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## Integrative revision of the African geometrid genus *Dargeia* HERBULOT, 1977 (Lepidoptera, Geometridae, Geometrinae)

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### Abstract

The genus *Dargeia* HERBULOT, 1977 is revised using and combining characters of external and internal morphology as well as molecular data from the DNA barcoding region (COI 5'). Phylogeny and possible relationships for the genus are discussed. One new species is described from Rwanda and Zambia: *Dargeia philippi* sp. n. The new species can easily be recognized by its paler, whitish underside of wings and a number of other differential features.

### Zusammenfassung

Die Gattung *Dargeia* HERBULOT, 1977 wird einer integrativen Revision unterzogen. Es werden sowohl Merkmale der äußeren und inneren Morphologie als auch molekulare Datensätze der DNA Barcoding Region (COI 5') berücksichtigt und miteinander kombiniert. Phylogenie und mögliche Verwandtschaftsbeziehungen dieser Gattung werden diskutiert. Eine neue Art aus Ruanda und Sambia wird beschrieben: *Dargeia philippi* sp. n. Die neue Art kann leicht an der blässeren, weißlichen Flügelunterseite sowie einigen weiteren Differentialmerkmalen erkannt werden.

### Introduction

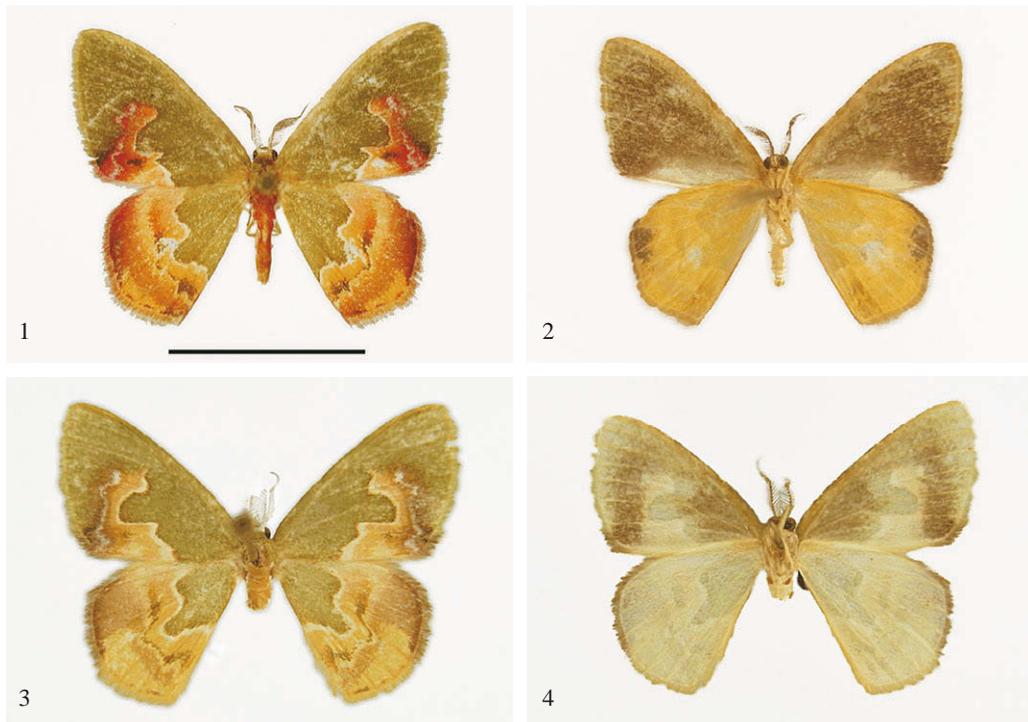
The genus *Dargeia* was described by HERBULOT (1977). This patronym accredits the merits of Philippe DARGE in the entomological exploration of various African countries. The numerous collected geometrids were deposited in the collection Herbulot which now is stored at the Bavarian State Collection of Zoology (ZSM). To date many further expeditions were launched by DARGE into Africa and most of the Lepidopteran material was deposited in the ZSM. In 2013, the ZSM honored Dr. Philippe DARGE with the 'RITTER-VON-SPIX medal' and in this article a new species belonging 'his' genus *Dargeia* will be dedicated to him. In this way we doubly recognize the merits of this outstanding entomologist with the genus and the species name.

SCOBLE (1999) and SCOBLE & HAUSMANN (2007) regarded the genus *Dargeia* to be monotypic. However, during a general screening program targeting the afrotropical biodiversity within the framework of the DNA Barcoding campaign 'Global Geometridae' (iBOL, CBOL), another, undescribed species of the genus *Dargeia* was detected through a remarkable sequence divergence from the known species, *D. micheleae* HERBULOT, 1977. The aim of this article is to revise the genus as an integrative revision (cf. GOLDSTEIN & DESALLE 2010; TELETCHEA 2010; PADIAL et al. 2010; HAUSMANN 2011).

### Material and Methods

#### Abbreviations

ZSM	Bavarian State Collection of Zoology, Munich
NHM	Nature History Museum, London
MRAC	Musée Royal de l'Afrique Central, Tervuren
CCDB	Canadian Centre for DNA Barcoding
BOLD	Barcode of Life Data System
COI	mitochondrial cytochrome <i>c</i> oxidase I (COI) gene, region near the 5' terminus (barcode fragment, 658 bp)



**Figs 1-4:** Holotypes. Scale bar = 1 cm. **Figs 1-2:** *Dargeia micheleae* Herbulot, 1977; Fig. 1: ♂ holotype, upperside; Fig. 2: ♂ holotype, underside. **Figs 3-4:** *Dargeia philippi* sp. n.; Fig. 3: ♂ holotype, upperside; Fig. 4: ♂ holotype, underside.

### **Sampling and morphological analysis**

The type series of *D. micheleae* HERBULOT, 1977, and some additional specimens are housed in the ZSM. Michael OCHSE (Weisenheim, Germany) collected one specimen in Cameroun and Jürgen LENZ (Harare, Zimbabwe) deposited two *Dargeia* specimens from Zambia. No other material of this genus could be found in several museums visited except for four specimens of *D. micheleae* the NHM (photograph kindly provided by Timm KARISCH; Dessau, Germany) and one in the MRAC. Altogether 14 specimens of this genus were examined at the ZSM. Dissection and preparation of genitalia slides were performed applying standard protocols (cf. ROBINSON 1976), the genitalia are embedded in Euparal. Measurements were done with a reticule in a WILD M3Z microscope.

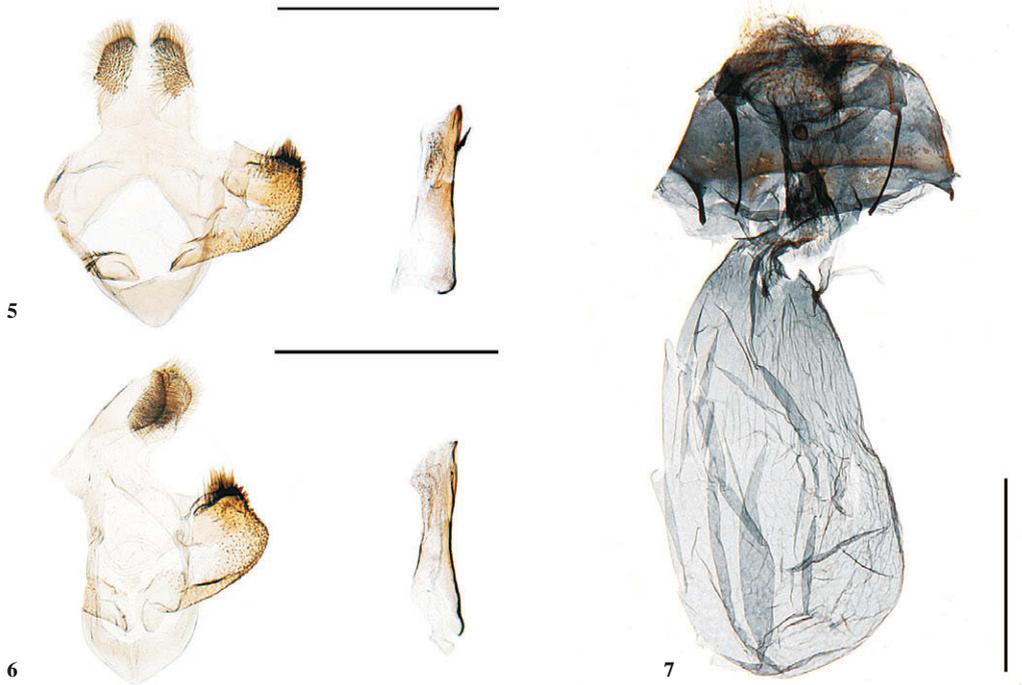
### **DNA Analysis**

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 easily be accessed in the Barcode of Life Data System (RATNASINGHAM & HEBERT 2007; RATNASINGHAM 2010) in the public project (GZPUV).

### **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.



**Figs 5-7: Genitalia.** Scale bar = 1 mm. **Fig. 5:** *Dargeia micheleae* HERBULOT, 1977, ♂ genitalia, paratype, left valva removed. **Figs 6-7:** *Dargeia philippi* sp. n.; Fig. 6: ♂ genitalia, holotype, left valva removed; Fig. 7: ♀ genitalia, paratype.

### Systematic account

#### *Dargeia* HERBULOT, 1977

Type species: *Dargeia micheleae* HERBULOT, 1977 (by monotypy).

**Diagnosis:** Ground colour of wing upperside olive green, with orange pattern in the forewing tornus and the distal half of hindwing. Underside of forewing dark, of hindwing white or yellow. Forewing veins Sc and R1 with long anastomosis. Palpi very short in ♂, length diagnostic for species discrimination in ♀. Proboscis very short, rudimentary. Antennae bipectinate in both sexes, longest branches in both sexes 0.6-0.8 mm. Hindtibia with only one pair of terminal spurs in both sexes. Abdomen without crests. Frenulum absent in both sexes. Sternum and tergum A8 simple.

**Male genitalia:** Very small. Uncus replaced by paired, bilobous, strongly setose patches. Tegumen very broad. Saccus triangular. Valva very short and broad, at tip spinulose, ventrobasally extended towards saccus. Aedeagus short, 0.8-0.85 mm, comparatively broad, not pistol-shaped as in many other Geometrinae, without cornuti.

**Female genitalia:** Apophyses short. Ductus bursae short, membranous, with longitudinal folds. Corpus bursae without signum.

#### *Dargeia micheleae* HERBULOT, 1977 (Figs 1, 2, 5)

*Dargeia micheleae* HERBULOT, 1977: Lambillionea 77 (7-8), 49-51, fig. (Cameroun: Ayos, galerie du Nyong, 15km E M'Balmayo). Holotype ♂ and five paratypes, examined (ZSM/HERBULOT). One ♂ paratype from north-eastern Cameroun ('village Kala, 11.X.1972') not conspecific, the underside of wings being pale without dark or yellowish pattern, genitalia matching those of the following species.

**Redescription:** Wingspan ♂ 18-20 mm, ♀ 25 mm. Frons olive green, vertex white. Upperside of forewing olive green, with orange blotch from tornus towards 2/3 costa, tapering and not reaching costa. Tornus blotch proximally sharply bordered by a fine white line towards the concavely projecting medial area. Tornus blotch distally rust brown with a fine, zigzagging, pale violet line. Basis of hindwing olive green, sharply bordered by a thin white line, concavely projecting towards termen between veins CuA1 and CuA2. Distal half of

hindwing yellowish orange, turning to rust brown at apex. Hindwing tornus with 1-3 small, green dots. Underside of forewing black brown, towards apex olive green, at inner margin white or yellow, sometimes dilated to a small whitish spot. Underside of hindwing yellow (fading to yellowish white in worn specimens) towards apex with brown tinge, not rarely condensed to a dark spot. Palpi very short in ♂, in ♀ long, protruding beyond the frons by length of diameter of eye. Antennae in both sexes 0.65-0.75 mm. For further characters see generic description.

Male genitalia (Fig. 5): See under description of genus. Valva rounded at tip, spinulose. Length of aedeagus 0.8-0.85 mm.

**Differential diagnosis:** see under *D. philippi* sp. n.

**Genetic data** (Fig. 8): Nearest neighbour: *D. philippi* sp. n. at a distance of 7.4%. Closest non-congeneric neighbours *Nemoria rectilinea* (WARREN, 1906) and *Nemoria carolinae* PITKIN, 1993 (Geometrinae, Nemoriini) from Central America at distances of 9.5%.

**Distribution:** Cameroun, Gabon and Congo (4♂♂ from the Republic of the Congo in the Herbulot collection, one ♂ dissected; new for the fauna of the Congo). One more specimen recorded by H. HOPPE on Bioko (Equatorial Guinea; KARISCH 2010).

### *Dargeia philippi* sp. n. (Figs 3, 4, 6, 7)

**Holotype:** 1♂, // Rwanda SW. / Forêt Nyungwe / Route Delvaux km17 / 2200 m – 23.IV.1977 / B. TURLIN // Holotypus *Dargeia philippi* HAUSMANN, 2013 // [gen.prp.] ZSM G 14961 // [DNA Barcode specimen ID] BC ZSM Lep 76050 // coll. ZSM. **Paratypes:** 1♂, Zambia, northern Zambia / Mutinondo, 1390 m / Miombo, 29.xii.2010 / S 12°23'30.9" E 31°19'23.8" // light trap, J. LENZ legit // Paratypus *Dargeia philippi* HAUSMANN, 2013 // [DNA Barcode specimen ID] BC ZSM Lep 62225 // coll. ZSM. 1♀, id., [DNA Barcode specimen ID] BC ZSM Lep 62224. Other material: One paratype of *D. micheleae* from north-eastern Cameroun belongs to this species (see above).

**Description:** Wingspan ♂ 20-23 mm, ♀ 27 mm. Frons olive green, vertex white. Upperside of forewing olive green, with broad, yellowish orange blotch from tornus towards 2/3 costa, tapering and not reaching costa. Tornus blotch proximally sharply bordered by a fine white line towards the strongly projecting medial area. Tornus blotch distally rust brown with a fine, zigzagging, pale violet line. Basis of hindwing olive green, sharply bordered by a thin white line, strongly projecting towards termen between veins CuA1 and CuA2. Distal half of hindwing yellowish orange, turning to rust brown at apex. Hindwing tornus with one small, green dot in the holotype, with orange shades in the paratypes from Zambia. Underside of forewing black brown in the basal and terminal areas, towards costa and apex olive green, in the medial area white. Underside of hindwing whitish, fringes towards apex brown. Palpi in both sexes very short. Antennae bipectinate in both sexes, longest branches 0.8 mm in ♂, 0.7 mm in ♀. Further characters see generic description.

Male genitalia (Fig. 6): See under description of genus. Valva sub-rectangular at tip, comparatively long spinose on costal margin. Length of aedeagus 0.85 mm.

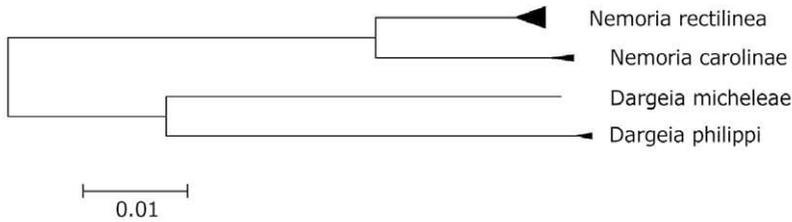
Female genitalia (Fig. 7): Apophyses posteriores short, 0.55 mm, apophyses anteriores very short, 0.15 mm only. Ductus bursae short, membranous, with longitudinal folds. Corpus bursae oval, without signum. Differential diagnosis: Slightly larger than *D. micheleae*. Upperside of forewing with tornus blotch more yellowish and broader towards costa. Borders of olive green basal areas stronger projecting towards termen on all wings, on hindwing obliquely reaching anal margin. Underside of forewing with large whitish medial area, underside of hindwing whitish rather than yellow. In external morphology differing in the short female palpi. In male genitalia valva sub-rectangular at tip, with longer spinules.

**Genetic data:** Nearest neighbour: *D. micheleae* at a distance of 7.4%, see also genetic data of preceding species.

**Distribution:** Rwanda, Zambia, Cameroun.

## Discussion

The genus *Dargeia* shows a combination of several unique characters in external morphology and genitalia which do not match the typical feature combinations of any of the established geometrine tribes (e.g. absence of frenulum, long bipectinate antennae in both sexes, shape of uncus and valvae). The systematic position of *Dargeia* therefore remains enigmatic. Interestingly, when blasting the COI data, the nearest neighbours are several neotropical species of the genera *Nemoria* and *Chavarriella* at minimum distances of approx. 9.5% (cf. Fig. 8). Tribe characters of the Nemoriini (= Ochrognesiini) according to PITKIN (1996) and VIIDALEPP & LINDT (2009; where it is misspelled to 'Nemoriini') are a) the presence of central sclerotization ("midrib")



**Fig. 8:** Neighbour Joining tree (Kimura 2 parameter, built with MEGA 5; cf. Tamura et al. 2007; 2011) of the species of the genus *Dargeia* and their closest neighbours in the genus *Nemoria*. Only barcodes (>500 bp) considered. Width of triangles represent sample size, depth of triangles the genetic variation within the genetic cluster.

of sternum A8; b) rod-like or spatulate uncus; and c) costal sclerotization of valva. None of these characters are found in *Dargeia*. Both Nemoriini-genera *Eucyclodes* (esp. '*Ochrognesia*' *difficta*) from East Asia and *Pyrochlora* from South America correspond well in several details of wing colouration and wing pattern. In male and female genitalia, however, none of the characteristic features of the genus *Dargeia* are found. The same applies to the external structure with the only exception being bipectinate antennae (though short) in both sexes of *Pyrochlora*. HERBULOT (1977) suggests certain relationships with the monotypic African genus *Luashia* DEBAUCHE, 1941, but the latter differs in many details, e.g. in well-developed abdominal crests, frenulum and medial spurs (hindtibia), concave hindwing termen between veins M1 and M3, forewing veins Sc and R1 not anastomosing. However, *Dargeia* and *Luashia* also share the distinctly bipectinate antennae in both sexes. VIIDALEPP & LINDT (2010) extensively discuss the relationships between the genera *Dargeia*, *Pyrochlora* and the Indo-Pacific genus *Rhanidopsis* concluding that there may be a real relationship between these genera rather than convergence, quoting their external similarity as 'putative ancestral wing pattern' while the strong genitalic differences are supposed to be subject of rapid 'modification in vicariance'.

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