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## Notes on the life history and taxonomy of *Cerurina marshalli* (Lepidoptera: Notodontidae: Cerurinae)

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**Abstract:** The final instar larvae of the Notodontidae species, *Cerurina marshalli* (Hampson, 1910) are described and illustrated in detail, with notes on habitat, host-plants and distribution of the species. Photographs of the eggs, larvae and adults are included with observations on characteristic larval defensive behaviour. Based on striking differences in the larvae and adult genitalia, *Cerurina marshalli argentata* (Gaede, 1934) is transferred from the genus *Cerurina* to *Afrocerura* and synonymised with *Afrocerura cameroona* (Bethune-Baker, 1927) (= *Afrocerura argentata* comb. nov., syn. nov.).

**Key words:** Lepidoptera, Afrotropical region, Zambia, Notodontidae, Cerurinae, taxonomy, larva, pupa, life history, caterpillar.

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### INTRODUCTION

The notodontid species *Cerurina marshalli* (Hampson, 1910) is an attractive medium sized moth with bold black markings on its silvery white wings. It has a particularly striking final instar larva with black and red aposematic colouration and yellow whip-like flagellae that it exudes in a defensive display to deter predators.

The taxonomy of *C. marshalli*, despite the rather conspicuous appearance of the moth, is poorly known and there have been a number of alterations to its taxonomy since the original description. In 1916 a similar looking species from Cameroon was described by Schultze as *Cerura argentina* but due to the homonymy with *Cerura argentina* Dognin, 1910 an objective replacement name, *Cerura argentata* Gaede, 1934, was introduced. Subsequently, Kiriakoff (1963) described the genus *Cerurina* and designated *C. marshalli* as the type species of the genus. He synonymised *C. argentata* with *C. marshalli* without providing any justification, only stating that despite the very extensive distribution of the species, *C. marshalli* does not appear to form geographic races (Kiriakoff, 1963).

In the most recent taxonomic overview of the genus provided by Schintlmeister & Witt (2015), *Cerura argentata* Gaede, 1934 was raised from synonymy to a subspecies of *marshalli* as it was recognised that there were sufficient differences between the genitalia of *C. marshalli marshalli* and *C. marshalli argentata* to do so. This taxonomic change however, was based on a misidentification of *argentata*, with the authors considering the West African specimens of *C. marshalli*

to be conspecific with *argentata*, due to the slight morphological differences between nominotypical and West African populations of *C. marshalli*.

Notes on the behaviour, habitat, host plants and life history of *C. marshalli* are presented for the first time herein, with a description of the final instar larva.

### MATERIAL AND METHODS

Putative larvae of *C. marshalli* were found in Mutinondo Wilderness Area, north-eastern Zambia by the author on 15 February 2019 and subsequently reared to adults in captivity. Notes on the life history, behaviour and habitat were made in the field and the larvae were photographed using an iPhone7.

Adults were photographed using a Nikon D90 Digital SLR camera equipped with a Nikon 105 mm f2.8G AF-S VR Micro-Nikkor lens.

Genitalia were dissected, macerated using potassium hydroxide 10% (KOH), stained using Eosin Red dye and mounted in Euparal on glass slides. The slides were photographed using a Canon EOS 700D Digital SLR camera mounted on a WILD M7A stereo microscope. Photo stacking software, Combine ZP, was used to stack habitus photographs and all images were processed using Adobe Photoshop CS5 software.

Label data of type material examined was transcribed verbatim using “/” to indicate a line break and “//” to indicate where one label ends and the next begins. Additional label information was captured in square brackets

### Abbreviations

ANHRT: African Natural History Research Trust, Leominster, United Kingdom.

NHMUK: Natural History Museum, London, United Kingdom.

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MRAC: Musée Royal de l'Afrique Centrale, Tervuren, Belgium.

TMSA: Ditsong National Museum of Natural History, Pretoria, Republic of South Africa.

ZMHB: Museum für Naturkunde, Berlin, Germany.

Other abbreviations:

LG: Genitalia slides prepared by Gyula M. László.

## RESULTS

### Behaviour of larvae in the wild

The final instar larvae of *C. marshalli* described in this paper were found on privately owned land on a plateau about 30 km west of the Luangwa Valley in a relatively unspoiled Miombo woodland and riverine forest (*mushitu*) habitat with large granite inselbergs and waterfalls supporting a rich diversity of flora and fauna (Fig. 1).



Violette Dérozier

**Figure 1** – Habitat at Mutinondo wilderness area in Zambia showing vast Miombo woodland and granite inselberg habitats.

Larvae were found feeding during the day on a single low-lying tree about 1.5 m high on the edge of Miombo woodland. The plant resembled *Flacourtia indica* (Burm.f.) Merr. (L. Merrett and S.C. Collins, pers. comm.), but had such high levels of herbivory to the leaves that this identification remains tentative.

There were roughly ten larvae on the tree with some individuals dropping to the ground when the tree was approached (behaviour previously observed in *C. argentina* Schultze, 1916). The remaining larvae continued to eat, but aware of a potential threat, began to exhibit characteristic defensive behaviour. When threatened, the larvae raised their heads and hind quarters into a poised defensive position whilst exerting their yellow whip-like flagellae from their anal claspers, flailing them backwards and forwards over their bodies demonstrating the full extent of their bright aposematic colouration in an effort to deter the perceived predator. (Video footage of this remarkable behaviour was captured and is available via the following link: <https://youtube.com/watch?v=4VRGUuVt5PA>).

When at rest, the larvae were seen extended out along a branch or in a more compact position, sometimes quite still. When eating, they grasped the host plant with their thoracic legs and were observed moving quite quickly around the host plant in the days leading up to pupation.

By the following day, the larvae had almost eaten every leaf on the tree and were also observed chewing the outer layer of bark from the branches while carefully avoiding the sharp tips of the spines.

### Description of the early stages of *Cerurina marshalli*

Four final instar larvae were collected on 16.ii.2019 and pupated within three to five days of collection (18–20.ii.2019). The unhatched cocoon was later dissected to observe the pupa in situ but only a desiccated larva was found. On opening the cocoon, it was observed that the larva had continued to eat the outer layer of bark from the twig inside the cocoon providing it with more woody material for cocoon building (see Discussion section below).

**Ovum** (Fig. 2). Approximate height 1 mm, diameter 2.3 mm. Colour: dark brown in centre with a translucent ring around outer edge. Shape: hemispherical, mostly smooth with a slightly dimpled surface texture. Description based on dry unfertilised eggs laid inside paper envelope, no information currently known about eggs in nature.



**Figure 2** – *Cerurina marshalli* ovum: left – dorsal view; right – lateral view. Scale bar = 1 mm.

**Larva: final-instar** (Figs 3 & 4). Length: 40–50 mm. Colour: head black, body red and black banded. Red colouration appearing brighter in lateral and ventral regions, more faded dorsally. Flagellae bright yellow-orange. Mouthparts: previous research on the mouth parts of this species' larva described stipital lobes present and with an acute tip, often curving dorsally in front of mandibles, mandibular margin smooth (Godfrey *et al.*, 1989). Thorax: lateral ground colour faded red, three to four globular black markings in upper portion of thorax laterally, more reduced globular markings in lower portion. A 'bell-curve' shaped dorsal plate present, directly behind head, shiny-black, smooth. Thoracic legs: shiny black. Abdomen: black parallel sided bands running around the entire circumference of the larva, separated by faded red intersegmental sections. Pro-legs: four pairs of non-sclerotized pro-legs present, black, apically rounded. Spiracles black. Larvae bearing one pair of modified anal claspers, shiny black, curved slightly towards body, bearing numerous short thorn-like spines. Flagellae: one pair of bright yellow-orange extendable flagellae, exuded during defensive display.

**Pupae and cocoons** (Fig. 5). Pupation occurs inside hardened cocoons. Information about colour and





Figure 3 – Final instar larvae of *C. marshalli* on host plant.



Figure 4 - Final instar larva of *C. marshalli* with its flagellae exerted.



Figure 5 – Cocoon of *Cerurina marshalli* – lateral view.

appearance of pupa not currently known. Cocoon oval; height approximately 10 mm, width 12 mm, length 20–30 mm. Formed on surface of branch using fragments of chewed bark spun into cocoon during construction, resulting in cocoons being robust and camouflaged in appearance, resembling the colour and texture of bark.

### Adult moths

Two adult moths emerged within a day of each other (15–16.iii.2019), both female (Figs 6 & 7). The third adult failed to eclose and the fourth larva escaped before pupation.



Figures 6 & 7 – Dorsal and lateral views of *C. marshalli* imago.

## DISCUSSION

### Host plants

Many African notodontid species are known to feed on plants in the Salicaceae family, including species in the genera *Scolopia*, *Trimeria* and *Flacourtia* (A. Schintlmeister, pers. comm.). European species also feed on species in the Salicaceae family, including *Salix* and *Populus*. Host plants recorded specifically for *C. marshalli* include *F. indica*, (Salicaceae), *Commiphora* sp. (Burseraceae) (Kroon, 1999; Schintlmeister & Witt, 2015), and *Populus wislizenii* (S. Wats.) (Salicaceae) (Schabel, 2006). In the original description of *C. argentina* this species was recorded feeding on *Doryalis* (Flacourtiaceae), now *Dovyalis* (Salicaceae).

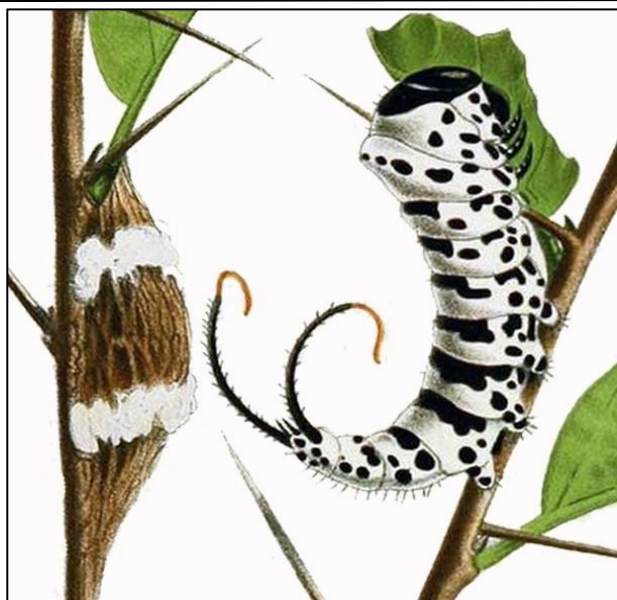
The high level of herbivory observed here has been recorded for *C. marshalli* before, where almost complete defoliation of a stand of *P. wislizenii* occurred at a forestry nursery in Mbeya, Tanzania, while they avoided other species of *Populus* growing in the vicinity (Schabel, 2006).

The use of masticated bark for cocoon spinning has been seen in other African notodontids such as *Hampsonita esmeralda* (Hampson, 1910) and *Notocerura spiritalis* (Distant, 1899) which have similar camouflaged cocoons incorporating woody particles (see Schintlmeister & Witt, 2015: 221).

### Comparing the larvae of *C. marshalli* and *C. argentata*

The larvae of *C. marshalli* found in Zambia (Figs 3 & 4) were compared with the larval image provided by Schultze (1916) in the original description of *Cerura argentina* in a painted plate showing the larva and cocoon (Fig. 8).

Hampson (1910) described the *C. marshalli* larva as follows: “Larva. Black-brown banded with white, the paired anal appendages long and thorny” It is speculated here that Hampson described a dried specimen and that the red bands seen in live specimens fade to white over time.



**Figure 8** – Painted images of the cocoon and final instar larva of *Cerura argentina* reproduced from Schultz (1916).

Even after considering the possibility of faded red bands, this is substantially different to the original description and primarily the painting of the larva of *C. argentina* where the habitus of the larva is described as ‘porcelain white’ or ‘brilliant white’ with some black markings and deep black dots and lines. The similarities in their general body plans is evident, however such marked differences in their colouration and patterning raised the idea that *marshalli* and *argentata* may differ more than at subspecific level. It has previously been shown in the literature that notodontid larvae, when available, are often a useful tool in separating closely-related species. In one example of a European notodontid, *Furcula loseri* Schintlmeister & Leipnitz, 2014, the male genitalia do not provide useful characters, but differences in the female genitalia and caterpillar-pattern revealed a cryptic species (Schintlmeister & Leipnitz, 2014).

Further investigations were carried out and after dissecting an adult male specimen housed in ANHRT, identified at the time as *C. marshalli argentata* from Ivindo National Park, Gabon, the same lowland rainforest habitat as the type locality of *argentata*, there was further support that *marshalli* and *argentata* were not conspecific or even congeneric due to the marked differences in the male genitalia. This led to the hypothesis that the species occurring in the lowland rainforest in the north-western part of the Congo basin is the taxon *argentata* and that it is not related to *C. marshalli*, but rather belongs to a different genus, *Afrocerura* Kiriakoff, 1963, rendering the genus *Cerurina* monotypic. This hypothesis is supported by differences observed in larval morphology. In addition it was revealed that *argentata* is sympatric with other, confusingly similar *Afrocerura* species. Following morphological studies of the habitus and genitalia of species currently in *Afrocerura* and *Cerurina* the following taxonomic changes are proposed:

## TAXONOMIC REVIEW

### Genus *Cerurina* Kiriakoff, 1963

Type species: *Cerura marshalli* Hampson, 1910 by original designation.

### *Cerurina marshalli* (Hampson, 1910)

(Figs 1–7, 9–17, genitalia Figs 32–35, 43–45)

*Cerura marshalli* Hampson, 1910: 456.

*Cerurina marshalli* (Hampson, 1910): Kiriakoff, 1963: 208.

*Cerurina marshalli marshalli* (Hampson, 1910): Schintlmeister & Witt, 2015: 32.

### Name bearing type:

Syntype ♀ (Fig. 9): “// *Cerura / marshalli / type ♀*. Hmpsn. [handwritten] // Mashonaland / Salisbury / bred Feb. 1902. [line handwritten] / G.A.K. Marshall // Type [circular label with red ring] // Photo by / A. SCHINTLMEISTER / #9.651 [yellow label]//” (NHMUK).

### Additional material examined: (all ANHRT):

ZAMBIA. 2♀♀ – 1460 m, Mutinondo Wilderness Area, Mpika, Northern Province, 12°27'06"S, 31°17'30"E, 14–17.ii.2019, General Coll., leg. Dérozier, V., Mulvaney, L. & Takano H., ANHRT:2019.4, unique numbers ANHRTUK00152996, Gen. slide No. LG5357♀ and ANHRTUK00152995, Gen. slide No. LG5366♀; 3♂♂, 2♀♀ – 1147 m, Lukwakwa, West Lunga National Park, (Cryptocephalum forest/Dambo), 12°39'40"S, 24°26'13"E, 9–15.xi.2018, MV Light Trap, leg. Aristophanous, M., Dérozier, V., László, G. & Oram, D., ANHRT:2018.40, unique numbers ANHRTUK00061237, ANHRTUK00061234, ANHRTUK00061232, Gen. slide No. LG5358♂, ANHRTUK00061206, and ANHRTUK00061207, ANHRT GEN. SLIDE NO. 00519♀; 2♂♂, 1♀ – same collecting locality and collectors but collected using LepiLED Light Trap, unique numbers ANHRTUK00063807, ANHRTUK00063860 and ANHRTUK00061386; 1♂ – 1316 m, Nkwaji, Mwinilunga, 11°36'22"S, 24°33'17"E, 29.x–3.xi.2013, MV Light Trap, leg. Smith, R., Takano, H., Chmurova, L. & Smith, L., ANHRT:2017.10, ANHRTUK00050386; 1♂ – 1179 m, Greystone, Kitwe, Copperbelt Province, 12°55'50"S, 28°14'29"E, 17–18.xi.2014, MV Light Trap, leg. Smith, R. & Takano, H., ANHRT:2017.12, ANHRTUK00050387; 1♂ – 1340 m, Jiwundu Swamp, 11°51'54"S, 25°33'20"E, 20–22.x.2014, MV Light Trap, leg. Smith, R., Takano, H. & Oram, D., ANHRT:2017.12, ANHRTUK00050388; 3♂♂ – same locality, but collected on 29.x–4.xi.2018 by leg. Aristophanous, M., Dérozier, V., László, G. & Oram, D., using a MV Light Trap, ANHRT:2018.40, unique numbers ANHRTUK00052879, ANHRTUK00074702 and ANHRTUK00062773; 2♂♂ – same locality, but collected by leg. Carter, M., Lloyd, A., Miles, W., Oram, D., & Smith, R. using a MV Light Trap, ANHRT:2017.32, unique numbers ANHRTUK00133729 and ANHRTUK00133712; 1♂ – 1205 m, Zambezi Rapids, (Miombo/Riverine forest mosaic), 11°7'30"S 24°11'6"E, leg. Aristophanous, M., Dérozier, V., László, G. & Oram, D., ANHRT:2018.40, ANHRTUK00052908; 1♀ – 1187 m, Kasanka National Park, Kabwe, 12°32'28"S, 30°12'42"E, 30.xi–1.xii.12, MV Light Trap, leg. Smith, R., & Takano, H., ANHRT:2017.7, ANHRTUK00073574, Gen. slide No. LG5365♀. IVORY COAST. 2♂♂ – 1171 m, Mt. Tonkou Peak, 07°27'15"N, 07°38'13"W, 1–8.xi.2015, MV Light Trap, leg. Aristophanous, M., Moretto, P. & Ruzzier, E., ANHRT:2017.16, unique numbers ANHRTUK00043082, ANHRT GEN. SLIDE NO. 00315♂ and ANHRTUK00042916, ANHRT GEN.



SLIDE NO. 00314♂. SIERRA LEONE. 1♂ – 420 m, Mansonia village at the foothills of Loma Mts., 09°07'47"N, 11°05'06"W, 6.vi.2016, MV Light Trap, leg. Takano, H., Miles, W. & Goff, R., ANHRT:2017.18, ANHRTUK00014085. TANZANIA. 7♂♂ – 1761 m, Mlangali, Livingstone Mts., 09°46'52"S, 34°31'22"E, xii.2012, MV Light Trap, leg. Smith, R. & Takano, H., ANHRT:2018.7, unique numbers ANHRTUK00050390, ANHRTUK00050391, ANHRTUK00050392, ANHRTUK00050393, ANHRTUK00050394, ANHRTUK00050389 and ANHRTUK00081591, ANHRT GEN. SLIDE NO. 00520♂. DEMOCRATIC REPUBLIC OF CONGO. 1♂ – 1700 m, Kanyatsi, Nord-Kivu, 1°22'S, 28°59'E, vi.2017, ex A. Colley, ANHRT:2018.22, ANHRTUK00158203, Gen. slide No. LG5367♂.

### Remarks

*Cerurina marshalli* is a widely distributed species throughout Sub-Saharan Africa. There are some differences in the external morphology of specimens collected in different regions, for example, specimens from western and eastern Africa having a somewhat narrower antemedial fascia with more undulated margins than topotypical specimens.

Kiriakoff (1963) reported that despite the very wide distribution of this species it does not appear to form geographic races. Despite some minor differences in the habitus of examined specimens collected in different regions of Africa, Kiriakoff's hypothesis probably does stand true, with there being one continuous population throughout. The male genitalia can be variable, especially the position and size of the terminal spines of the socii and the shape of the uncus tip making it difficult to split the different geographic populations, which is in agreement with Kiriakoff's concept. It cannot be excluded however that genetic analyses could reveal that there are distinct populations, but such analyses were unfortunately beyond the scope of the current paper.

It should be emphasised that *C. marshalli* can be externally very similar to species in the genus *Afrocerura* and that in some regions they are known to be sympatric (see map, Fig. 47). Three species, *C. marshalli*, *A. bifasciata bifasciata* and *A. cameroona* were all recorded from the same light trap over a two day period in Kitwe, Zambia and are likely to be sympatric throughout the northern and eastern parts of the country as well. *C. marshalli* and *A. leonensis* are both known from a similar area in West Africa (see examined material below) and it is hypothesised that they too are sympatric and that further sampling in this region will reveal this. In such instances, dissections may be necessary to confirm identifications.

According to the collecting data, *C. marshalli* is on the wing in the wet season. The syntype from Zimbabwe was collected in February and other material examined from Zambia was collected in February, October, November and December. In Ivory Coast specimens were collected in November (end of rains) and in Sierra Leone in June. Specimens from Tanzania were collected in December which for much of the country is the dry season but in the

south of Tanzania (where the specimens are from) it is the rainy season.

It is worth noting that Schintlmeister & Witt (2015) refer to a holotype female despite Hampson clearly stating in the original description that the type series consisted of three males and six females.

### Distribution

*C. marshalli* is known to occur in the Central African Republic, Ivory Coast, Democratic Republic of Congo, Malawi, Mozambique, Namibia, Tanzania, Zambia, Zimbabwe and South Africa (Schintlmeister & Witt, 2015, De Prins & De Prins, 2019). The records for Gabon and Cameroon in Schintlmeister & Witt (2015) likely refer to *Afrocerura cameroona* (see below). *Cerurina marshalli* mainly inhabits dry savannah habitats but also occurs in moist forests of high elevation for example in Tanzania and D.R. Congo (Kivu). Specimens collected recently on ANHRT expeditions from Sierra Leone, represent a new country record for this species.

### Genus *Afrocerura* Kiriakoff, 1963

(Figs 18–31, genitalia Figs 36–42, 46)

Type species: *Cerura leonensis* Hampson, 1910 by original designation.

Species:

*Afrocerura leonensis* (Hampson, 1910)  
*Afrocerura bifasciata bifasciata* (Janse, 1920)  
*Afrocerura bifasciata tanganyikae* Kiriakoff, 1963  
*Afrocerura cameroona* (Bethune-Baker, 1927)  
 = *Cerura argentata* Gaede, 1934 **syn. nov.**  
*Afrocerura thomensis* (Talbot, 1929)

### Diagnostic characters of *Afrocerura*

Species in the genera *Cerurina* and *Afrocerura* are externally very similar but differences in both external and genital morphology can be used to separate them. In general, species in the genus *Cerurina* have a more silvery whitish forewing ground colour, while species in *Afrocerura* have a more off-white or creamy ground colour. In addition to this, species in the genus *Cerurina*, have a wider, continuous, more sharply defined blackish oblique antemedial fascia and almost completely absent subterminal fascia on the upper side of their forewings (arrows indicate these characters on Fig. 9 [a & b]), compared to species of *Afrocerura* where the former character is often interrupted or even absent and the latter almost always present (arrows on Fig. 18 [a & b]). These differential characters based on observations in the current paper are added to characters provided by Kiriakoff (1963) such as wing venation and have proved to be more relevant for distinguishing the two genera.

The two genera can clearly be distinguished by the notable differences in the male genitalia described by Kiriakoff (1963). He referred to *Cerurina* having a narrowly based uncus, widening distally with a more or less triangular end. Based on examinations in the current paper and observed variation in uncus shape it can be described more accurately as the apex of the uncus having a rounded terminal margin with a depression in the middle (referred to as notched by Kiriakoff), resulting in a slight bifid protuberance in some specimens, but this is quite variable

(as seen in Figs 32–35 p.10). The lateral margins of the uncus tip bear a few small denticulations (Fig. 32 a). Conversely, species in the genus *Afrocerura* (Figs 36–42 p. 10) have a broad and rounded uncus base with a narrow tip without denticulate margins like in *Cerurina* species (Fig. 36 a). A particularly useful character is the presence of the dorsal ridge on the uncus in *Afrocerura* which can only be seen in certain orientations (Fig. 42 a) and which is absent in *Cerurina*. In *Cerurina* the *socii* (erroneously referred to as the *gnathos* by Kiriakoff) are well developed, about as long as the uncus, wide, with parallel margins and are somewhat arched, bearing 2 or 3 terminal denticulations (Fig. 32 b) In contrast, *Afrocerura* have relatively short, slender, slightly arched *socii* without denticulations (Fig. 36 b). There are differences in their valvae also, with those of *Cerurina* being club-like and apically rounded (Fig. 32 c) whereas the valvae of *Afrocerura* are narrower in general (Fig. 37 c), ranging from long and thin (*thomensis*, *cameroona*) to shorter, stouter and wider at the base (*leonensis*, *bifasciata*).

Although *Afrocerura* does not occur in South Africa, Schintlmeister & Witt (2015: 31) discussed the genus briefly in context with *Notocerura* and executed two taxonomic changes, treating *tanganyikae* as a subspecies of *bifasciata* and raising *thomensis* to species rank.

#### ***Afrocerura leonensis* (Hampson, 1910)**

(Figs 18–19, genitalia Fig. 36)

*Cerura leonensis* Hampson, 1910: 457.

*Afrocerura leonensis leonensis* (Hampson, 1910): Kiriakoff, 1963: 213.

#### **Name bearing type:**

Holotype ♀ (Fig. 18): “// Cerura / leonensis / type ♀. Hmpsn. [handwritten] // Type [circular label with red ring] // S. Leone [handwritten] / Crowley / Bequest. / 1901-78 // Photo done by / A. SCHINTLMEISTER / #9.668 [yellow label]//” (NHMUK).

#### **Additional material examined:** (all ANHRT)

GUINEA. 3♂♂ – 1413 m, Dalaba, Foret de Goubel, 10°39'27"N, 12°15'44"W, 10–18.ix.2019, MV Light Trap, leg. Geiser, M., Leno, M., Koivagui, S., Miles, W., Mulvaney, L., & Sáfián, Sz., ANHRT:2019.19, unique numbers ANHRTUK00103027, ANHRTUK00103028 and ANHRTUK00103029, Gen. slide No. LG5368♂.

#### **Remarks**

This species was described by Hampson (1910), based on a single female holotype from Sierra Leone. Kiriakoff's (1963) decision to designate a species described from a single female specimen as the type species of a new genus is rather perplexing. The generic description and diagnoses he provides are based on male specimens tentatively identified as conspecific with Hampson's type. Kiriakoff did not consider the differences he observed in the genitalia of specimens from different geographical regions of Africa to be substantial enough for species level separation and therefore proposed *Afrocerura leonensis leonensis* (Hampson, 1910) to be the northern race, *A. leonensis bifasciata* (Janse, 1920) to be the southern race and *A. leonensis tanganyikae* Kiriakoff, 1963 to be the eastern race of the species. He also referred to the genitalia of *leonensis* as having a subterminal tooth or hook on the valvae.

Kiriakoff however failed to provide the provenance of the specimen he dissected and as he states that he has examined '*leonensis*' specimens from Togo and eastern D.R. Congo, the true identity of *leonensis* males remains problematic. There is a male specimen from Nyamunyunye, D.R. Congo in MRAC which was identified as *A. leonensis leonensis* by Kiriakoff and dissected for his 1963 publication and it is possible that this is the genitalia figured in the publication (although this has not been corroborated).

Nevertheless, on the basis of West African material in the ANHRT, the Nyamunyunye specimen is almost certainly not conspecific with true *leonensis*. On comparing the genitalia of West African '*leonensis*' and southern African *bifasciata* specimens with Kiriakoff's figure of *leonensis*, it appears Kiriakoff did not figure the genitalia of true *leonensis*, but a taxon near *bifasciata* (then a ssp. of *leonensis*). To add to this conundrum, there are at least two *Afrocerura* taxa in West Africa of which one almost certainly remains undescribed. A male specimen from Guinea that is phenotypically similar to the holotype female of *leonensis* exhibited markedly different genitalia (bearing no terminal or subterminal spike or tooth) to Kiriakoff's figure whilst a male specimen from Liberia (ANHRTUK00101699, LG5361♂) possessed subterminal spikes on its valvae and a similarly broad uncus base but the spike was positioned in a completely different orientation to the figure.

With the ambiguity in the literature and without longer series of both sexes from West Africa, it is impossible to identify which of the two West African taxa is true *leonensis* and therefore, which one requires description. Due to external similarities with the holotype of *leonensis* the Guinean specimens are tentatively considered here as males of true *leonensis* and its genitalia illustrated for the first time (Fig. 36). The observed differences in the male genitalia of *bifasciata* and *leonensis* support the species rank distinction between the two taxa where *leonensis* is likely to be a West African vicariant of the southern African *bifasciata*.

#### ***Afrocerura bifasciata bifasciata* (Janse, 1920)**

(Figs 20–21, genitalia Figs 37–38, 46)

*Cerura bifasciata* Janse, 1920: 171.

*Afrocerura leonensis bifasciata* (Janse, 1920): Kiriakoff, 1963: 213.

*Afrocerura bifasciata bifasciata* (Janse, 1920): Schintlmeister & Witt, 2015: 31.

#### **Name bearing type:**

Holotype ♀ (Fig. 20): “// Cerura / bifasciata Janse. [handwritten] / Type No. 1655 [number handwritten] // S. Rhodesia / ex. Bulaw. Mus. [handwritten] // Photo done by / A. SCHINTLMEISTER / #25.977 [yellow label]//” (TMSA).

#### **Additional material examined:** (all ANHRT)

ZAMBIA. 1♂ – 1400 m, Kankonde Camp, Mutinondo Stream, 12°23'29"S, 31°19'24"E, 12–15.xi.2014, MV Light Trap, leg. Smith, R. & Takano, H., ANHRT:2017.12, ANHRTUK00073573, Gen. slide No. LG5364♂; 1♂ – 1197 m, Bufumu Forest, Kasanka National Park, 12°29'50"S, 30°11'31"E, 1.xii.2012, Actinic Light, leg. Smith, R. & Takano, H.,

ANHRT:2017.7, ANHRTUK00073572, Gen. slide No. LG5363♂; 1♂ – 1340 m, Jiwundu swamp, 11°51'54"S, 25°33'20"E, 21–24. xi.2014, MV Light Trap, leg. Smith, R. & Takano, H., ANHRT:2017.12, ANHRTUK00010143, ANHRT GEN. SLIDE NO. 00313♂; 2♀ – 1179 m, Greystone, Kitwe, Copperbelt Province, 12°55'50"S, 28°14'29"E, 17–18.xi.2014, MV Light Trap, leg. Smith, R. & Takano, H., ANHRT:2017.12, ANHRTUK00043083 and ANHRTUK00042917, ANHRT GEN. SLIDE NO. 00316♀.

### Remarks

This species was originally described from a single female specimen from Zimbabwe. Kiriakoff (1963: 214) designated a (redundant) neallotype (NHMUK) and transferred *bifasciata* to the genus *Afrocerura* as a subspecies of *A. leonensis*. Schintlmeister & Witt (2015) considered *bifasciata* to be a good species, a view which is upheld here. As previously stated under *leonensis*, the morphological differences between the genitalia of *leonensis* and *bifasciata* are found to be distinctive enough to consider them as being separate species. The male genitalia and habitus of true *bifasciata* are illustrated here for the first time (Figs 37–38, 21).

### Distribution

The specimens collected in Zambia represent a new country record. The species is now known from Zimbabwe, Tanzania (De Prins & De Prins, 2019) and Zambia.

### *Afrocerura bifasciata tanganyikae* (Kiriakoff, 1963)

(Fig. 22)

*Afrocerura leonensis tanganyikae* Kiriakoff, 1963: 215.

*Afrocerura bifasciata tanganyikae* (Kiriakoff, 1963): Schintlmeister & Witt, 2015: 31.

**Name bearing type:** (Fig. 22) Holotype ♂: [without type label] “// [Kenya] Mombasa, / ~~October~~ 05. / (Jackson). [black bordered label] // bifasciata Janse [handwritten] // Photo done by / A. SCHINTLMEISTER / #9.669 [yellow label] //” (NHMUK).

### Remarks

The holotype of this taxon was dissected and figured by Kiriakoff (1963) but the corresponding genitalia slide could not be located in NHMUK. Any future assessment of the holotype and conclusions drawn about its ranking at species or subspecies level therefore remains ambiguous. Schintlmeister & Witt (2015) considered *tanganyikae* to be a subspecies of *bifasciata* rather than *leonensis* and figured the male genitalia of a specimen from southern Tanzania (labelled incorrectly as *Afrocerura tanganyikae*). Without access to any further material, their subspecific concept is here maintained.

### *Afrocerura cameroona* (Bethune-Baker, 1927)

(Figs 8, 26–31, genitalia Figs 39–41)

*Cerura argentina* Schultze, 1916: 70 (preocc.).

*Cerura cameroona* Bethune-Baker, 1927: 328.

*Cerura argentata* Gaede 1934: 46 (nom. nov.).

*Cerurina argentata* (Gaede, 1934): Kiriakoff, 1963: 208.

*Afrocerura cameroona* (Talbot [sic], 1927): Kiriakoff, 1963: 215.

*Cerurina marshalli argentata* (Gaede, 1934): Schintlmeister & Witt, 2015: 32.

*Afrocerura argentata* (Gaede, 1934): **comb. nov., syn. nov.**

### Name bearing types:

Holotype ♀ (Fig. 27): “// Cameroona / B-B // Bitye, 2000 ft. / Ja River / Cameroons / G.L. Bates // Type. [circular label with turquoise above and below and text and a horizontal white band] // Photo done by A. SCHINTLMEISTER / #9.672 [yellow label] //” (NHMUK).

*Cerura argentina*. Schultze, 1916

Syntype ♀, (Fig. 30): “// Süd-Kamerun, / Molundu. / Dr. Arnold Schultze / e. 1. leg. 26.XI.1910 // Cerura argentina / Schultze [handwritten] / Dr. Arn. Schultze ♀ / determ. 1916 [rectangular red bordered label] // Photo done by / A. SCHINTLMEISTER / #25.097 //” (ZMHB).

Syntype ♂, (Fig. 31): “// Typus [rectangular red label with thin black border] // Cerura / argentina Arn. / Schultze [handwritten] // Süd-Kamerun, / Molundu. / Dr. Arnold Schultze / leg. 17–22.XII.1910 // Photo done by / A. SCHINTLMEISTER / #19.981 //” (ZMHB).

### Additional material examined: (all ANHRT)

GABON. 1♂ – Ogooué Ivindo, National Park, Ivindo – Station de Recherche d’Ipassa, 450 m, 0°30'43"N, 12°48'12"E, 14–26.vi.2016, MV Light Trap, leg. Ruzzier, E. & Tasane, T., ANHRT:2017.19, ANHRTUK00044930, ANHRT GEN. SLIDE NO. 00521♂. ZAMBIA. 1♂, 1♀ – 1191 m, Kasanka River pontoon, Kasanka National Park, 12°34'23"S, 30°14'05"E, 2–4.xii.2012, MV Light Trap, leg. Smith, R. & Takano, H., ANHRT:2017.7, unique numbers ANHRTUK00050395 and ANHRTUK00050396; 1♂ – 1400 m, Hillwood, Ikelenge, 11°16'02"S, 24°18'59"E, 21–28.x.2013, MV Light Trap, leg. Smith, R., Takano, H., Chmurova, L. & Smith, L., ANHRT:2017.10, ANHRTUK00073571, Gen. slide No. LG5359♂; 1♂ – 1080 m, Mayukuyuku, Kafue National Park, 14°54'55"S, 26°03'47"E, 9–11.iv.2014, MV Light Trap, leg. Smith, R., Takano, H., Chmurova, L. & Smith, L., ANHRT:2017.11, ANHRTUK00081592, ANHRT GEN. SLIDE NO. 00522♂; 1♀ – 1179 m, Greystone, Kitwe, Copperbelt Province, 12°55'50"S, 28°14'29"E, 17–18.xi.2014, MV Light Trap, leg. Smith, R. & Takano, H., ANHRT:2017.12, ANHRTUK00081593, ANHRT GEN. SLIDE NO. 00523♀.

### Remarks

Schintlmeister & Witt (2015) reinstated the taxon *argentata* as the West African subspecies of *C. marshalli*. Upon examination of specimens in ANHRT collected near the type locality of *argentata*, the taxon was found not to be conspecific with *C. marshalli*, but belonging instead to the genus *Afrocerura*. The ANHRT specimen from Gabon was compared to the syntypes of *argentata* and to the holotype of *A. cameroona*, and the following conclusions were drawn: all specimens were collected in similar lowland forest environments in close proximity to one another (see map in Fig. 48) and all specimens are phenotypically identical. Therefore all of these specimens



are considered to be conspecific and consequently, *argentata* is synonymised with *cameroona*.

Kiriakoff (1963) erroneously refers to Talbot as the author of *cameroona*, the correct author being Bethune-Baker.

#### ***Afrocerura thomensis* (Talbot, 1929)**

(Figs 23–25, genitalia Fig. 42)

*Cerura thomensis* Talbot, 1929: 63.

*Afrocerura cameroona thomensis* (Talbot, 1929): Kiriakoff, 1963: 215.

*Afrocerura thomensis* (Talbot, 1929): Schintlmeister & Witt, 2015: 31.

#### **Name bearing type:**

Holotype ♂ (Fig. 23): “// Cerura / thomensis / Talb. 1929. / ♂ Holotype. // Type / H.T. [circular label with red ring] // 25.26. / Sao Thome, / 24.i.–25.ii. [19]26. / T.A. Barnes // Photo done by A. SCHINTLMEISTER / #9.670 [yellow label] //” (NHMUK).

**Additional material examined:** (all ANHRT, unless otherwise indicated)

SAO TOME. Paratype ♀, (Fig. 24): Sao Thome, Sept. – Oct. 1926., T.A. Barnes, (NHMUK); 1♂ – 1303 m, Antenna, Bom successo, 0°16'33.7"N, 6°36'19.7"E, 21.x.2016, MV Light Trap, leg. Turner, C. R. & Tasane, T., ANHRT:2017.21, ANHRTUK00074983; 1♂ – 1321 m, Antenna, Bom Successo (plantation-dry scrub forest), 0°16'31"N, 6°36'14"E, 22–25.i.2018, MV Light Trap, leg. Aristophanous, M., Lima, D., Miles, W. & Turner, C. R., ANHRT:2018.1, ANHRTUK00041722, Gen. slide No. LG5362♂.

#### **Remarks**

The extent of the differences between the male genitalia of *A. thomensis* and *A. cameroona* justify the species level distinction between the two taxa (Figs 39–42) which was recognised by Schintlmeister & Witt (2015) who raised it to species rank.

#### **CONCLUSIONS**

The main results of the present study can be summarised as follows: the final instar larva of *C. marshalli* is described and illustrated in full with new information on the bionomics and behaviour of the larva. Taxonomic investigations initiated by the strikingly different habitus of the caterpillars of *marshalli* and *argentata* have resulted in the following nomenclatural changes: *Cerura argentata* is moved from the genus *Cerurina* to *Afrocerura* (*Afrocerura argentata* comb. nov.) based on the examination of type material and recently collected specimens, *A. argentata* is found to be conspecific with *A. cameroona* (Bethune-Baker, 1927), (*Afrocerura argentata* syn. nov.). Three of the five species of *Afrocerura* currently known to science were originally described from a single female holotype (in the case of *A. bifasciata*, *A. leonensis*) and a female holotype and a female paratype (in the case of *A. cameroona*) which has led to certain ambiguities in the literature arising from tentative association of male specimens as seen in Kiriakoff (1963). An attempt has been made in this present paper to clarify the morphological characters of these three *Afrocerura* species and illustrate the habitus and genitalia, some for the first time.

To conclude, the present paper has taken a step forward in elucidating the rather complicated taxonomy of the *Cerurina*–*Afrocerura* genera through morphological studies although there still remains some ambiguity around the pairing of males with females in the genus *Afrocerura*. Despite external morphology being a useful indicator, confirmation of these pairings will only be strictly possible either by genetic analysis of the female holotypes and suspected conspecific males or through rearing experiments.

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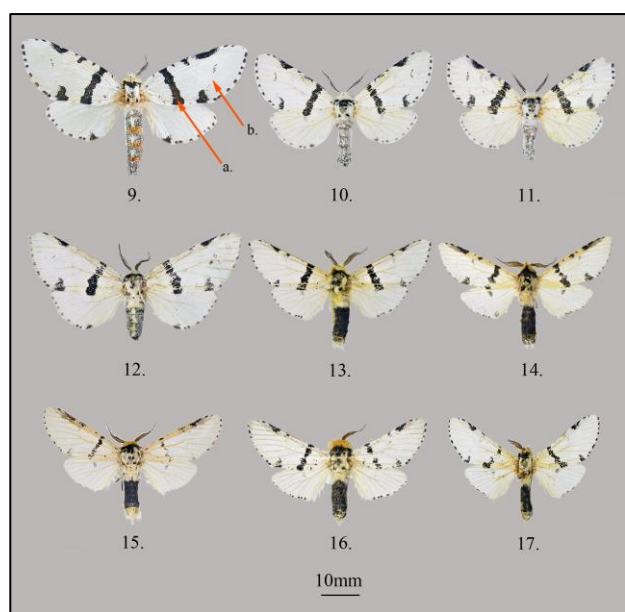
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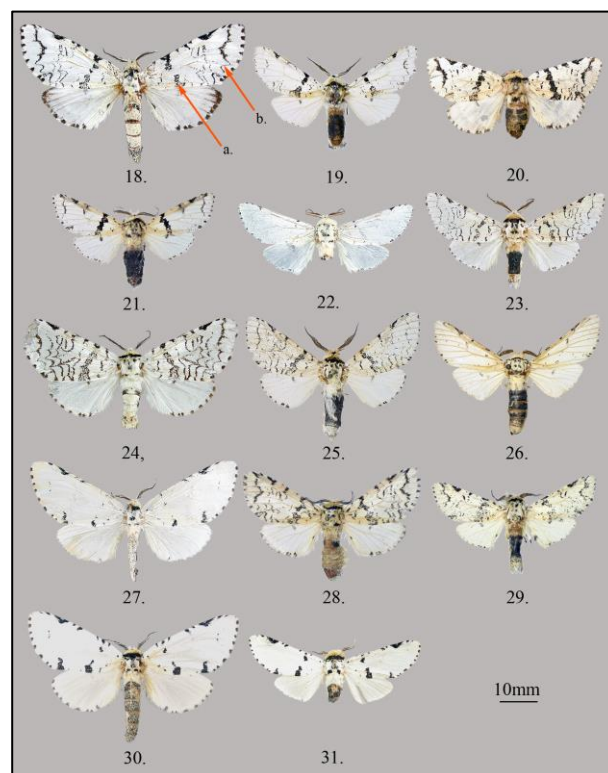
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**FIGURES – EXTERNAL MORPHOLOGY**

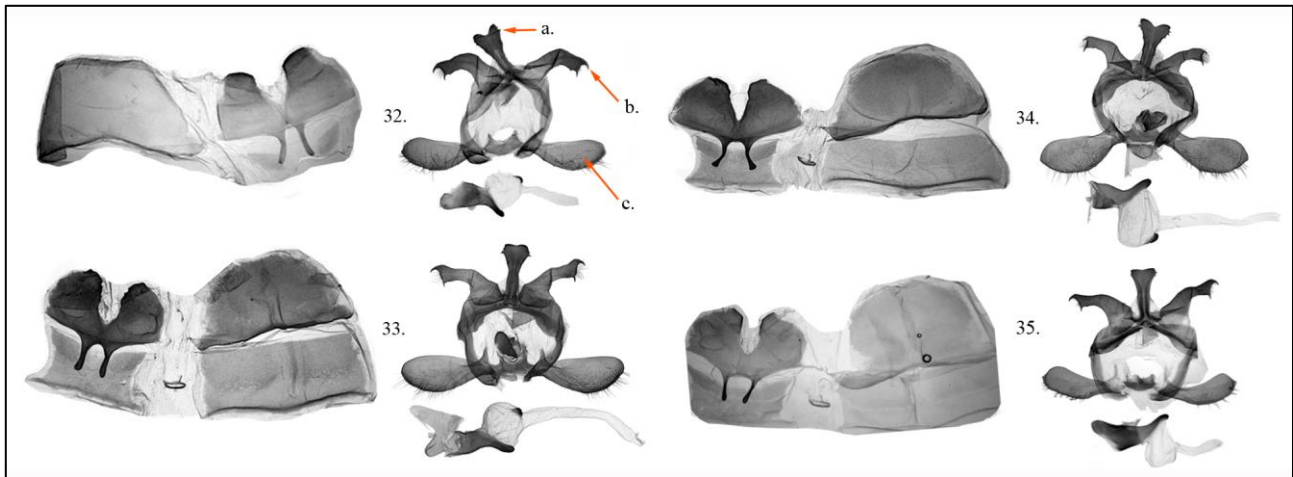


**Figures 9–17:** Comparative adult specimens of *Cerurina marshalli* (all ANHRT, unless otherwise indicated), arrows indicate diagnostic generic characters. 9. Syntype ♀, Zimbabwe, Mashonaland (NHMUK), a. defined antemedial fascia, b. almost completely deleted subterminal fascia; 10. Zambia, Mutinondo (ANHRTUK00152995, LG5366♀); 11. Zambia, Mutinondo (ANHRTUK00152996, LG5357♀); 12. Zambia, Lukwakwa (ANHRTUK00061207, ANHRT Gen. slide no. 00519♀); 13. Zambia, Lukwakwa (ANHRTUK00061232, LG5358♂); 14. Zambia, Kitwe (ANHRTUK00050387, ♂); 15. Ivory Coast, Mt. Tonkoui (ANHRTUK00043082, ANHRT Gen. slide no. 00315♂); 16. Tanzania, Livingstone Mts. (ANHRTUK00081591, ANHRT Gen. slide no. 00520♂); 17. D. R. Congo, Nord Kivu (ANHRTUK00158203, LG5367♂).

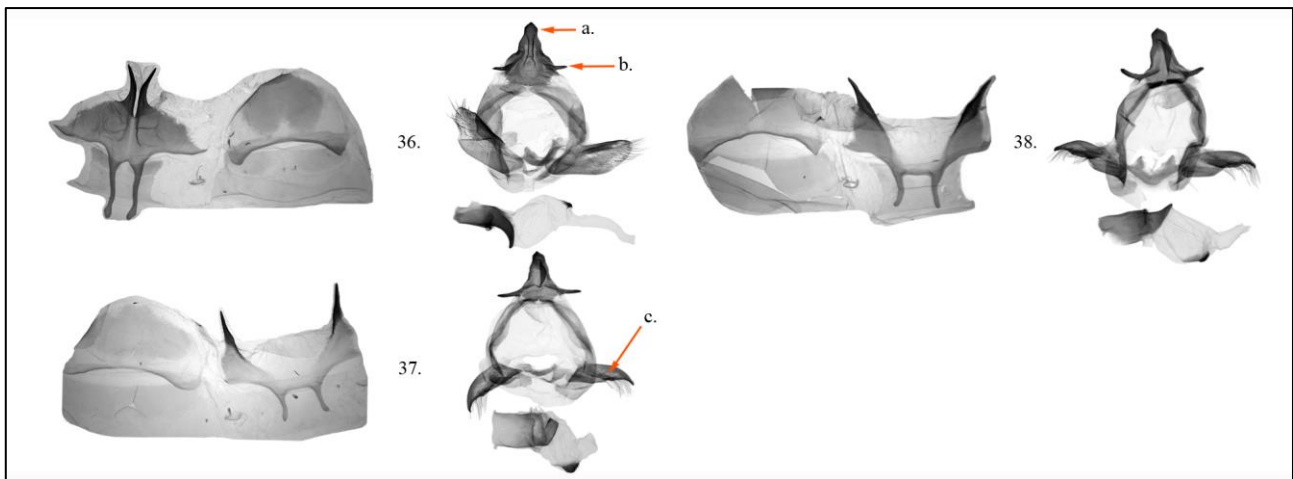


**Figures 18–31:** Adults of examined *Afrocerura* spp. (all ANHRT, unless otherwise indicated), arrows indicate diagnostic generic characters. 18. *A. leonensis*, holotype ♀, Sierra Leone (NHMUK), a. antemedial fascia often interrupted or deleted entirely, b. subterminal fascia almost always present; 19. *A. leonensis*, Guinea, Dalaba (ANHRTUK00103029, LG5368♂); 20. *A. bifasciata bifasciata*, holotype ♀, Zimbabwe, (Type no. 1655) (TMSA); 21. *A. bifasciata bifasciata*, Zambia, Kasanka N.P. (ANHRTUK00073572, LG5363♂); 22. *A. bifasciata tanganyikae*, holotype ♂ [without holotype label] Kenya, Mombassa (NHMUK); 23. *A. thomensis*, holotype ♂, São Tomé (NHMUK); 24. *A. thomensis*, paratype (allotype) ♀, São Tomé (NHMUK); 25. *A. thomensis*, São Tomé, Bom Successo (ANHRTUK00041722, LG5362♂); Comparative specimens of *A. cameroona*: 26. *A. cameroona*, Gabon, Ivindo N.P. (ANHRTUK00044930, ANHRT slide no. 00521♂); 27. *A. cameroona*, holotype ♀, Cameroon, Bitye, (NHMUK); 28. *A. cameroona*, Zambia, Kitwe (ANHRTUK00081593, ANHRT slide no. 00523♀); 29. *A. cameroona*, Zambia, Kafue N.P. (ANHRTUK00081592, ANHRT slide no. 00522♂); 30. ♀(ZMHB) & 31. ♂(ZMHB) *A. cameroona*, (= *Cerura argentina* Schultze, 1916 syntypes), Süd-Kamerun, Molundu.

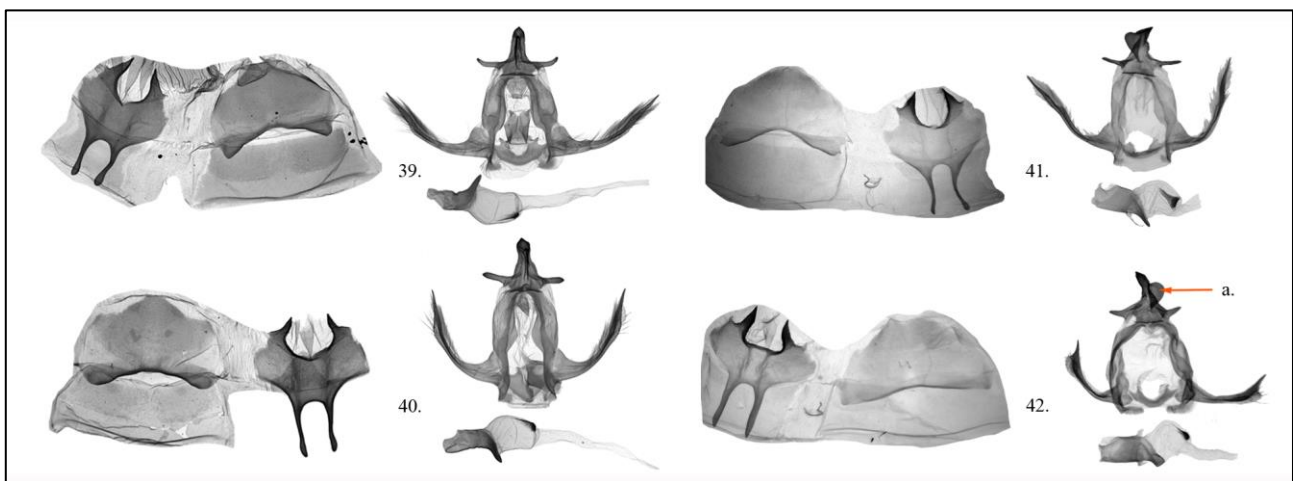
**FIGURES – MALE GENITALIA**



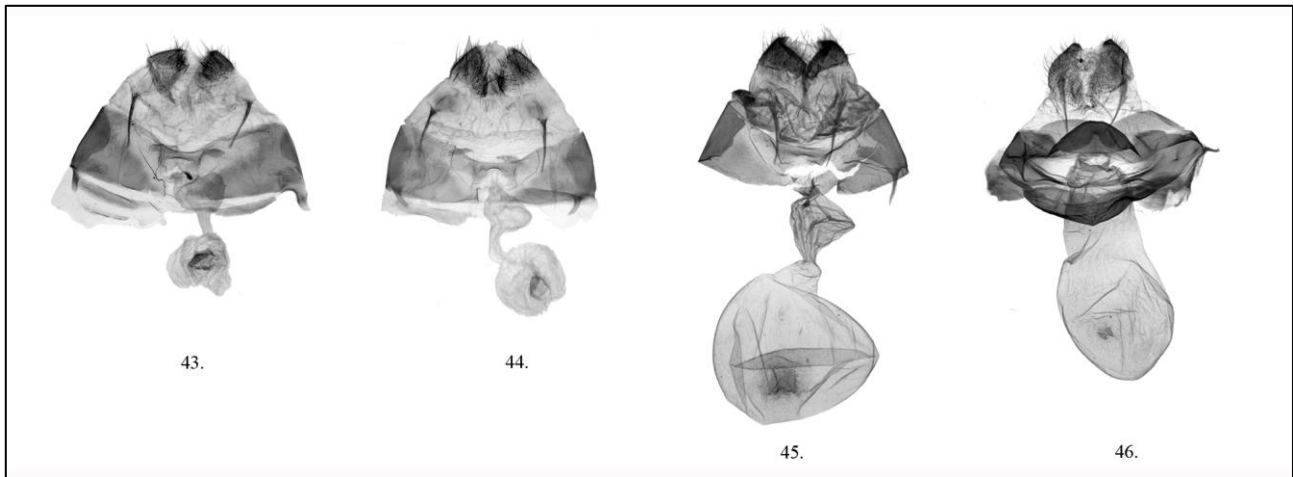
**Figures 32–35:** Male genitalia of *Cerurina marshalli* (Hampson, 1910) (all ANHRT), arrows indicate diagnostic generic characters. 32. Zambia, Lukwakwa (ANHRTUK00061232, LG5358♂), a. bifid uncus tip and lateral denticulations, b. socii well developed with 2–3 denticulations, c. valvae club-like and apically rounded; 33. Ivory Coast, Mt. Tonkoui, (ANHRTUK00043082, ANHRT Gen. slide no. 00315♂); 34. Tanzania, Livingstone Mts. (ANHRTUK00081591, ANHRT Gen. slide no. 00520♂); 35. D.R. Congo, Nord Kivu (ANHRTUK00158203, LG5367♂).



**Figures 36–38** – Male genitalia of *Afrocerura* spp. (all ANHRT), arrows indicate diagnostic generic characters. 36. *A. leonensis* (Hampson, 1910), Guinea, Dalaba (ANHRTUK00103029, LG5368♂), a. narrow uncus tip without denticulate margins, b. relatively short, slender, slightly arched socii without denticulations; 37. *A. bifasciata bifasciata* (Janse, 1920), Zambia, Kasanka N.P. (ANHRTUK00073572, LG5363♂), c. narrow valvae; 38. *A. bifasciata bifasciata*, Zambia, Kankonde Camp, Mutinondo Stream (ANHRTUK00073573, LG5364♂).



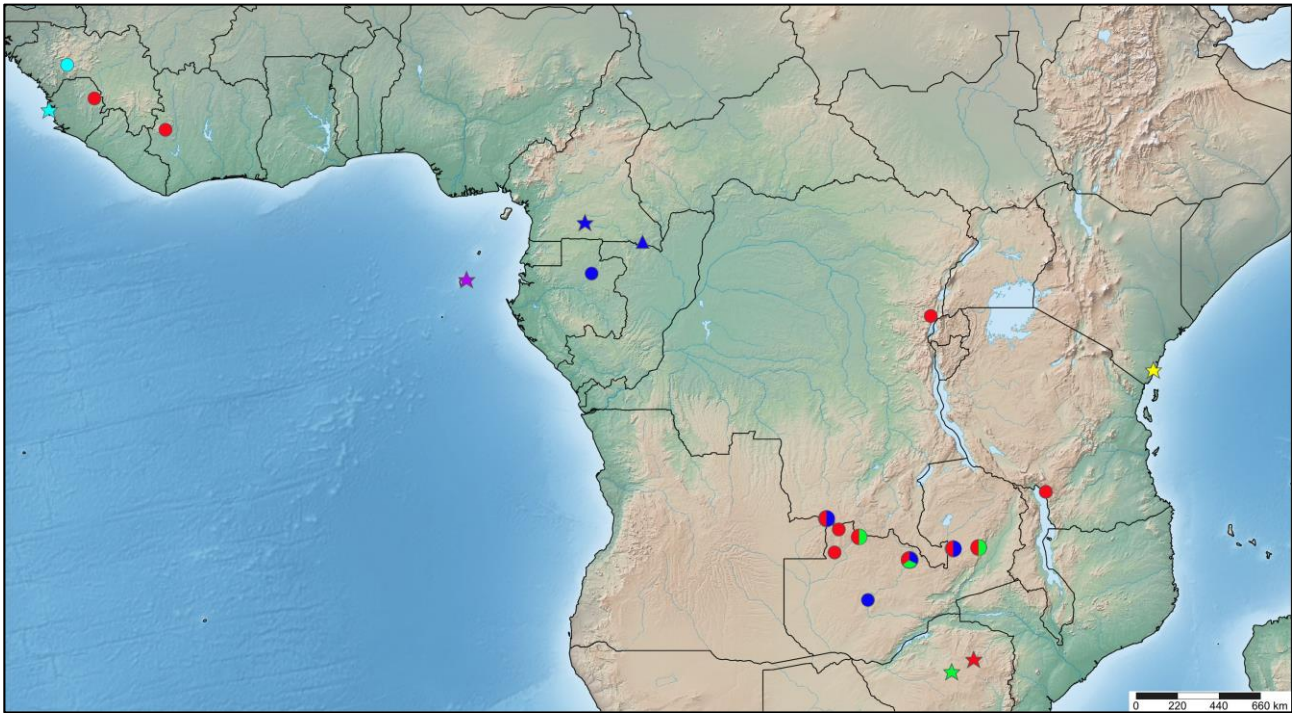
**Figures 39–42** – Male genitalia of *Afrocerura* spp. (all ANHRT), arrow indicates a diagnostic generic character. 39. *A. cameroona* (Bethune-Baker, 1927), Gabon, Ivindo N.P. (ANHRTUK00044930, ANHRT slide no. 00521♂); 40. *A. cameroona*, Zambia, Kafue N.P. (ANHRTUK00081592, ANHRT slide no. 00522♂); 41. *A. cameroona*, Zambia, Hillwood, Ikelenge (ANHRTUK00073571, LG5359♂); 42. *A. thomensis* (Talbot, 1929), São Tomé, Bom Sucesso (ANHRTUK00041722, LG5362♂), a. dorsal crest on the uncus.

**FIGURES – FEMALE GENITALIA**

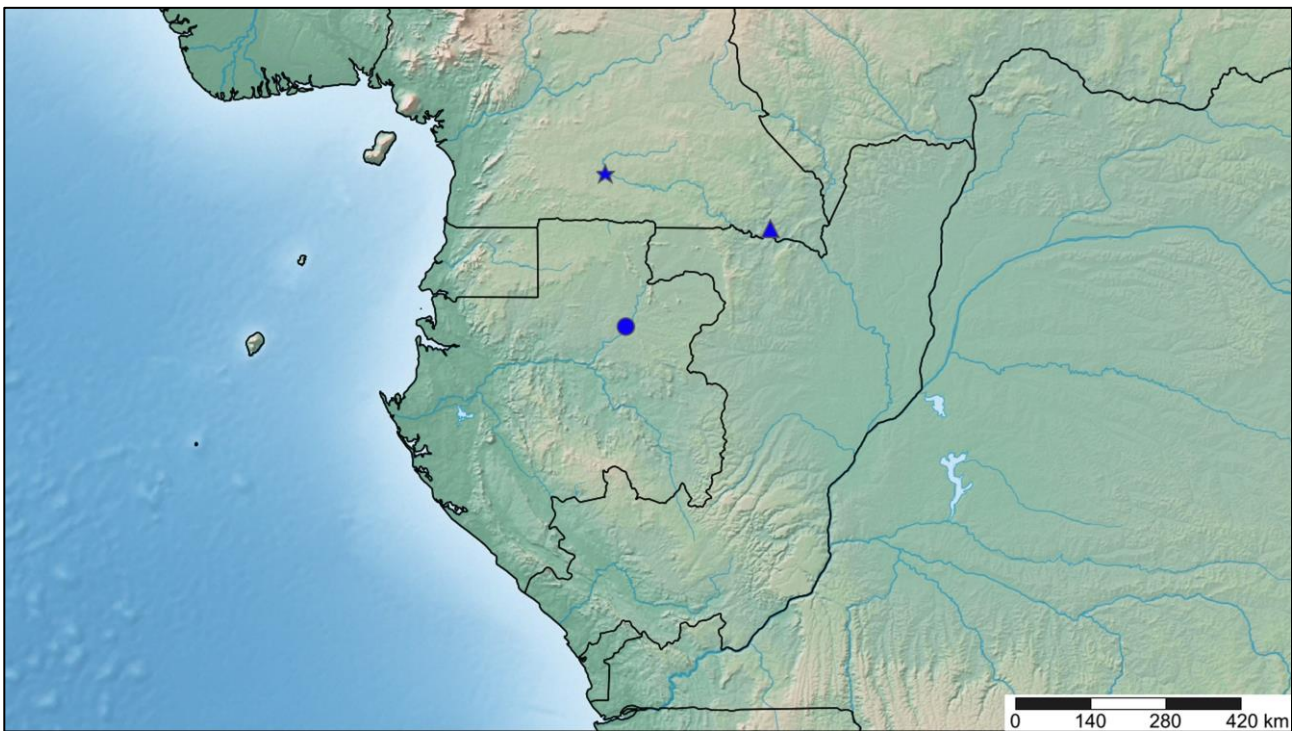
**Figures 43–46** – Female genitalia of *Cerurina* and *Afrocerura* spp. (all ANHRT). 43. *C. marshalli* (Hampson, 1910), Zambia, Mutinondo (ANHRTUK00152996, LG5357♀); 44. *C. marshalli*, Zambia, Mutinondo (ANHRTUK00152995, LG5366♀); 45. *C. marshalli*, Zambia, Lukwakwa (ANHRTUK00061207, ANHRT Gen. slide no. 00519♀); 46. *A. bifasciata bifasciata* (Janse, 1920), Zambia, Kitwe (ANHRTUK00042917, ANHRT Gen. slide no. 00316♀).



**FIGURES – BIOGEOGRAPHICAL**



**Figure 47:** Locality map for material examined of *Cerurina* and *Afrocerura* spp., showing areas where species are known to occur sympatrically. ● *C. marshalli* (★ST♀); ● *A. leonensis* (★HT♀); ● *A. bifasciata bifasciata* (★HT♀); *A. bifasciata tanganyikae* (★HT♂); ● *A. cameroona* (★HT♀); *Cerura argentina* Schultze, 1916 (▲ST♀); *A. thomensis* (★HT♂).



**Figure 48:** Geographical proximity of the type locality of *Afrocerura cameroona* (★HT♀), the type locality of *Cerura argentina* Schultze, 1916 (▲ST♀♂) and the collecting locality of the ANHRT Gabon specimen (●ANHRTUK00044930, ♂), all believed here to be conspecific with *A. cameroona*.