ith]. type, 10.XII.12. All

ocelli identical. Butler's ♀ has transverse lines on underside rather more wavy [handwritten]/BMNH(E) 1422119/; and two others labels will be added later: /Lectotype/ Lectotype *Neonympha numeria* C. Felder & R. Felder, 1867. T. Zacca, det. 2016/NHMUK. Another female specimen from Iguarassu, Pernambuco, Brazil, was also found at the NHMUK, but this specimen is not part of the type series.

Euptychia ambigua Butler 1867 was described based on an unstated number of specimens from Rio de Janeiro, Brazil. One syntype without an abdomen (but apparently a female based

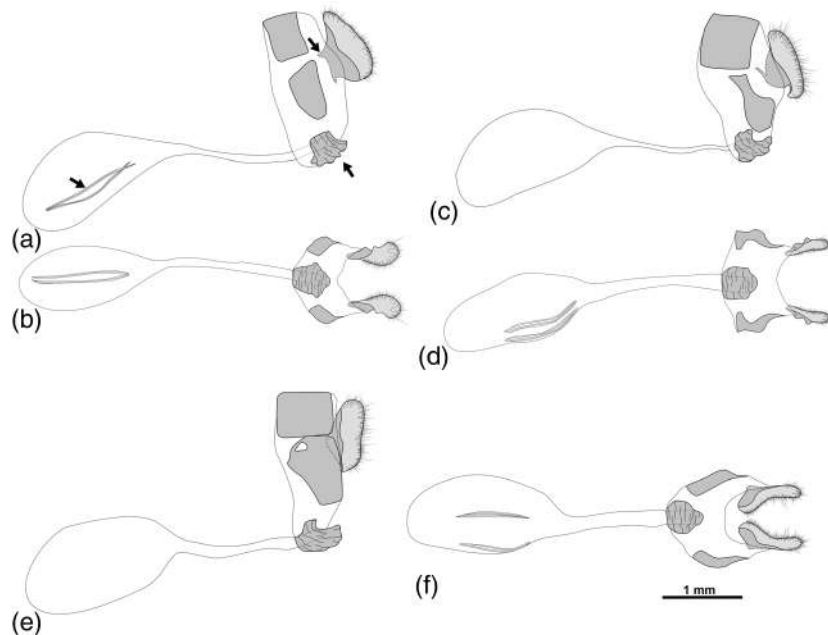


Fig. 8. Female genitalia of *Emeryus argulus argulus* (DZ 33.895): (a) lateral, (b) ventral. *Emeryus difficilis* (DZ 38.023): (c) lateral, (d) ventral. *E. numeria* (DZ 28.430): (e) lateral, (f) ventral.

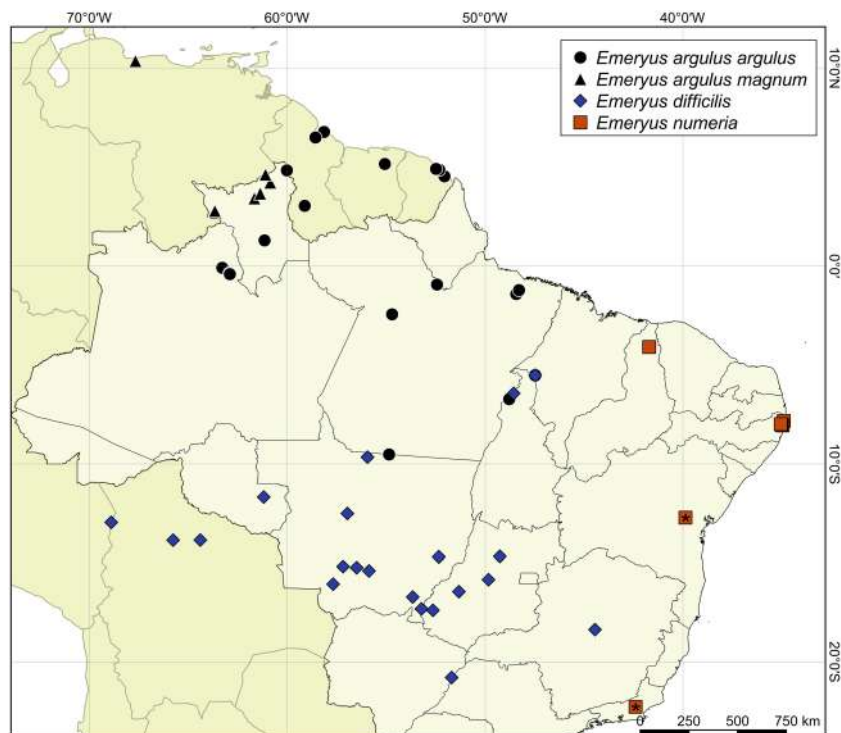


Fig. 9. Map showing the distribution of *Emeryus* gen. nov. species. ‘*’ = no specific locality.



Fig. 10. *Emeryus argulus argulus*: (a) live adult in Surama, Guyana (photo: D. Geale). White-sand savanna with typical ‘campina’ vegetation in Barcelos, Amazonas, Brazil: (b) Campina Tucano (photo: R. Ramos), (c,d) Boca do Aracá (photos: R. Ramos (c), A. Rosa (d)).

on the rounded FW) was found at NHMUK (Fig. 4d), and this specimen is herein designated as the lectotype of *E. ambigua* to fix the identity of the name, since its wing pattern resembles that of other Euptychiina species. This lectotype specimen has the following labels: /Type/*Euptychia ambigua* Butler Monog

[raph]/B. M. TYPE No Rh 3212 *Euptychia ambigua* ♂ Butl [er]/Rio de Janeiro, Pres by Mrs Smith 52-52/Rio/BMNH(E) 1267065; and two others will be added later: /Lectotype/Lectotype *Euptychia ambigua* Butler 1867. T. Zacca, det. 2016/NHMUK.

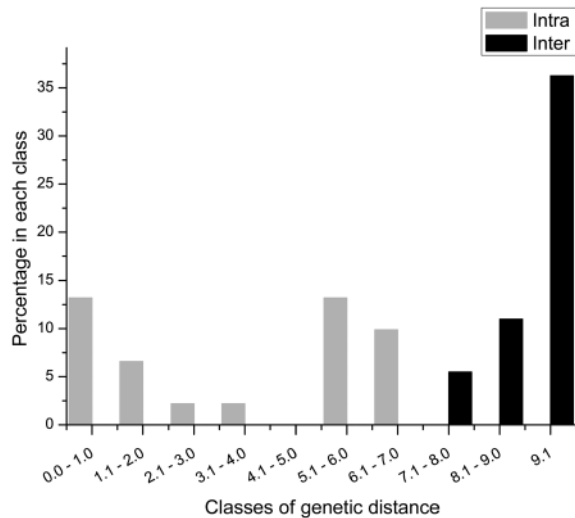


Fig. 11. Intraspecific (grey bars) and interspecific (black bars) frequency distribution (%) of pairwise individual genetic distances based on the COI in *Emeryus argulus* and *Emeryus difficilis*.

Male genitalia. Only differs from characteristics listed in description section of *Emeryus* by uncus being about 2/3 length of tegumen and dorsally elliptical, anterior projection of saccus almost same length as gnathos, valva with apex wide, aedeagus smaller than valva with posterior region about 1 1/2 times longer than anterior region (Fig. 7).

Female genitalia. Only differs from characteristics listed in description section of *Emeryus* by lamella antevaginalis being trapzoidal (Fig. 8e,f).

Variation

There is slight sexual dimorphism with females (FW length: 20–21 mm, $n = 5$) larger than males (FW length: 17–19 mm, $n = 5$).

Ecology and distribution

This species is widely distributed in north-eastern Brazil (Piauí, Pernambuco and Bahia), with a single record supposedly from Rio de Janeiro (the lectotype of *E. ambigua*) (Fig. 9 and Suppl. Mat. S1). It occurs in association with forested and open vegetation areas in the Atlantic forest, from sea level to 200 m. Data from specimens in collections and literature suggest that *E. numeria* flies from February to October. Hostplant and immature stages are unknown.

DISCUSSION

Our molecular phylogeny together with morphological evidence shows *Emeryus* is a well-supported clade, comprising three species, *Emeryus argulus* comb. nov., *E. difficilis* comb. nov. and *E. numeria* comb. nov., distinct from the type species of *Paryphthimoides*, *P. poltys* (Prittwitz, 1865). The three species of *Emeryus* were never sampled nor included in previous

molecular phylogenies of Euptychiina (Murray & Prowell 2005; Peña *et al.* 2006, 2010; Wahlberg *et al.* 2009; Marín *et al.* 2017; Espeland *et al.* 2019). The relationship between *E. argulus* and *E. difficilis* might change with the inclusion of *E. numeria* in future molecular analysis, since our attempt to sequence the DNA of this species was unsuccessful. In the present study, *E. numeria* is included in the genus based only on morphological evidence.

Additional molecular phylogenies inferred by us and our colleagues using much more extensive sampling of >400 species of euptychiines (*E. Barbosa*, M. Espeland & K. Willmott unpub. data) also support the monophyly of *Emeryus*, and the lack of an obvious close sister group could be evidence of rapid evolution that potentially only genomic data at the subtribe level might resolve. Notably, this situation is not exclusive to *Emeryus* with similar cases for other recently described small Euptychiina genera, such as *Cristalinaia* (see Freitas *et al.* 2019) and *Amiga* (see Nakahara *et al.* 2019a).

The low number of specimens of *Emeryus* in collections is likely partly related to the drab colouration and small size of its species, which may prove unpopular with collectors. Nevertheless, species of *Emeryus* are easily captured in fruit baited traps, so inventories of butterflies should include these methods to enhance studies of the spatio-temporal variation of *Emeryus* species and other frequently overlooked euptychiine butterflies.

Structures of the male genitalia in butterflies have considerable taxonomic value, being useful for the delimitation of taxa at generic and specific levels in Euptychiina (e.g. Forster 1964; Freitas *et al.* 2016, 2018; Zacca *et al.* 2013, 2018). The morphology of the male and female genitalia of *Emeryus* species is indeed helpful in distinguishing the genus from other genera of Euptychiina. However, male genitalia structures are highly conserved among the species of *Emeryus*, a similar condition also reported in the *F. boliviana*-group of *Forsterinaria* (Peña and Lamas 2005). On the other hand, wing pattern characters and the morphology of the female genitalia (e.g. the wrinkled appearance of the sclerotised lamella antevaginalis and the posterior projection and shape of the papilla anales) allow easy recognition and delimitation of the species of *Emeryus*. However, the marked seasonal variation in the wing pattern of *E. difficilis*, which can impede its prompt recognition, is a phenomenon also reported in other Euptychiina species from the Brazilian seasonal savannahs (Freitas 2007; Freitas *et al.* 2010; Siewert *et al.* 2013; Zacca *et al.* 2014; Freitas *et al.* 2016; Barbosa *et al.* 2018) and that should be investigated in more detail.

In the case of *E. argulus*, the homogeneity of the genitalia morphology in association with the allopatric distribution and other differences in the wing pattern led us to describe the new subspecies *E. argulus magnum* which is restricted to Brazil (Roraima) and Venezuela (Aragua and Bolívar). Furthermore, *Emeryus argulus argulus* and *E. argulus magnum* differ in several ecological aspects. *Emeryus argulus argulus* seems to be restricted to lowlands areas at altitudes up to 150 m, while *E. argulus magnum* has a broad altitudinal range (200–1125 m). While *E. argulus magnum* is restricted to dry savanna areas in the Amazon basin (except by the record in Aragua, Venezuela), *E. argulus argulus* seems to be more associated with forested areas in the Amazon, as well as the Iwokrama forests

that harbour a mixture of Guianan and Amazonian fauna and flora (Clarke *et al.* 2001), in addition to white-sand savanna with ‘campina’ vegetation. Interestingly, some habitats where *E. argulus argulus* occurs in Brazil (Amazonas, Barcelos) (Fig 10b–d) and Guyana (Surama) are areas that are flooded during the rainy seasons (Clarke *et al.* 2001; R. Ramos, *pers. comm.*). Unfortunately, we did not have success in sequencing DNA from individuals of this subspecies, likely due to preservation of available specimens in naphthalene or phenol and their age, a similar problem also observed in sampled specimens of *E. numeria*.

A high level of variation was observed in the ground colour of the wings, and the shape and size of the ventral ocelli of some specimens of *E. argulus argulus* from Barcelos, Amazonas, Brazil (Fig. 10b–d). Two distinct wing pattern phenotypes were observed in the population of Barcelos, but we did not find any differences in the genitalia morphology between the phenotypes (Fig 5a–f), the genetic divergence was only 0.007% across the phenotypes and these phenotypes are not reciprocally monophyletic. A similar case was also observed in the populations of *E. difficilis*, which had two wing phenotypes (‘typical’ vs. ‘sprinkled pattern’), but no differences in the genitalia morphology. Interestingly, intraspecific genetic divergences within *Emeryus argulus* and *E. difficilis* (0–6.8%) are relatively similar to those found in some species of *Ypthimoides* (0–8% – Barbosa *et al.* 2015, 2016) and *Amiga* (c. 6% – Nakahara *et al.* 2019a) but higher than has been reported in other Euptychiina genera, such as *Hermeuptychia* (0–3% – Seraphim *et al.* 2013), *Nhambikuara* (0–2% – Freitas *et al.* 2018), *Moneuptychia* and *Cissia* (0–3.5% – Freitas *et al.* 2015; Zacca *et al.* 2018). Considering the significant variation in the wing pattern, the homogeneous morphology of the genitalia and high intraspecific genetic divergence, (Fig. 11) future studies examining the population structure of *Emeryus argulus* and *E. difficilis* in greater depth would be valuable to explore the possibility of cryptic diversity within each species.

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Data S1. Supporting info item