Mitt. Münch. Ent. Ges.	**107**	5-18	München, 15.10.2017	ISSN 0340-4943

Revision of the neotropical *Rhodochlora exquisita* species-group, with description of three new species (Geometridae, Geometrinae)

Axel HAUSMANN

Abstract

Eight species of the *exquisita* species-group of the genus *Rhodochlora* WARREN, 1894 are revised using and combining characters of external and internal morphology as well as molecular data from the DNA barcoding region (COI 5'). All relevant type specimens have been examined. Phylogeny and possible relationships for the genus are discussed. Three new species are described: *Rhodochlora claushippi* sp. n. from Ecuador, *Rhodochlora sordida* sp. n. from western Colombia, *Rhodochlora brechlini* sp. n. from central Colombia.

Introduction

The present study is a fruit of two major research and collecting activities in the Neotropics, the first having been initiated approx. ten years ago by Thomas GREIFENSTEIN (Pfaffenhofen, Germany), Robert BECK (Munich) and Hubert THÖNY (Brazil) at the Bellavista Station, 30km west of Quito in the western part of the Ecuadorian Andes chain. In 2016 the HIPP company (baby foods) decided to give financial support to extended biodiversity research at the Bellavista Lodge in order to foster protection of Neotropical biodiversity. For this purpose, the Bavarian State Collection of Zoology, Munich (ZSM) cooperates with the Museum Witt, Munich and – based on the agreements of a Memorandum of Understanding (2015) – with the Pontifica Universidad Catolica de Quito (PUCE, facultad de ciencias exactas y naturales). The second research and collecting activity was organized, in the past ten years, by Dr. Ron BRECHLIN (Pasewalk) in several South American countries, with major collecting activities by Viktor SINYAEV (Moscow). The geometrid samples are investigated at the ZSM. For the present paper Sinyaev's expeditions to Ecuador (Bellavista station, see above, and other localities) and Colombia are particularly important.

The genus *Rhodochlora* WARREN, 1894 includes the largest representatives of the Neotropical emerald moths (Geometrinae) and currently includes 14 species and 4 additional taxa at subspecies rank (SCOBLE 1999; SCOBLE & HAUSMANN 2007). DNA barcodes from 124 specimens cluster to 39 BINs (a good proxy for species), suggesting a surprisingly high amount of undescribed diversity considering the colourful and beautiful appearance of the members of this genus which has not seen any comprehensive taxonomic analysis in the past 85 years after PROUT (1932), the treatment in literature being restricted to the genus description and checklist given in PITKIN (1996). The high rate of cryptic diversity may be explained by (often) minor differences in colouration between species, and by the large intraspecific variability and the considerable sexual dimorphism, offering problems to taxonomic analyses. The aim of this paper is to revise, in an integrative approach (GOLDSTEIN et al. 2010; PADIAL et al. 2010; HAUSMANN 2011), the *exquisita* species-group which appears to be a well defined and putatively monophyletic sub-group within the genus *Rhodochlora*.

So far, no host-plants were known for this genus, but recently caterpillars have been found on and reared with *Clusia* (Clusiaceae) (pers. comm. Dan H. JANZEN & Winnie HALLWACHS).

Material and Methods

Abbreviations

BIN Barcode Index Number

BOLD Barcode of Life Data System

COI mitochondrial cytochrome c oxidase I (COI) gene, region near the 5' terminus (barcode fragment, 658 bp)

NHMUK	Natural History Museum, London, U.K.
USNM	Smithsonian Institution, United States National Museum, Washington, U.S.A.
ZSM	Zoologische Staatssammlung München (Bavarian State Collection of Zoology, Munich) in SNSB (Staatliche Naturwissenschaftliche Sammlungen Bayerns)

Sampling and morphological analysis

Altogether >600 specimens of *Rhodochlora* were examined at the ZSM, 94 belonging to the *exquisita* species-group. In addition, type specimens have been studied at the NHMUK, in the case of the type of *R. gaujoniaria* (USNM), good photographs were available of upper- and underside, as well as of the labels. Dissection and preparation of genitalia slides were performed applying standard protocols (cf. ROBINSON 1976), the genitalia are embedded in Euparal. Dissections were restricted to males because females were available just for two of the eight species in the *exquisita* species-group. Measurements were done with a reticule in a Wild M3Z microscope.

DNA Analysis

DNA sequencing was performed at the CCDB following standard high-throughput protocols (IVANOVA et al. 2006; DEWAARD et al. 2008). PCR amplification with a single pair of primers consistently recovered a 658 bp region near the 5' terminus of the mitochondrial cytochrome *c* oxidase I (COI) gene that included the standard 648 bp barcode region for the animal kingdom (HEBERT et al. 2003). DNA extracts are stored at the CCDB, with aliquots being deposited in the DNA-Bank facility of the ZSM (see http://www.zsm.mwn.de/dnabank/). All sequences are deposited also in GenBank according to the iBOL data release policy. Complete specimen data including images, voucher deposition, GenBank accession numbers, GPS coordinates, sequence and trace files can be accessed in the Barcode of Life Data System (RATNASINGHAM & HEBERT 2007; RATNASINGHAM 2017) in the dataset (DS-RHODOCHL).

Data Analysis

Sequence divergences for the barcode region were calculated using the Kimura 2 Parameter model, employing the analytical tools on BOLD. Genetic distances between species are reported as minimum pairwise distances, while intraspecific variation is reported as maximum pairwise distances. Species delimitation was investigated using the BIN system as implemented on BOLD (RATNASINGHAM & HEBERT 2013).

Systematic account

Rhodochlora WARREN, 1894

Rhodochlora WARREN, 1894: Novit. zool. 1: 385.

Type species (by original designation): *Achlora roseipalpis* FELDER & ROGENHOFER, 1875. Reise öst. Fregatte Novara (9), 2(Abt.2): pl.127, fig.33.

Differential diagnosis: Large (wingspan 33-50 mm), colourful geometrines, characterized by a semitransparent basal area of hindwing. Forewing apex slightly tapering. Hindwing termen rounded. Ground colour green, readily fading under wet conditions. Postmedial line usually conspicuous on all wings, reddish, zigzagging. Abdominal crests absent. Frons usually red with orange scales, sometimes brown or black. Palpi usually reddish, of medium length in male, longer in female (2-3 times diameter of eye). Proboscis present. Antennae bipectinate in male, filiform in female. Legs white, checkered with black spots. Foretibia of both sexes short, with small dark pencil and epiphysis (claw). Male hindtibia usually with four spurs (both pairs very close to each other), in some species, however, with terminal pair of spurs only. Frenulum developed as a single stout bristle in male, as a weak brush of bristles or almost absent in female. Venation with all characteristics of subfamily Geometrinae (cf. HAUSMANN 2001), on forewing R1 arising slightly separate from origin of R2-R5, R2-R4 and R5 stalked. On hindwing Rs and M1 distinctly stalked. Male genitalia with narrow, rod-shaped uncus, socii long, stoutly sclerotized, obliquely or rectangularly diverging from uncus, transtilla flat, bilobed, valva usually narrow, base of valva with posterior process at junction with transtilla, coremata absent, sternum A8 long, with a more or less sclerotized mid-rib, posteriorly bilobed. *R. rufaria* shows strongly modified genitalia (see below), the close relationship, however, is supported by COI similarity.

Biology: So far, no larval host-plant is known for any of the described species. Female ratio low at light. Most records from mountainous habitats (1300 m up to 3000 m a.s.l.).

Remarks: In the original description, WARREN (1894) suggests relationship with the Indo-Pacific genus *Aporandria* GUENÉE, 1858. COI data (>10% distance) and genitalia do not confirm this hypothesis. Currently, the genus *Rhodochlora* is included into the tribe Nemoriini (PITKIN 1996; VIIDALEPP 2017).

The *exquisita* species-group

The male hindtibia character (presence of pencil / number of spurs) was used by PROUT (1932) to subdivide the genus into two groups, a grouping which cannot be confirmed as natural by the present study. There are at least two sister species pairs with different number of male hindtibial spurs. The „*exquisita* species-group" is defined here as those six species which show close similarity in the COI gene (clustering separately from all other *Rhodochlora* species (Figs 18, 19) and which are characterized by their dirty green ground colour and the extended red suffusion, mainly in the medial area of the hindwing and in the tornal area of the forewing. *R. rufaria* shows strongly modified genitalia (see below) but COI similarity justifies inclusion in the *exquisita* species-group. On the grounds of the congruous wing colouration, *R. mathani* and *R. niepelti* are tentatively added to this group of six species (cf. preliminary check-list below). The very long aedeagus with terminal, paired spinulose crests seems furthermore to suggest their relationship with *R. rufaria*.

Rhodochlora exquisita WARREN, 1905

Rhodochlora exquisita WARREN, 1905: Novit. Zool. 12: 320 (south-eastern Peru, Carabaya, Santo Domingo, 6500ft). Holotype ♂ (NHMUK, examined).

Material examined: ♂ holotype (see above); 1♂, Costa Rica, Moravia, Fils Talamanca, 1400m, VII/83, leg. C. Moinier, coll. Herbulot/ZSM, DNA barcode sample ID BC ZSM Lep 69504; 2♂♂, Bolivia, Coroico, Rte. Unduavi, 2800m, XII-1981, leg. G. Jeannot, G. Lachaume, coll. Herbulot/ZSM; 1♂, Ecuador, Pichincha Prov., Rio Pachijal, los Bancos, 0°04‘06“ N, 78°54‘17“ W, 29.10.2011, 928m, leg. V. Sinyaev & Oleg Romanov, coll. ZSM; 1♂, Ecuador, Pichincha, 3.5km S Tandyapa, Bellavista-Lodge, 2310m, 0°01‘19“ S, 78°41‘15“ W, 3.-16.X.2008, leg. R. Beck & M. Dietl, coll. ZSM, 1♂, Colombia, Antioquia, Municipio de Yarumal, Vereda Ventanita, 2020m, 7°04’15” N, 75°26’59” W, 1.-4.XII.2014, leg. V. Sinyaev, M. Marquez, J. Machado, ex coll. R. Brechlin, coll. ZSM; 1♂, Colombia, Cundinamarca, Municipio de Gachala, Vereda Tunja, 1600m, 4°53’33” N, 73°30’24” W, 1.-3.IV.2015, leg. V. Sinyaev, ex coll. R. Brechlin, coll. ZSM.

Diagnosis: PROUT (1932): „Forewing apex falcate, antemedian line conspicuously red, tornus blotch large, conspicuous. Postmedial line of hindwing more distally than in close allies. Proximal spurs vestigial in male, without pencil“. The examined specimens perfectly agree with that description and with the holotype. Further characters: Wingspan male 33-41 mm. Frons red-brown, specimens from Ecuador and Costa Rica with paired white-scaled patches in the ventral half. Length of male palpi 1.1-1.3 times diameter of eye. Forewing cell spots conspicuous, hindwing with an elongate red shadow from antemedial line to apex. Transverse lines red on all wings. On the forewing differing from the other species with falcate forewing apex (*R. niepelti*), by the dark blotches in the terminal area, on the hindwing by the very small basal area, the reddish tinge towards costa, and by the conspicuous, dentate postmedial line.

Male genitalia: Uncus (0.85 mm) and socii (0.75 mm) short, valva narrow, aedeagus short (1.55 mm), sternum A8 deeply notched, posterior lobes round.

Genetic data: BIN: BOLD:AAL9701. Genetically nearest species: *R. claushippi* sp. n. (6.1%). The specimen from Costa Rica diverging from the Ecuadorian populations by 3.1%, potentially indicating the need of separating the former at subspecies rank. More material required.

Distribution: Widely distributed from Costa Rica across Colombia, Ecuador and Peru to Bolivia.

Rhodochlora claushippi sp. n.

Holotype: ♂, Ecuador, Prov. Pichincha, 3,5km S Tandayapa, Bellavista Lodge, 2310m, 00°01’19” S, 78°41’15” W, 3.-16.X.2008, leg. R. Beck & M. Dietl, coll. ZSM, DNA barcode sample ID: BC ZSM Lep add 00263.

Paratypes: 9♂♂, Ecuador, Prov. Pichincha, 3,5km S Tandayapa, Bellavista Lodge, 2310m, 00°03.694’ N, 78°40.929’ W, 1.-20.IX.2012, leg. M. Dietl, S. & R. Beck, coll. ZSM; 3♂♂1♀, id., Tandayapa 2340m, 00°01.59” N, 78°43.42” W, 1.-10.XI.2014; 4♂♂, id., 00°01’19” S, 78°41’15” W, 3.-16.X.2008; 1♂, id., 2100m, 16.-30.VIII.2014, leg. H. Thöny, coll. ZSM; 4♂♂, Ecuador, Prov. Pichincha, Reserva Bellavista Lodge, 2100m, 00°01’ S, 78°32’ W, 05.-30.V.2017 leg. H. Thöny, coll. ZSM; 1♂, id., 01.-30.VI.2017; 2♂, id., 01.-29.VIII.2017; 5♂♂, id., coll. H. Thöny; 5♂♂, Ecuador, Prov. Pichincha, Reserva Bellavista Lodge, Sao Luis, 2340m, 00°01’ S, 78°41’ W, 15.-30.VI.2017, leg. H. Thöny, coll. QCAZ, Mus. de Zool. Sec. Invertebrates, Pont. Univ. Catol. del Ecuador, Quito; 1♂, id., coll. ZSM; 6♂♂, Ecuador, Pichincha, Camping Tambo Tanda, 1969m, 00°01’22” S, 78°38’48” W, 25.X.2011, leg. V. Sinyaev & O. Romanov, ex coll. R. Brechlin, coll. ZSM; 2♂♂, Ecuador, Pichincha, Camping Bella Vista, 2230, 00°00’41” S, 78°41’17” W, 27.X.2011, leg. V. Sinyaev & O. Romanov, ex coll. R. Brechlin, coll. ZSM; 2♂♂, id., 01.XII.2011; 1♂, Ecuador, [Pichincha], km 34 de la vieille route de Quito à Sto. Domingo, 2600m, 9.-10.II.1975, leg. C. Herbulot, coll. Herbulot/ZSM; 2♂♂, Ecuador, Pichincha, Nanegalito, Bellavista Reserve, 00°1,6´S, 78°41,4´W, 2350m, 8.-9.XI.2014, A.Moser (leg. et coll. A. Moser); 1♀, Ecuador, Pichincha, Nanegalito, Bellavista Res., 00°0,75´S, 78°40,7´W, 2100m, 12.XI.2014, (leg. et coll. A. Moser); 1♂, Ecuador, Pichincha,3,5km s. Tandayapa, Bellavista Lodge, 00°01,19´S, 78°41,15´W, 2310m, 3.-16.X.2008, leg. R. Beck & M. Dietl (coll. A. Moser).

Fig. 1: *Rhodochlora claushippi* sp. n., aquarelle of Ruth Kühbandner.

Description: Wingspan male 32-38 mm, female 38 mm. Forewing apex slightly pointed, but not falcate as in the preceding species. Ground colour dirty green, on forewing costa and forewing apex vivid green. Antemedial line of forewing zigzagging, red with yellow borders, rarely reaching costa. Postmedial line zigzagging, blackish, but red at tornus, here distally bordered by a yellow spot. Terminal area with 2-3 blackish brown blotches, forewing apex remaining green, without blotches. Hindwing antemedial fascia dark grey, broad, postmedial line zigzagging, dark grey, medial area slightly darker than ground colour, at hindwing apex the postmedial line is distally bordered by an ochre shade. Forewing underside with an oblique, narrow, dark streak from tornus towards costa. Hindwing underside with a dark grey spot in the apex, ground colour whitish, with a narrow green terminal area. In the only female available the dark areas on fore- and hindwing undersides are lacking. Venation as described for genus *Rhodochlora*, but R2-R5 and M1 of forewing shortly stalked. Male antennae bipectinate, longest branches 0.5-0.7 mm. Female antennae filiform, slightly dentate. Frons and upperside of palpi dark brown, length of palpi 1.2-1.6 times diameter of eye in male, 2 times in female. Hindtibia of both sexes (!) without pencil, with terminal spurs only.

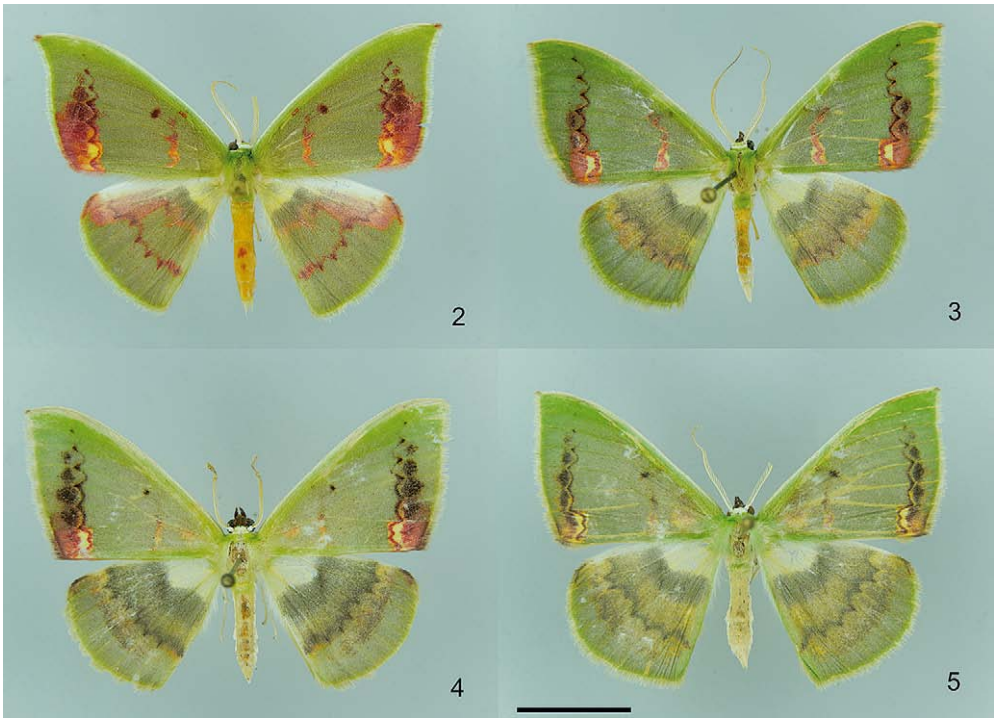
Male genitalia: Uncus (0.95 mm) and socii (0.7 mm) short, the latter straight, basal posterior projection of valva small, aedeagus short (1.55 mm) and narrow, sternum A8 long (1.05 mm), with mid-rib, posterior notch narrow (0.25 mm).

Diagnosis: *R. exquisita* differs in the reddish frons and palpi, in the clearly falcate forewing apex, and in the extended red suffusion, mainly the red shadow near the hindwing costa. Allopatric *R. gaujoniaria* differs in the male hindtibia with 4 spurs, frons and palpi darker, male palpi longer, forewing terminal area with more dark blotches, hindwing with dark shadow in the terminal area, in male genitalia similar to *R. exquisita*, differing in the narrow, shallow notch of sternum A8 and in the inconspicuous basal posterior projection of valva. From *R. gaujoniaria* furthermore differing in shorter uncus, shorter aedeagus. Differential diagnoses from *R. sordida* and *R. brechlini* see below. From all closely allied species clearly different in the DNA barcode (see genetic data).

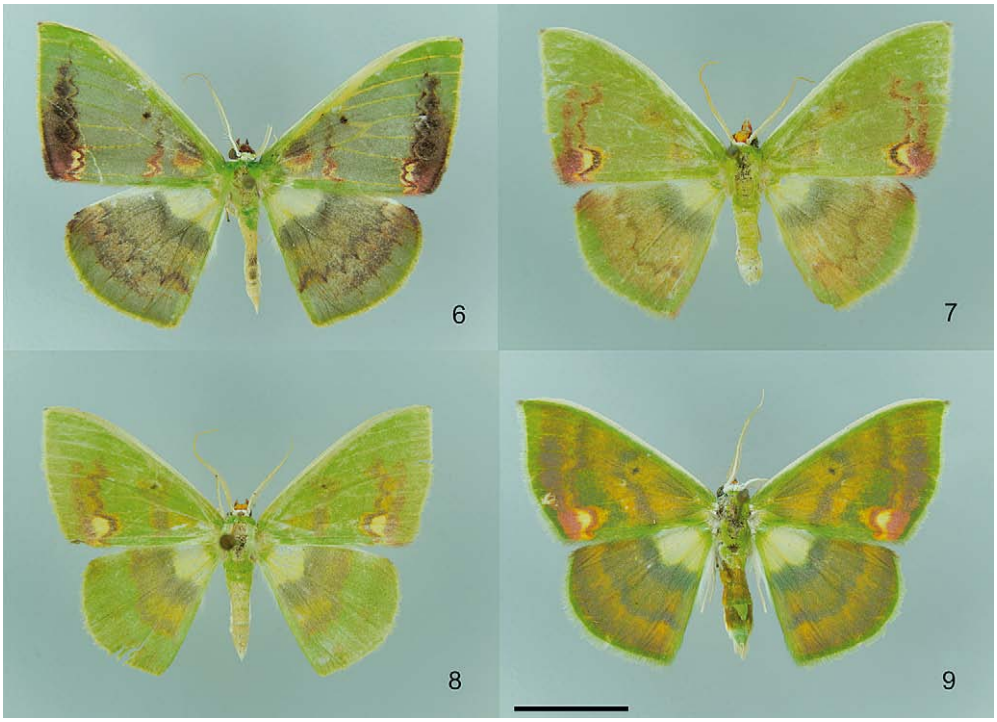
Genetic data: BIN: BOLD:AAN0418. Intraspecific variation low (0.0%; n=4). Genetically nearest species: *R. exquisita* (6.1%), *R. gaujoniaria* from type locality Loja (7.6%), *R. gaujoniaria* from Zamora Chinchipe and Morona Santiago (7.0%).

Distribution: So far, only recorded in Pichincha province, at elevations from ca. 2000-2600 m a.s.l. west of the Andes mountain chain, in allopatry with the following species.

Etymology: This species is dedicated to Prof. Claus HIPP, for his generous support of our biodiversity research on Neotropical lepidoptera which aims to foster major efforts to protect the environment around the type locality of *R. claushippi*.



Figs 2-5: *Rhodochlora* species, adults, scale bar = 1 cm. **2:** *R. exquisita* WARREN, 1905 (Costa Rica); **3:** *R. claushippi* sp. n., holotype (Ecuador); **4:** *R. gaujoniaria* DOGNIN, 1892 (Ecuador); **5:** *R. sordida* sp. n., holotype (Colombia).



Figs 6-9: *Rhodochlora* species, adults, scale bar = 1 cm. **6:** *R. brechlini* sp. n., holotype (Colombia); **7:** *R. rufaria* PROUT, 1932 (Peru); **8:** *R. mathani* PROUT, 1932 (Ecuador); **9:** *R. niepelti* PROUT, 1932 (Colombia).

***Rhodochlora gaujoniaria* (Dognin, 1892)**

Achlora gaujoniaria Dognin, 1892: Naturaliste 14: 186 (Ecuador, Loja area). Lectotype ♂ (USNM, photo examined).

Material examined: ♂ lectotype (see above); 1♂, Ecuador, road Loja – Zamora, 2714m, 3°58'45" S, 79°08'28" W, 25.XI.2011, leg. V. Sinyaev & O. Romanov, ex coll. R. Brechlin, coll. ZSM; 1♂, Ecuador, Morona Santiago, road Gualaceo – Plan de Milagro, 2157m, 3°01'24" S, 78°35'06" W, 21.XI.2011, leg. V. Sinyaev & O. Romanov, ex coll. R. Brechlin, coll. ZSM; 1♂, id., 28.I.2012, leg. R. Brechlin & V. Sinyaev; 1♂, Ecuador, Morona Santiago, 9km road Plan de Milagro - Gualaceo, 2375m, 3°00'04" S, 78°30'49" W, 26.01.2012, leg. R. Brechlin & V. Sinyaev, coll. ZSM; 1♂1♀, Ecuador, km 41 de la route Gualaceo – Limòn, 2400m, 10.I.1975, leg. C. Herbulot, coll. Herbulot/ZSM; 1♀, Ecuador, Napo, Rte. Cosanga – Tena, km 5, 2170m, 17.I.1983, leg. C. Lemaire & N. Venedictoff, coll. Herbulot/ZSM.

Diagnosis: Wing colouration as described for *R. claushippi*, but the forewing terminal area shows 3-4 dark blotches reaching closer to costa, hindwing with dark shadow (fascia) in the terminal area, almost reaching tornus. Antemedial line of forewing usually inconspicuous. Adults slightly larger, wingspan male 33-39 mm, female 44-47 mm. Frons and palpi black, male palpi comparatively long, 1.5-2 times diameter of eye, 2 times in female. Male hindtibia without pencil and four spurs, female hindtibia with two spurs. Female antennae slightly dentate.

Male genitalia: Uncus long (1.15 mm), socii short (0.75 mm), the latter curved at tip, basal posterior projection of valva conspicuous, valva at base much broader than at tip, length of aedeagus 1.8 mm, tip of vesica with cornutus-like sclerotization, sternum A8 (length 0.9 mm) with stout mid-rib and posterior notch (distance of lobes 0.35 mm).

Genetic data: Two BINs: BOLD:ABA9239 (n=2 from Zamora Chinchipe and Morona Santiago); BOLD:ADF4854 (n=1 from Loja = type locality). Both BINs diverging by 2.1%. Genetically nearest species (reference: minimum distance as resulting from *R. gaujoniaria* from Zamora Chinchipe): *R. rufaria* (4.0%), *R. sordida* sp. n. and *R. brechlini* sp. n. (both 5.0%), *R. claushippi* sp. n. (7.0%).

Distribution: So far, only recorded in Loja, Zamora Chinchipe, Morona Santiago, and Napo provinces, at elevations from ca. 2100-2700 m a.s.l. east of the main Andes mountain chain, in allopatry with the preceding species.

***Rhodochlora sordida* sp. n.**

Holotype: ♂, Colombia, Tolima, Nevado del Tolima, 2600m, 4°36'02" N, 75°19'51" W, 5.-7.XII.2013, leg. V. Sinyaev & M. Marquez, ex coll. R. Brechlin, coll. ZSM; DNA barcode sample ID: BC ZSM Lep 59346.

Paratypes: 1♂, id., 2850m, 4°36'20" N, 75°19'36" W, 8.-11.XII.2013; 1♂, Colombia, Antioquia, Municipio de Yarumal, Vereda Ventanita, 2020m, 7°04'15" N, 75°26'59" W, 1.-4.XII.2014, leg. V. Sinyaev, M. Marquez, J. Machado, ex coll. R. Brechlin, coll. ZSM; 1♂, Colombia (W), Risaralda, Termales de San Vicente, 2560m, 04°51'18" N, 75°31'46" W, 27.-29.III.2014, leg. V. Sinyaev, M. Marquez, J. Machado, ex coll. R. Brechlin, coll. ZSM.

Description: Large, wingspan male 37-39 mm. Forewing apex slightly pointed, but not falcate. Ground colour dirty green. Antemedial line of forewing slightly undulate, inconspicuous, restricted to the inner half. Postmedial line slightly zigzagging, blackish, at tornus distally bordered by a narrow, yellow spot. Terminal area with five confluent blackish brown blotches, forming a narrow row. Hindwing antemedial fascia dark grey, broad, postmedial line zigzagging, dark grey. Medial area and proximal half of terminal area with dirty yellow-grey suffusion. Forewing underside with an oblique, narrow, dark streak from tornus towards costa. Hindwing underside with a small spot in the apex. Hindwing underside entirely whitish, forewing underside green but whitish towards inner termen. Venation as described for genus *Rhodochlora*, but on forewing origin of R1 connate with R2-R5, R2-R5 and M1 shortly stalked. Male antennae bipectinate, longest branches 0.7-0.8 mm. Frons and upperside of palpi blackish brown, length of male palpi 1.5-1.8 times diameter of eye. Male hindtibia without pencil, with four spurs, proximal pair shortened. Female unknown.

Male genitalia: Uncus (1.15 mm) and socii long (0.9 mm), the latter curved at tip, basal posterior projection of valva conspicuous, length of aedeagus 1.75 mm, tip of vesica with cornutus-like sclerotization, sternum A8 (length 1.0 mm) with stout mid-rib and posterior notch (distance of lobes 0.35 mm).

Diagnosis: Allopatric *R. claushippi* is smaller and differs in the shorter palpi, forewing terminal area with only 2-3 dark blotches, male hindtibia with two spurs only. Allopatric *R. gaujoniaria* is smaller and differs in the forewing terminal area with broader dark blotches and strong red suffusion in the forewing tornus. For differences from *R. brechlini* see diagnosis of following species. From all closely allied species clearly different in the DNA barcode (see genetic data).

Genetic data: BIN: BOLD:ADF4850 (n=1). Genetically nearest species: *R. rufaria* (4.7%), *R. gaujoniaria* from Zamora Chinchipe and Morona Santiago (5.0%), *R. brechlini* sp. n. (5.1%).

Distribution: So far, only recorded in western Colombia (Cordillera central), provinces Tolima, Risaralda and Antioquia, from ca. 2000-2900 m, in allopatry with the following species.

Etymology: The name refers to the dirty green ground colour (lat.: sordidus, -a, -um = dirty).

***Rhodochlora brechlini* sp. n.**

Holotype: ♂, Colombia, [south-western] Boyaca prov., Villa Pinzón, Paramo de Guanacheque, 3360m, 5°13'54" N, 73°31'12" W, 29.-30.XI.2013, leg. Sinyaev, ex coll. Brechlin, coll. ZSM, DNA barcode sample ID: BC ZSM Lep add 00262.

Paratypes: 1♂, id.; 2♂♂, Colombia, Santander, rd. Barbosa – Arcabuco, km 23, 2360m, 5°49'14" N, 73°30'14" W, 26.-27.XI.2013, leg. V. Sinyaev, ex coll. R. Brechlin, coll. ZSM; 2♂♂, id., 21.-27.I.2014; 3♂♂, id., 21.-23.IV.2014; 2♂♂, Colombia, Santander, Vereda Vicinia, carretera via Velez – Landazuri, 2200m, 6°05'41" N, 73°42'29" W, 27.-28.II.2015, leg. V. Sinyaev, M. Marquez, J. Machado; ex coll. R. Brechlin, coll. ZSM; 1♂, Colombia, Santander, road Duitama – Charala, 2925m, 5°58'13" N, 73°10'07" W, 24.-27.II.2016, leg. V. Sinyaev, J. Machado; ex coll. R. Brechlin, coll. ZSM; 1♂, Colombia, Boyacà, Arcabuco, Vereda Peñas Blancas, 2670m, 5°47'05" N, 73°26'17" W, 20.-22.IV.2015, leg. V. Sinyaev, M. Marquez, J. Machado; ex coll. R. Brechlin, coll. ZSM; 1♂, id., Vereda El Centro, 2800m, 5°44'14" N, 73°26'52" W, 27.I.-3.II.2014; 1♂, Colombia, Boyacà, Municipio Togui, Vereda Japa, 2080m, 5°53'04" N, 73°29'27" W, leg. V. Sinyaev, M. Marquez, J. Machado; ex coll. R. Brechlin, coll. ZSM; 2♂♂, Colombia, Boyacà, Alto de la Virgen, via Sogamoso – Pajarito, 2280m, 5°26'41" N, 73°42'24" W, leg. M. Marquez, J. Machado; ex coll. R. Brechlin, coll. ZSM; 1♂, Colombia, Boyacà, Paramo del Bijagual near Ramiriqui, 2800m, 5°20'40" N, 73°16'47" W, leg. V. Sinyaev; ex coll. R. Brechlin, coll. ZSM; 2♂♂, Colombia, Boyacà, Arcabuco, road Arcabuco – Togui, 2700m, 5°49'11" N, 73°28'09" W, 1.-8.II.2016, leg. V. Sinyaev, J. Machado; ex coll. R. Brechlin, coll. ZSM; 1♂, id., 3.-4.III.2016; 4♂♂, id., 10.III.2016; 4♂♂, id., 1.-4.XII.2015; 1♂, Colombia, [eastern] Cundinamarca, Vereda Tilata Abajo, km 49, Alto del Sisga, 2830m, 5°05'02" N, 73°44'30" W, 22.-24.II.2014, ex coll. R. Brechlin, coll. ZSM.

Further material outside the type series (see remarks): 2♂♂, Colombia, Boyaca, Vereda Suralá, 2750m, 5°04'23" N, 73°39'17" W, 12.XI.2013, leg. Sinyaev, ex coll. Brechlin, coll. ZSM; 1♂, id., 2600m, 5°04'35" N, 73°39'24" W, 7.-10.XI.2013.

Description: Large, wingspan male 37-42 mm. Forewing apex slightly pointed, with a small black dot. Ground colour dirty green. Antemedial line of forewing strongly zigzagging at inner termen, conspicuous, reaching costa. Postmedial line of forewing zigzagging, black brown, at forewing tornus distally bordered by a narrow, yellow spot. Terminal area with 4-5 confluent blackish brown, broad blotches, forewing tornus suffused with many dark scales. Hindwing antemedial fascia dark grey, broad, postmedial line strongly zigzagging, dark grey. Medial area and proximal half of terminal area with dirty yellow-grey-brown suffusion. Forewing underside with an oblique, broad, dark streak from tornus towards costa. Hindwing underside whitish but more green towards termen, with a dark spot in the apex. Venation as described for genus *Rhodochlora*, but on forewing R2-R5 and M1 very shortly stalked, R2-R5 on a very long stalk. Male antennae bipectinate, longest branches 0.6-0.7 mm. Frons and upperside of palpi red brown or dark brown with copper tinge, length of male palpi 1.6-1.8 times diameter of eye. Male hindtibia without pencil, with four spurs. Female unknown.

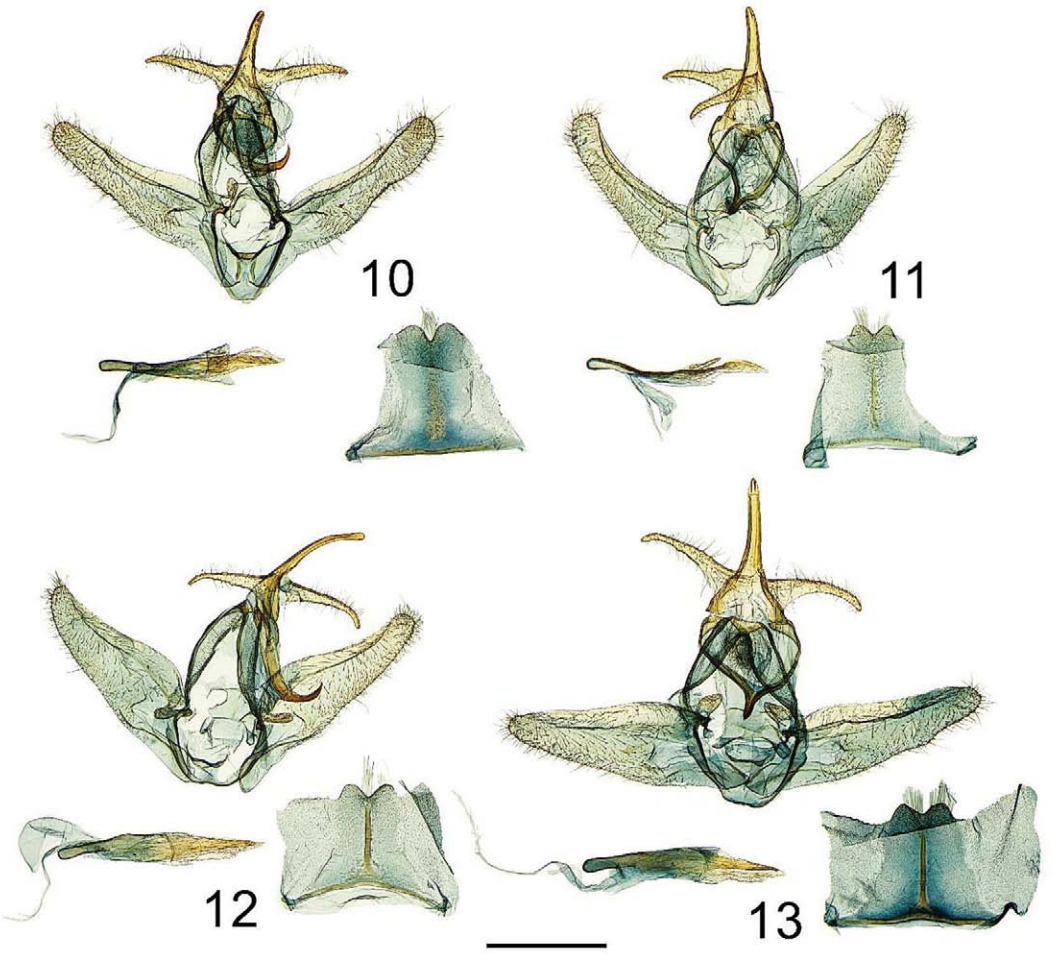
Male genitalia: Uncus long (1.3 mm), socii much shorter (0.8 mm) and narrow, slightly curved, basal posterior projection of valva comparatively small, length of aedeagus 1.9 mm, with centroterminal cornutus-like sclerotization, sternum A8 (length 1.0 mm) with stout mid-rib and posterior notch (distance of lobes 0.35 mm).

Diagnosis: Allopatric *R. claushippi* is smaller and differs in the shorter palpi, forewing terminal area with only 2-3 dark blotches, male hindtibia with two spurs only. Allopatric *R. gaujoniaria* is smaller and differs in the strong red suffusion in the forewing tornus, antemedial line of forewing and postmedial line of hindwing less strongly zigzagging. *R. sordida* differs in the darker palpi and frons, and the much less extended dark suffusion and the narrower dark blotches in the forewing terminal area. In male genitalia *R. brechlini* differs from *R. sordida* and *R. claushippi* by the slightly curved socii, being considerably shorter than uncus, from *R. gaujoniaria* by the constant width of valva from base to tip and by the smaller basal posterior projection of valva. From all closely allied species clearly different in the DNA barcode (see genetic data).

Genetic data: BIN: BOLD:ADD5306 (n=1). Genetically nearest species: *R. gaujoniaria* from Zamora Chinchipe and Morona Santiago (5.0%), *R. sordida* sp. n. (5.1%).

Distribution: So far, only recorded in Boyaca, Santander and easternmost Cundinamarca provinces (Cordillera oriental), Colombia, from ca. 2000-3400m, in allopatry with the preceding species.

Etymology: This species is dedicated to Dr. Ron BRECHLIN, for organizing and fostering research on Neotropical lepidoptera and for directing major collections of geometrid moths from various South American countries to the ZSM.



Figs 10-13: ***Rhodochlora*** **species, male genitalia,** scale bar = 1 mm. **10:** *R. exquisita* Warren, 1905 (Bolivia; ZSM G 20368); **11:** *R. claushippi* sp. n., paratype (Ecuador; ZSM G 20366); **12:** *R. gaujoniaria* Dognin, 1892 (Ecuador; ZSM G 20367); **13:** *R. sordida* sp. n., paratype (Colombia; ZSM G 20369).

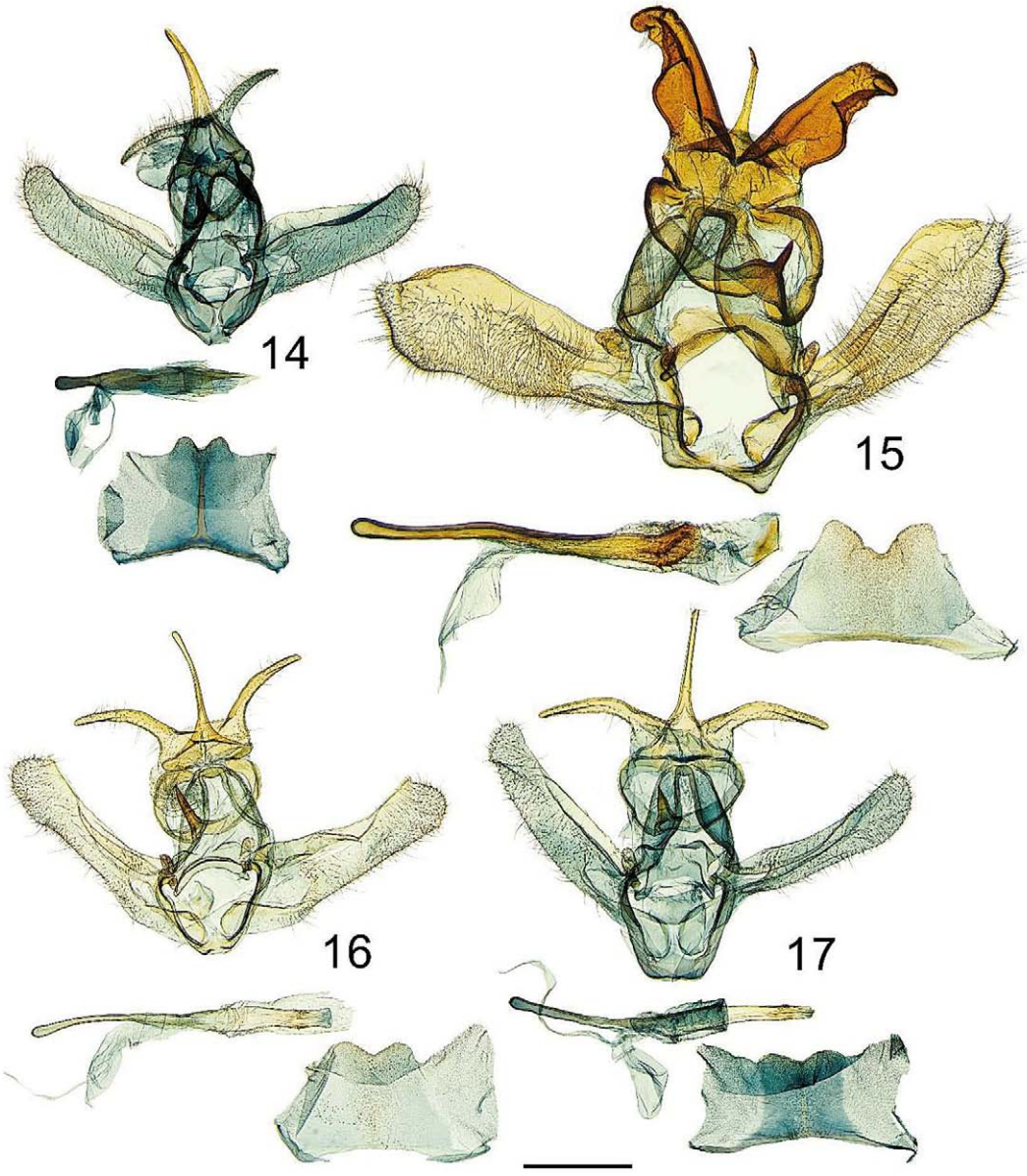
Remarks: Three males from Colombia, "Boyacá" [recte north-eastern Cundinamarca], Vereda Suralá (just 25km south-west of the type locality of *R. brechlini*) in habitus reminiscent of the type series except for the slightly undulate forewing antemedial line and the completely dissolved blotches of forewing terminal area, moreover clearly differing in the dark brown frons and upperside of palpi (without reddish tinge), as well as in the male hindtibia bearing two terminal spurs only, in male genitalia the strongly curved socii as long as uncus (0.9 mm), aedeagus shorter than in *R. brechlini* (1.75 mm). These three males probably deserve a separate taxon name as soon as DNA barcodes will be available.

Rhodochlora rufaria PROUT, 1932

Rhodochlora rufaria PROUT, 1932: in SEITZ: The Macrolepidoptera of the World 8: 21, pl. 3:a (Peru: Carabaya, Rio Huancamayo, La Union, 2000ft). Holotype ♂ (NHMUK, examined, genitalia of holotype figured in PITKIN 1996: fig. 124, 173).

Material examined: ♂ holotype (see above); 1♂, "SW" [recte: south-eastern] Peru, Cusco, Chontachaca, Manu Park, 800m, I.1999, leg. R. Marx, coll. ZSM; DNA barcode sample ID: BC ZSM Lep 69503; 1♂, Bolivia, [La Paz] Sarampiuni, San Carlos, 1000m, 2.IX.1950, leg. W. Forster, coll. ZSM; 1♂, id., 11.-20.IX.1950.

Diagnosis: Differing from the other species of this group by the diffuse red suffusion around antemedial line and cell spot of forewing, and over large parts of the hindwing, from antemedial line almost to termen, leaving green just a small stripe close to termen. Postmedial lines reddish, zigzagging on all wings. Fore-



Figs 14-17: *Rhodochlora* species, male genitalia, scale bar = 1 mm. **14:** *R. brechlini* sp. n., paratype (Colombia; ZSM G 20370); **15:** *R. rufaria* Prout, 1932 (Peru; ZSM G 20372); **16:** *R. mathani* Prout, 1932 (Ecuador; ZSM G 20373); **17:** *R. niepelti* Prout, 1932 (Colombia; ZSM G 20374).

wing postmedial line at inner termen semicircular, including a yellow spot, distally borded by a red spot in the tornus. Forewing terminal area with reddish stripe. Underside whitish with just small spots in forewing tornus and hindwing apex. Frons light orange, towards palpi red brown. Hindtibia of male with four spurs.

Male genitalia: strongly diverging from all other congeners, as already stated by PITKIN (1996): twice as large as those of other *Rhodochlora* species, socii broadly sclerotized, bearing a subapical spine, uncus reduced and fine, valva broad, dilating to tip, saccus rectangularly sclerotized, aedeagus very long (3.3 mm), narrow, with two terminal spinulose crests, sternum A8 deeply bilobous, distance of posterior lobes 0.9 mm, without mid-rib.

Genetic data: BIN: BOLD:ACL1812 (n=1). Genetically nearest species: *R. gaujoniaria* from Zamora Chinchipe and Morona Santiago (4.0%), *R. sordida* sp. n. (4.7%).

Distribution: So far, only recorded in a small area from south-eastern Peru to north-western Bolivia, sampling localities restricted to low elevations from 600-1000m.

Remarks: The taxon was suggested by PROUT (1932) as potentially being a form of *R. brunneipalpis*, species rank was confirmed in SCOBLE (1999). Despite the huge differences in male genitalia, it is nevertheless kept here in the *exquisita* species-group, tentatively, because of the great genetic similarity with other members of the group. Under the sample ID "Pe-Geo-0453" (Gunnar BREHM) a Peruvian specimen is figured in BOLD in habitus very similar to our *R. rufaria* (confimed by dissection) whilst genetically being very far from both our *R. rufaria* and our Peruvian *R. brunneipalpis minor* (the latter deserving species status), however, closely clustering with *R. brunneipalpis* from French Guiana.

Tentatively assigned to the *exquisita* species-group:

***Rhodochlora mathani* PROUT, 1932**

Rhodochlora mathani PROUT, 1932: in SEITZ: The Macrolepidoptera of the World 8: 22 (Ecuador, Bolivar: Balzapamba). Holotype ♂ (NHMUK, examined).

Material examined: ♂ holotype (see above); 1♂, Ecuador, [Tungurahua], Oriente, Rio Anzú, Apuya, 600m, 1./2.I.1970, leg. H. Descimon, coll. Herbulot/ZSM; 1♂, Ecuador, [Morona Santiago], Km17 de la route Limón – Mendez, 900m, 12.-13.I.1975, leg. C. Herbulot, coll. Herbulot/ZSM.

Diagnosis: Differing from the other species of this group by the reduced red or dark suffusion, on hindwing restricted to the medial area between ante- and postmedial line. Forewing terminal area with some reddish, confluent blotches. In the forewing tornus much less reddish than in *R. rufaria*. Underside green (!), with a whitish (!) spot in the forewing tornus, and a very small dark spot in the hindwing apex. Frons light orange, towards palpi red brown. Hindtibia of male with four spurs.

Male genitalia: Uncus long (1.2 mm) and narrow, socii curved, costa of valva apically slightly projecting, aedeagus very long (2.8 mm) and narrow, with two small, terminal, slightly spinulose crests, sternum A8 without mid-rib (thus reminiscent of *R. rufaria*), posteriorly bilobed, distance of lobes 0.5 mm.

Genetic data: Not yet DNA barcoded, hence it is not excluded that this taxon better is placed into the *roseipalpis* species-group near *minor*.

Distribution: So far, only recorded in Ecuador (provinces Bolivar, Tungurahua, Morona Santiago), sampling localities restricted to low elevations from 600-900m (the type locality being at 750m).

Remarks: Claude HERBULOT identified one of the two specimens as „*rufaria*" but – on a separate label – explains some differences from the type specimen.

***Rhodochlora niepelti* PROUT, 1932**

Rhodochlora niepelti PROUT, 1932: in SEITZ: The Macrolepidoptera of the World 8: 22, pl. 3: a (western Colombia: Rio Micay). Holotype ♂ (NHMUK, examined).

Material examined: ♂ holotype (see above); 1♂, [northern] Colombia (Magdalena), Municipio de Minca, road Minca – Cerro Kennedy, El Dorado Reserv., 2110m, 11°05'49" N, 74°04'34" W, 5.VII.2016, leg. V. Sinyaev & C. Pinilla, ex coll. R. Brechlin, coll. ZSM; 1♂, Colombia (SW), Valle del Cauca near El Queremal, PN Farallones de Cali, 3°31'43" N, 76°44'00" W, 1500m, 8.IV.2017, leg. Sinyaev & Pinilla, ex coll. R. Brechlin, coll. ZSM.

Diagnosis: Differing from the other species of this group by the diffuse red suffusion covering both wings completely, except for the basal area of hindwing and the conspicuous yellow spot in the forewing tornus. Forewing apex falcate, similar to that of *R. exquisita*. Differences from the latter see under *R. exquisita*. Forewing terminal area without dark blotches. Underside of forewing green, with a minute dark spot in the tornus. Underside of hindwing whitish, sharply separated from the narrow, vivid green terminal area. Frons brown, with two large patches of white scales. Upperside of palpi brown. Hindtibia of male with two terminal spurs only.

Male genitalia: Uncus long (1.3 mm) and narrow, socii bent, valva long and narrow, saccus rectangularly sclerotized (thus reminiscent of *R. rufaria*), aedeagus very long (2.8 mm) and narrow, with two small, terminal, slightly spinulose crests, sternum A8 with weak mid-rib, posteriorly bilobed, distance of the very shallow lobes 0.5 mm.

Genetic data: Not yet DNA barcoded, hence the correct attribution to species-group still awaits confirmation.

Distribution: So far, only recorded in western and northern Colombia.

Preliminary checklist for the genus *Rhodochlora*:

Systematics and assigning to species-groups are preliminarily based on the wing pattern and COI similarity (cf. fig. 19). So far, 14 species and 4 subspecies were described, this paper increases the list to 21 taxa.

Rhodochlora WARREN, 1894

The *exquisita* species-group

R. exquisita WARREN, 1905 (*Rhodochlora*): Peru (south-east): Carabaya, Santo Domingo, 6500ft
R. gaujoniaria (DOGNIN, 1892) (*Achlora*): Ecuador: Loja area
R. claushippi sp. n. (*Rhodochlora*): Ecuador
R. columbiana sp. n. (*Rhodochlora*): Colombia
R. brechlini sp. n. (*Rhodochlora*): Colombia
R. rufaria PROUT, 1932 (*Rhodochlora*): Peru: Carabaya, Rio Huancamayo, La Union, 2000ft

Tentatively assigned to species-group (potentially more related to *roseipalpis* species-group):
R. mathani PROUT, 1932 (*Rhodochlora*): Ecuador, Bolivar: Balzapamba
R. niepelti PROUT, 1932 (*Rhodochlora*): Colombia (west): Rio Micay

The *trifasciata* species-group (COI-data suggest certain relationship with the *exquisita* species-group)

R. trifasciata WARREN, 1909 (*Rhodochlora*): Peru: Carabaya, Agualani, 9000ft
R. tornistriga tornistriga PROUT, 1916 (*Rhodochlora*): Colombia: Monte Tolima, 3200 m [this may not be conspecific with the following two taxa]
R. tornistriga achroma PROUT, 1932 (*Rhodochlora*): Colombia (west): San Antonio, [5800 ft]
R. tornistriga libanensis PROUT, 1932 (*Rhodochlora*): Colombia: Sierra del Libane, [6000 ft] [COI data and wing pattern suggesting this and – possibly – the previous taxon to be different from *tornistriga* and to belong to the *albipuncta* species-group]

[Currently including three BINs of putatively undescribed species]

The *basicostalis* species-group

R. basicostalis basicostalis DOGNIN, 1900 (*Rhodochlora*): Ecuador: Loja area
R. basicostalis unicolor WARREN, 1907 (*Rhodochlora*): Peru: Carabaya, Agualani, 9000 ft [possibly not conspecific and requiring transfer to *albipuncta* species-group]
R. ustimargo WARREN, 1909 (*Rhodochlora*): Peru: Cerro de Pasco, Huancabamba

[Currently including five BINs of putatively undescribed species]

The *albipuncta* species-group

R. albipuncta WARREN, 1909 (*Rhodochlora*): Peru: Huanuco, Cushi, 1900m
R. endognoma PROUT, 1916 (*Rhodochlora*): Peru: Carabaya, Rio Inambari, La Oroya, 3100ft

[Currently including nine BINs of putatively undescribed species]

The *roseipalpis* species-group

R. roseipalpis (FELDER & ROGENHOFER, 1875) (*Achlora*): Venezuela
R. brunneipalpis brunneipalpis WARREN, 1894 (*Rhodochlora*): Guyana: Rio Demerara
R. brunneipalpis minor PROUT, 1932 (*Rhodochlora*): Peru: Carabaya, Rio Huancamayo, La Union, 2000ft
R. rothschildi WARREN, 1901 (*Rhodochlora*): Panama: Chiriqui

[Currently including ten BINs of putatively undescribed species]

Acknowledgements

I thank Gunnar BREHM (Jena), Daniel H. JANZEN and Winnie HALLWACHS (both Pennsylvania) for kindly allowing me to include DNA barcodes from their projects into my study. Daniel H. JANZEN and Winnie HALLWACHS provided interesting information on larval host-plants. Robert BECK (Munich), Thomas GREIFENSTEIN (Pfaffenhofen), Hubert THÖNY (Brazil), Ron BRECHLIN (Pasewalk) and Viktor SINYAEV (Moscow) collected numerous Neotropical geometrines for this study. Claus HIPP (Hipp baby foods, Pfaffenhofen) gave financial support for the study of tropical biodoversity at the Bellavista lodge in Ecuador.

For mounting of moths, tissue sampling and databasing (DNA Barcoding) I am very grateful to Mei-Yu CHEN (Munich). I thank John CHAINEY and Geoff MARTIN (both London) for access to NHMUK collections and kind help in photography and digitizing the genitalia slides. Patricia GENTILI-POOLE (Washington) provided photographs of two *Rhodochlora* type specimens in the USNM. The genetic analyses have received considerable support from Paul D. N. HEBERT and the Biodiversity Institute of Ontario (BIO) and the Canadian Centre for DNA Barcoding (CCDB University of Guelph). The data management and analysis system BOLD was provided by Sujeevan RATNASINGHAM. The work was financially supported by Genome Canada (Ontario Genomics Institute) and special grants from Life Technology in the framework of the iBOL program, WG 1.9.

Zusammenfassung

Acht Arten der *exquisita* Artengruppe aus der Gattung *Rhodochlora* WARREN, 1894 werden unter Verwendung und Kombination von Merkmalen der äußeren und inneren Morphologie sowie molekularen Daten mittels DNA-Barcoding (COI 5') revidiert. Es wurden alle relevanten Typenexemplare untersucht. Phylogenie und mögliche Verwandschaftsverhältnisse für die Gattung werden diskutiert. Drei neue Arten werden beschrieben: *Rhodochlora claushippi* sp. n. aus Ecuador, *Rhodochlora sordida* sp. n. aus dem westlichen Kolumbien, und *Rhodochlora brechlini* sp. n. aus Zentral-Kolumbien.

Neighbour Joining trees

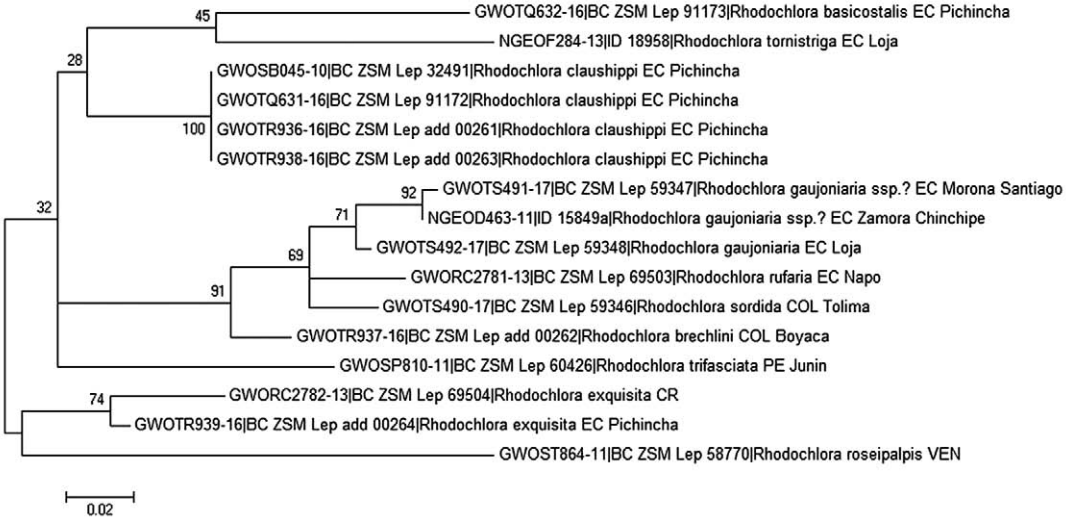
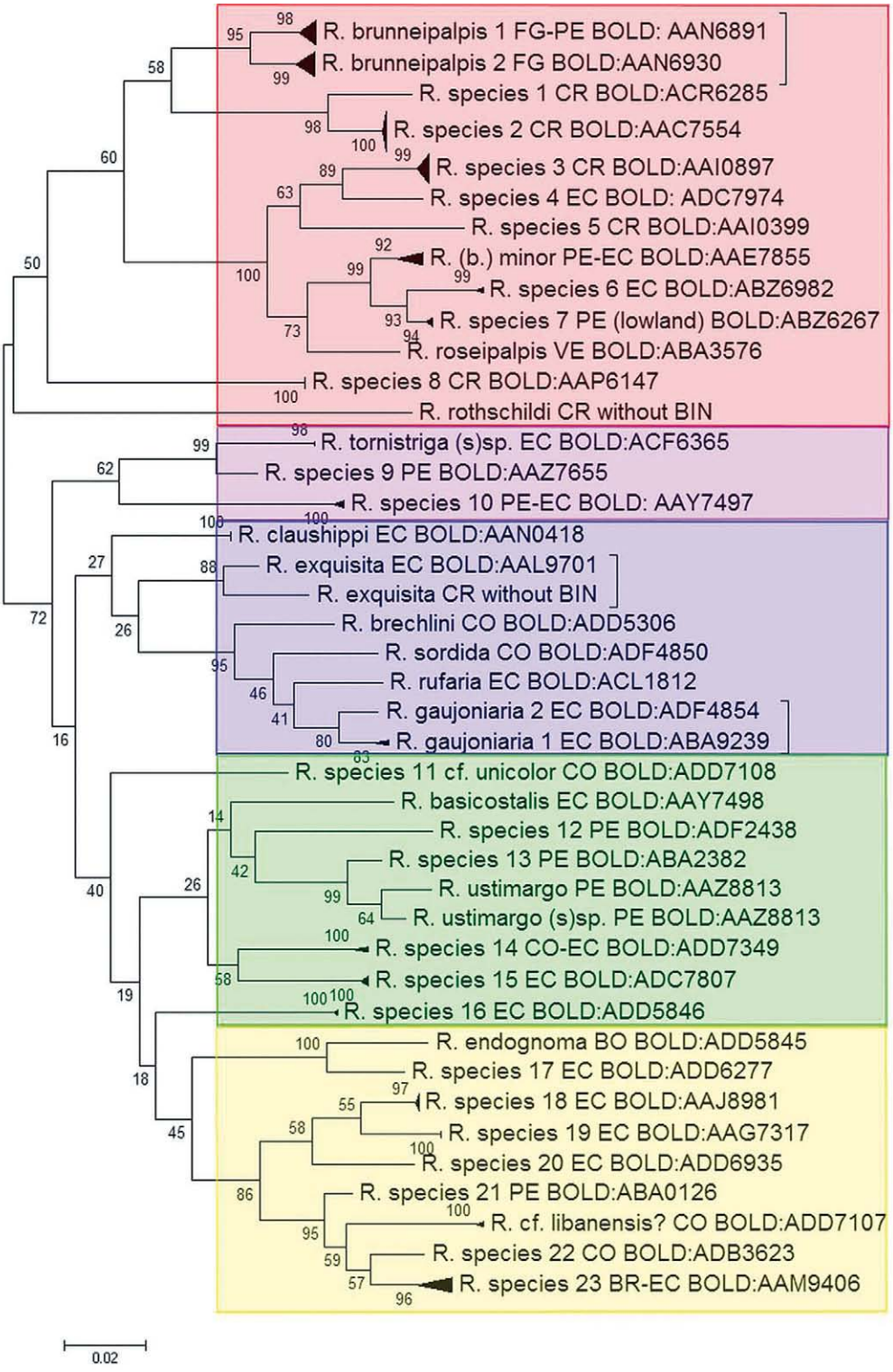


Fig. 18: Maximum likelihood tree (bootstraps with 500 replications, Kimura 2 Parameter; COI 5'; >500bp), including 12 specimens and six species of the *exquisita* species group as well as the type species (*R. roseipalpis*), and the closest intrageneric species (*R. tornistriga; R. trifasciata; R. basicostalis*). Constructed with MEGA 6 (Tamura et al. 2013). EC = Ecuador, COL = Colombia, PE = Peru, CR = Costa Rica, VEN = Venezuela.

Fig. 19 (next page): Maximum likelihood tree (bootstraps with 500 replications, Kimura 2 Parameter; COI 5'; >500bp), including 124 specimens and 39 BINs of the genus *Rhodochlora*. Individuals of each BIN collapsed into triangles, depth of triangles reflecting genetic variation, width of triangles reflecting the number of individuals. Constructed with MEGA 6 (Tamura et al. 2013). For the definition of (colourized) species groups also the wing pattern was considered. FG = French Guiana, EC = Ecuador, CO = Colombia, PE = Peru, CR = Costa Rica, BO = Bolivia, VE = Venezuela. ►



Literature

deWAARD, J.R., IVANOVA, N.V., HAJIBABAEI, M. & P.D.N. HEBERT (2008): Assembling DNA barcodes: analytical protocols. In: Martin C ed. Methods in molecular biology: environmental genetics. – Totowa, NJ: Humana Press. pp. 275-293.

DOGNIN, P. (1892): Descriptions de Lépidoptères nouveaux. – Le Naturaliste, **14**: 185–186.

GOLDSTEIN, P.Z. & R. deSALLE (2010): Integrating DNA barcode data and taxonomic practice: Determination, discovery, and description. – Bioessays **33**, 135-147.

HAUSMANN A. (2001): Introduction. Archiearinae, Orthostixinae, Desmobathrinae, Alsophilinae, Geometrinae. – In: A. HAUSMANN (ed.): The Geometrid Moths of Europe 1. – Apollo Books, Stenstrup, 282 pp. & 8 colour pls.

HAUSMANN, A. (2011): An integrative approach to resolving some difficult questions in the Larentiinae of the Mediterranean region (Lepidoptera, Geometridae). – Mitt. Münch. Ent. Ges. **101**: 73-97.

HEBERT, P.D.N., CYWINSKA, A., BALL, S.L. & J.R. deWAARD (2003): Biological identifications through DNA barcodes. – Proc. R. Soc. London B 270: 313-321 (doi:10.1098/rspb.2002.2218).

IVANOVA, N.V., deWAARD, J.R. & P.D.N. HEBERT (2006): An inexpensive, automation-friendly protocol for recovering high-quality DNA. – Mol. Ecol. Notes **6**: 998-1002.

PADIAL, J.M., MIRALLES, A., DE LA RIVA, I. & M. VENCES (2010): The integrative future of taxonomy. – Frontiers in Zoology **7**, 16.

PITKIN, L. (1996): Neotropical emerald moths: a review of the genera (Lepidoptera: Geometridae, Geometrinae). – Zool. J. Linn. Soc. **118** (4): 309-440.

PROUT, L.B. (1932): [American] Geometridae. In: SEITZ, A. (ed.): The Macrolepidoptera of the world, **8**: 1–149, pls 1–13, 15, 17.

RATNASINGHAM, S. (2017): BOLD Barcode of Life Data System. – http://www.boldsystems.org/views/login.php. Accessed 2017 Jun 02.

RATNASINGHAM, S. & P.D.N. HEBERT (2007): BOLD: The Barcode of Life Data System (http://www.barcodinglife.org). – Mol. Ecol. Notes **7** (3): 355-364.

RATNASINGHAM, S. & P.D.N. HEBERT (2013): A DNA-based registry for all animal species: The Barcode Index Number (BIN) System. PLOS ONE 8(8): e66213. doi:10.1371/journal.pone.0066213.

ROBINSON, G.S. (1976): The preparation of slides of Lepidoptera genitalia with special reference to the Microlepidoptera. – Entomologist´s Gazette **27**: 127-132.

SCOBLE, M.J. & A. HAUSMANN [update 2007, accessed 21.5.2013]: Online list of valid and nomenclaturally available names of the Geometridae of the World. – http://www.lepbarcoding.org/geometridae/species_checklists.php.

SCOBLE, M.J. (1999): Geometrid Moths of the World: a catalogue (Lepidoptera, Geometridae). Vol. **1** and **2**. – CSIRO Publishing and Apollo Books, Stenstrup. 1016 pp.

TAMURA, K., STECHER, G., PETERSON, D., FILIPSKI, A. & S. KUMAR (2013): MEGA6: Molecular Evolutionary Genetics Analysis Version 6.0. Molecular Biology and Evolution **30**: 2725-2729.

VIIDALEPP, J. (2017): A morphology based key to the genera of the tribe Nemoriini (Lepidoptera: Geometridae, Geometrinae). – Zootaxa **4236** (3): 521–532.

WARREN, W. (1894): New genera and species of Geometridae. – Novitates Zoologicae **1**: 366–466.

WARREN, W. (1905): New American Thyrididae, Uraniidae, and Geometridae. – Novitates Zoologicae **12**: 307–379.

Author´s address:

Dr. Axel HAUSMANN
Zoologische Staatssammlung München
Staatliche Naturwissenschaftliche
Sammlungen Bayerns SNSB
Münchhausenstr. 21
D-81247 Munich, Germany
Axel.Hausmann@zsm.mwn.de