ISBN 1-920187-21-9
9 781920 187217
ISSN 1018 6490

METAMORPHOSIS

JOURNAL OF THE LEPIDOPTERISTS' SOCIETY OF AFRICA

THE LEPIDOPTERISTS' SOCIETY OF AFRICA

Volume 22 Number 2 • June 2011 • www.lepsoc.org.za

ISSN 1018 6490

ELECTED COUNCILLORS

[illegible]

PROVINCIAL BRANCH CHAIRMEN

[illegible]

AREA REPRESENTATIVES

[illegible]

CO-OPTED MEMBERS

[illegible]

MEMBERSHIP

[illegible] www.lepsoc.org.za [illegible]

Metamorphosis [illegible]

[illegible]

Category of Membership	South Africa	Rest of Africa	Overseas
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]

[illegible] *Metamorphosis* [illegible]

CORRESPONDENCE

[illegible]

Metamorphosis [illegible]

EDITORIAL POLICY

[illegible]

[illegible]

[illegible]

[illegible]

[illegible] *Metamorphosis* [illegible]

[illegible]

NOTE [illegible] *International Code of Zoological Nomenclature* [illegible] *Metamorphosis* [illegible] *Metamorphosis* [illegible] taxon" [illegible]

METAMORPHOSIS

ISSN 1018-6490

CONTENTS

Front cover: *Callioratis grandis* ♀: H. Staude
Back cover: Mulanje Crater: H. Staude

The geometrid fauna (Lepidoptera: Geometridae) of Mount Mulanje, Malaŵi and the importance of Mount Mulanje as an area of conservation priority

Hermann Staude[1] & Ray Murphy[2]

[1]P.O. Box 398, Magaliesburg, 1791, South Africa.
E-mail: hermann@busmark.co.za
[2]P.O. Box 914, Mzuzu, Malaŵi.
E-mail: rj.murphy@hotmail.com

Abstract

One hundred and forty-three species of Geometridae occurring in the greater Mount Mulanje area, thirty-one of which probably undescribed, are reported. This is a high number considering that only a few of the available habitats have been surveyed. Mount Mulanje, being a significant climate changing inselberg, probably harbours a high diversity of habitats. It is argued that inselbergs, such as Mount Mulanje, allow for a high diversity of micro-climatic conditions to persist. This in turn allows for the survival of a high diversity of micro-habitats, the communities of each uniquely adapted to different climatic conditions. This makes Mount Mulanje well equipped to survive future climate change and the area should be preserved at all cost. Micro-habitat diversity is often difficult to define. It is shown that Geometridae are excellent indicators of habitat diversity.

Introduction

The Mount Mulanje massif (15°50′ - 16°03′S/35°30′ - 35°47′E) is a granitic inselberg that rises over 2 kms from the surrounding plains, with the highest peak (Sapitwa) reaching 3000 m. It is situated in the south western corner of Malaŵi on the Mozambique border. It is the highest mountain in tropical southernAfrica, and the second highest in southern Africa. The mountain covering an area of approximately 650 km^2 is an essential water catchment area with at least 9 rivers originating from the plateau. The Mountain was formed about 130 million years ago. The area was made a Forest Reserve in 1927. It was designated a UNESCO 'Man and the Biosphere Reserve' in 2000 (Mulanje Mountain Conservation Trust, 2005).

The following information on the bio-diversity of the mountain is available: 1330 vascular plant species of which about 70 are strict endemics; 180 bird species (1 endemic subspecies, 6 near endemic species); 250 butterflies (8 endemic species, 3 near endemic species); 32 amphibians (3 endemic species, 3 near endemic species); 55 reptiles (6 endemic species: 2 chameleons, 2 geckos, 1 skink, 1 lizard).

The Mulanje cedar (*Widdringtonia whytei*) is the flagship species and covers an area totaling 10 km^2 (Mulanje Mountain Conservation Trust MMCT, 2005).

No inventory of the geometrid moths of the mountain has before been published. This article serves to provide an interim list of the Geometridae of Mount Mulanje, based largely on recent surveys conducted by the authors.

Materials and methods

Nocturnal moths were collected from standard "Oberprieler Beach Umbrella light attractors" (Oberprieler *in* Woodhall, 1992) modified to suit the collecting of Geometridae. Diurnal moths were collected using a standard "Butterfly type" hand net.

The material was sorted and prepared in the standard way for Lepidoptera and identified using an updated version of Staude, 2008a as the main reference. Data were entered into Lepidops (Coetzer & Coetzer, 2009), from which the survey report was generated.

Most of the voucher specimens are housed in the Staude collection, Magaliesburg, South Africa and the Murphy collection, Mzuzu, Malaŵi. Records extracted from specimens housed in the Natural History Museum London (BMNH) are included. Specimens from which tissue was extracted for DNA 'Barcoding' are housed in The Bavarian State Collection of Zoology, Munich, Germany.

Surveying the Geometridae of Mount Mulanje

Many moths were collected by early Lepidopterists in colonial times at Mulanje. Mount Mulanje is therefore the type locality for a number of geometrid moths (e.g. *Pitthea neavei*, *Callioratis grandis*, *Scopula nigricosta*, *Zamarada gamma,* etc). Locality data from these early specimens are mostly cryptic and it is not known in many cases where on the mountain the specimens came from. Specimens from these early collections are housed in museums in the UK and Europe, the locality data are mostly neither published nor readily available. Available data from these early collections are included in the report. New data gathered by the authors therefore form the basis for the Mount Mulanje geometrid inventory.

One hundred and forty-three (143) species of geometrid moths are here recorded by the authors from Mulanje. This is already a high number considering that only a fraction of the mountain with its many habitats has been surveyed. Mostly only habitats which are on the mountain periphery were surveyed. The northern side of the mountain has not been surveyed at all. It is expected that this number will grow significantly once a higher percentage of habitats on Mount Mulanje have been sampled.

Thirty-one (31) species of Geometridae were found that could not readily be assigned to named species and these are presumed to be species new to science awaiting taxonomic description. Most of these have been submitted for DNA barcoding (see Ratnasingham & Hebert, 2007) and the results available so far support our initial diagnosis of the specific status of these taxa. These results clearly show how little we know of the geometrid moths of the area and how much work still needs to be done both in the field and in taxonomic analysis, both of which lay the foundations for further study.

Geometridae are excellent indicators of unique habitats for the following reasons:

They are highly diverse and are found in all known terrestrial habitats (Scoble, 1999).
They do not seem to venture far from their preferred habitats (Staude, 1999).
Many specialized species are restricted to single habitats (Staude, 2008b).
They are attracted to light and are therefore easily surveyed.

A high diversity of Geometridae is thus a good indicator that an area is home to a high diversity of habitats. A systematic survey of the Geometridae of Mount Mulanje would be one of the easiest and best ways of highlighting the high habitat diversity which the mountain seems to harbour.

The importance of Mount Mulanje as an area of high habitat diversity and the significance of this in a temporal context.

Typical of large inselbergs the mountain has a profound influence on the local climate. The northern parts are in a rain-shadow and the southern parts enjoy an above average rainfall. This extends into the surrounding plains.

As a result unique rain forests exist on the southern slopes and on the adjacent plains. Most of the forests on the lower slopes and on the plains have long ago made way for tea plantations. The 'Tea Segregation Forest' is a good example of the very few remaining patches of this unique habitat. These remaining patches should be protected at all costs.

By contrast, in the northern parts of the mountain there are vegetation types adapted to a drier climate, even drier than that of the surrounding plains.

In addition the extreme topography of Mount Mulanje creates a high diversity of different micro habitats found in the different biomes from tropical forest through woodland savannahs to alpine grassland. This all culminates in a complex high diversity of habitats, most of which are still unexplored due to the difficulty in gaining access to them. Many of these unique habitats are not easily differentiated.

It seems appropriate that the temporal aspect to conservation is highlighted in these times where global warming and other induced threats to current climate are enjoying a public high profile. Forest & Manning (2007) in an article dealing with the evolutionary potential of floras in biodiversity hotspots, state that the likelihood of an ecosystem surviving into an uncertain future is probably provided by measuring its evolutionary potential. The authors have a point in that 'number of species' does not necessarily mean maximum potential for surviving change and that phylogenetic diversity probably is a better indicator for evolutionary potential, but evolutionary potential would be too slow to be effective in adapting to a rapidly changing climate.

The potential to survive future rapid climate change is probably better expressed in existing habitat diversity. We know that current climatic change is happening far too quickly for species to 'evolve adaptations to survive the rapid change in climate'. It is therefore communities that are already adapted to a future changed climate, which will find that their current fundamental niche is expanding and these communities will respond accordingly by expanding their range. Species currently restricted to narrow climatic refugia (micro-habitats) may well be the dominant species of the future. Each one of these micro-habitats with their own 'community of life' has evolved to survive a particular climatic condition and/or terrestrial substrate. One would probably find that for most of the climatic variation the future may hold there will already be a community of life available best adapted to it, even if it exists at present in a small refuge and even if it does not have at present an impressive biodiversity or 'phylogenetic diversity count'. Some communities will expand and others will shrink. Some will change into new communities with increasing biodiversity and others will go extinct.

In short, to focus on conserving habitats and habitat diversity rather than species diversity *per se*, as we (Lepidopterists) have always advocated, still makes the most sense.

Thus conserving a maximum diversity of habitats seems to be the best way of conserving maximum biodiversity and is probably the best way of ensuring that maximum current genetic potential for the survival of future climate change is conserved.

Mount Mulanje can be regarded as such an area of high habitat diversity. The Mount Mulanje inselberg is like an 'arc of habitats' floating in a sea of uncertainty ready for any climatic change the future may hold and must be conserved at all costs.

Acknowledgements

The National Authority of Malaŵi is thanked for permission to conduct Lepidoptera research in Malaŵi. Julian Bayliss for his enthusiastic support and encouragement and for looking after us so well in his home. The Mulanje Mountain Conservation Trust for permission to work in the area and for the use of their facilities, specifically Carl Bruessow (Director) and David Nangoma (Biodiversity Officer). Rick and Barbara Illingworth for their kind hospitality and permission to work on their farm. The staff of the Likhubula Mission Station for their kind hospitality and for permission to work and camp in their garden.

References

COETZER, B.H. & COETZER, A.J. 2009, Lepidops Ver. 4.04ah - database software programme, LepiAfrica.

FOREST, F. & MANNING, J. 2007.The future of Biodiversity, *Veld & Flora* 93(3) 150-152.

MULANJE MOUNTAIN CONSERVATION TRUST 2005. Ecological Monitoring Programme, Digital Viewer 1.1, CD ROM.

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

SCOBLE, M.J., (Ed.) 1999. *Geometrid Moths of the World - a catalogue.* CSIRO Publishing, Melbourne, Australia.

STAUDE, H.S. 1999. An illustrated report of 510 geometrid moth taxa (Lepidoptera: Geometridae) recorded from 28 protected areas from the northern and eastern parts of South Africa. *Metamorphosis* **10**: 97–150.

STAUDE, H.S. 2008a. Geometroidea, Drepanoidea and Uranioidea – a database, version 1.0. *LepiAfrica Living Books Series*, LepiAfrica.

STAUDE, H.S. 2008b. An annotated report on 115 further host-plant associations for African Loopers (Lepidoptera: Geometridae). *Metamorphosis* **19**(4):193-209.

WOODHALL, S.E. (Ed.) 1992. *A Practical guide to Butterflies and Moths in Southern Africa.* The Lepidopterists' Society of Southern Africa, Florida Hills.

Survey Report

Genus	Species	Subfamily	Latitude	Longitude	Altitude in metres	Year Month Day	Locality	Surveyor
Conolophia	*aemula*	Desmobathrinae	-16.03	35.52	694	2005-11-7	Mulanje Boma	H. S. Staude
Callioratis	*grandis*	Diptychinae	-15.94	35.50	840	2005-4-10	Likhubula Mission	H. S. Staude/ R. J. Murphy
Callioratis	*grandis*	Diptychinae	-15.94	35.50	840	2009-6-6	Likhubula Mission	H. S. Staude
Cabera	*nevillei* cf.1	Ennominae	-16.03	35.52	694	2005-1-7	Mulanje Boma	H. S. Staude
Cabera	*nevillei* cf.1	Ennominae	-16.10	35.62	605	2005-04-11	Tea Research Segregation Forest	R. J. Murphy
Chiasmia	*assimilis*	Ennominae	-15.97	35.55	1800	2004-12-11	Lichenya Plateau Hut	R. J. Murphy
Chiasmia	*assimilis*	Ennominae	-15.95	35.50	840	2008-04-7/ 2008-04-9	Likhubula Forest	R. J. Murphy
Chiasmia	*assimilis*	Ennominae	-15.98	35.65	900	2009-02-20/ 2009-02-23	Ruo River Valley	R. J. Murphy
Chiasmia	*brongusaria*	Ennominae	-16.03	35.52	694	2005-11-7	Mulanje Boma	H. S. Staude
Chiasmia	*confuscata*	Ennominae	-15.95	35.50	840	2008-04-7/ 2008-04-9	Likhubula Forest	R. J. Murphy
Chiasmia	*confuscata*	Ennominae	-15.98	35.65	900	2008-04-05/ 2008-04-07/ 2004-9-26	Ruo River Valley	R. J. Murphy
Chiasmia	*contaminata*	Ennominae	-15.97	35.55	1800	2004-12-12	Lichenya Plateau Hut	R. J. Murphy
Chiasmia	*contaminata*	Ennominae	-15.98	35.65	900	2004-10-28/ 2004-11-08	Ruo River Valley	R. J. Murphy
Chiasmia	*feraliata*	Ennominae	-15.98	35.65	900	2004-10-28/ 2004-11-08	Ruo River Valley	R. J. Murphy

Chiasmia	*getula*	Ennominae	-16.03	35.52	694	2002-5-4/ 2005-11-7	Mulanje Boma	H. S. Staude
Chiasmia	*getula*	Ennominae	-15.98	35.65	900	2002-5-5/ 2004-02-07/ 2004-02-10	Ruo River Valley	R. J. Murphy
Chiasmia	*infabricata*	Ennominae	-15.98	35.65	900	2004-10-28/ 2004-11-08	Ruo River Valley	R. J. Murphy
Chiasmia	*inquinata*	Ennominae	-15.98	35.60	900	2009-11- 20/23	Ruo River Valley	R. J. Murphy
Chiasmia	*kilimanjarensis*	Ennominae	-15.94	35.50	840	2005-4-10	Likhubula Mission	H. S. Staude
Chiasmia	*kilimanjarensis*	Ennominae	-16.03	35.52	694	2005-11-7	Mulanje Boma	H. S. Staude
Chiasmia	*majestica*	Ennominae	-16.02	35.55	800	? ? ?	Lichenya River	BMNH
Chiasmia	*majestica*	Ennominae	-16.03	35.52	694	? ? ?	Mulanje Boma	BMNH
Chiasmia	*nana*	Ennominae	-15.97	35.65	900	2004-09-24/ 2004-10-07/ 2004-11-1	Ruo River Valley	R. J. Murphy
Chiasmia	*natalensis*	Ennominae	-15.95	35.50	840	2009-03-30/ 2009-03-31	Likhubula Forest	R. J. Murphy
Chiasmia	*natalensis*	Ennominae	-15.97	35.65	900		Ruo River Valley	R. J. Murphy
Chiasmia	*normata*	Ennominae	-15.97	35.65	900	2008-04-05/ 2008-04-07	Ruo River Valley	R. J. Murphy
Chiasmia	*orientalis*	Ennominae	-16.02	35.56	800	1912-12-13	Lichenya River	BMNH
Chiasmia	*orientalis*	Ennominae	-16.02	35.52	694	1913-02-14 1913-05-06	Mulanje Boma	BMNH
Chiasmia	*rectistriaria*	Ennominae	-16.10	35.62	605	2009-6-7	Tea Research Segregation Forest	H. S. Staude
Chiasmia	*semicolor*	Ennominae	-15.97	35.55	1800	? ? ?	Lichenya Plateau	BMNH
Chiasmia	*separata*	Ennominae	-15.97	35.65	900	2008-11-23	Ruo River Valley	R. J. Murphy

Chiasmia	*simplicilinea*	Ennominae	-15.97	35.65	900	2006-11-24/ 2006-11-28	Ruo River Valley	R. J. Murphy
Chiasmia	*sororcula*	Ennominae	-15.97	35.65	900	2008-04-05/ 2008-04-07	Ruo River Valley	R. J. Murphy
Chiasmia	*subcurvaria*	Ennominae	-15.95	35.50	840	2010-04-20/ 2010-04-25	Likhubula Forest	R. J. Murphy
Chiasmia	*umbrata*	Ennominae	-16.1	35.6	600	2005-04-11	Tea Research Forest	R. J. Murphy
Cleora	*betularia*	Ennominae	-15.97	35.55	1800	2004-12-11	Mount Mulanje	R. J. Murphy
Cleora	*betularia*	Ennominae	-15.06	35.67	200	1956-08-03	Little Ruo Plateau	BMNH
Cleora	*echinodes*	Ennominae	?	?	?	1913-02-15 1913-03-17	Mlanje	BMNH
Cleora	*munda*	Ennominae	-16.02	35.52	694	2010-04-27	Mulanje Boma	BMNH
Cleora	*nigrisparsalis*	Ennominae	-15.97	35.55	1800	2004-12-11	Mount Mulanje	R. J. Murphy
Cleora	*panarista*	Ennominae	-16.02	35.52	694	1913-03-17 1914-04-14	Mulanje Boma	
Cleora	*pavlitzkiae*	Ennominae	-15.95	35.67	1000	2002-5-4	Ruo River Valley	R. J. Murphy
Cleora	*pavlitzkiae*	Ennominae	-15.98	35.65	800	2004-9-26	Ruo River Valley	R. J. Murphy
Cleora	*rostella*	Ennominae	-16.03	35.52	694	2005-11-7	Mulanje Boma	H. S. Staude
Cleora	*rostella*	Ennominae	-15.3	35.55	1800	2004-12-11	Lichenya Plateau Hut	R. J. Murphy
Cleora	*rostella*	Ennominae	-15.98	35.65	800	2004-9-26	Ruo River Valley	R. J. Murphy
Cleora	*rostella*	Ennominae	-16.02	35.56	800	1928 Feb	Lichenya River	BMNH
Cleora	*thyris*	Ennominae	-15.97	35.55	1857	2005-11-7	Mnt. Mulanje	H. S. Staude
Cleora	*thyris*	Ennominae	-15.98	35.65	800	2002-5-4	Ruo River Valley	R. J. Murphy
Cleora	*thyris*	Ennominae	-15.97	35.55	1800	2004-12-11	Mount Mulanje	R. J. Murphy

Cleora	*thyris*	Ennominae	-15.97	35.55	1867	2009-6-6	Mulanje Boma	H. S. Staude
Cleora	*thyris*	Ennominae	-15.97	35.55	1800	2004-12-11	Mount Mulanje	R. J. Murphy
Cleora	*thyris*	Ennominae	-15.98	35.65	800	2004-9-26	Ruo River Valley	R. J. Murphy
Cleora	*thyris*	Ennominae	-16.02	35.52	694	1913-04-30	Mulanje Boma	BMNH
Colocleora	*divisaria*	Ennominae	-16.03	35.52	694	2005-11-7	Mulanje Boma	H. S. Staude
Colocleora	*divisaria*	Ennominae	-15.95	35.67	1000	2002-5-5	Ruo River Valley	R. J. Murphy
Colocleora	*leucostephana* cf.1	Ennominae	-15.98	35.65	800	2004-9-26	Ruo River Valley	R. J. Murphy
Colocleora	*spuria* cf.1	Ennominae	-15.95	35.67	1000	2002-5-5	Ruo River Valley	R. J. Murphy
Darisodes	*oritropha*	Ennominae	-15.97	35.55	1800	2004-12-12	Lichenya Plateau Hut	R. J. Murphy
Ectropis	sp.5	Ennominae	-15.97	35.55	1800	2004-12-12	Lichenya Plateau Hut	R. J. Murphy
Encoma	sp.2	Ennominae	-15.97	35.55	1800	2005-11-6	Mnt. Mulanje	H. S. Staude
Epigynopteryx	*ansorgei*	Ennominae	-16.03	35.52	694	2005-11-7	Mulanje Boma	H. S. Staude
Epigynopteryx	sp.17	Ennominae	-16.03	35.52	694	2005-11-7	Mulanje Boma	H. S. Staude
Epigynopteryx	sp.3	Ennominae	-16.03	35.52	694	2005-11-7	Mulanje Boma	H. S. Staude
Epigynopteryx	*termininota*	Ennominae	-15.97	35.55	1800	2004-12-11	Lichenya Plateau Hut	R. J. Murphy
Erastria	*madecassaria* cf.1	Ennominae	-16.03	35.52	694	2005-11-7	Mulanje Boma	H. S. Staude
Ereunetea	*horitropha*	Ennominae	-16.03	35.52	694	2005-11-7	Mulanje Boma	H. S. Staude
Hypochrosis	*haderleini*	Ennominae	-15.97	35.55	1800	2004-12-11	Lichenya Plateau Hut	R. J. Murphy
Hypochrosis	*meridionalis*	Ennominae	-15.97	33.65	1000	2004-10-5/ 2008-4-5	Ruo River Valley	R. J. Murphy
Idiodes	*flexilinea*	Ennominae	-15.97	35.55	1800	2005-11-6	Lichenya Plateau Hut	H. S. Staude

Idiodes	*flexilinea*	Ennominae	-15.97	35.55	1800	2004-12-12	Lichenya Plateau Hut	R. J. Murphy
Isturgia	*exospilata*	Ennominae	?	?	?	?	Mul & Mul Plateau	BMNH
Mesocoela	*obscura*	Ennominae	-15.97	35.55	1800	2004-12-11/ 2004-12-13	Lichenya Plateau Hut	R. J. Murphy
Mesocoela	*obscura*	Ennominae	-15.98	35.65	1000	2004-11-1	Ruo River Valley	R. J. Murphy
Miantochora	*venerata* cf.1	Ennominae	-15.97	33.65	1000	2008-4-5	Ruo River Valley	R. J. Murphy
Oaracta	*neophronaria*	Ennominae	-16.00	35.72	1625	2005-2-7	Chisongeli Forest	R. J. Murphy
Ochroplutodes	*hova* cf.	Ennominae	-15.94	35.50	840	2005-4-10	Likhubula Mission	H. S. Staude
Odontopera	*integraria* cf.1	Ennominae	-15.97	35.55	1800	2004-12-11	Lichenya Plateau Hut	R. J. Murphy
Odontopera	*stevensoni* cf.1	Ennominae	-16.02	35.54	1100	2009-6-7	Mount Mulanje Crater	H. S. Staude
Oedicentra	*albipennis*	Ennominae	-15.97	35.55	1800	2004-12-11	Lichenya Plateau Hut	R. J. Murphy
Oedicentra	*albipennis*	Ennominae	-16.03	35.52	694	2005-11-7	Mulanje Boma	H. S. Staude
Pitthea	*neavei*	Ennominae	?	?	?	?-?-?	Mount Mlanje	BMNH
Pitthea	*neavei*	Ennominae	-15.98	35.65	900	2008-12-20	Ruo River Valley	R. J. Murphy
Plateoplia	*acrobelia*	Ennominae	-15.97	35.55	1800	2004-12-11	Lichenya Plateau Hut	R. J. Murphy
Psilocerea	*pulverosa*	Ennominae	-15.98	35.65	1000	2004-11-1	Ruo River Valley	R. J. Murphy
Psilocladia	*obliquata*	Ennominae	-16.00	35.73	1625	2005-02-07/ 2005-02-10	Chisongeli	R. J. Murphy
Pycnostega	sp.2	Ennominae	-15.94	35.50	840	2005-4-10	Likhubula Mission	H. S. Staude
Racotis	*squalida*	Ennominae	-15.98	35.65	900	2008-10-28 Nov 2004	Ruo River Valley	R. J. Murphy
Terina	*circumcincta*	Ennominae	-15.98	35.65	1000	2004-11-1	Ruo River Valley	R. J. Murphy

Terina	*circumcincta*	Ennominae	-16.03	35.52	694	2005-11-7	Mulanje Boma	H. S. Staude
Xanthisthisa	*fulva*	Ennominae	-15.97	35.55	1800	2004-12-11	Lichenya Plateau Hut	R. J. Murphy
Xanthisthisa	sp.1	Ennominae	-15.98	35.65	800	2003-3-4/ 2004-9-26	Ruo River Valley	R. J. Murphy
Xanthisthisa	*tarsispina*	Ennominae	-15.94	35.50	840	2005-4-10	Likhubula Mission	H. S. Staude
Xanthisthisa	*tarsispina*	Ennominae	-15.97	35.55	1800	2004-12-11	Lichenya Plateau Hut	R. J. Murphy
Xenimpia	*erosa*	Ennominae	-16.03	35.52	694	2005-11-7	Mulanje Boma	H. S. Staude
Xenimpia	*erosa*	Ennominae	-15.95	35.50	840	2008-04-07	Likhubula Forest	R. J. Murphy
Xenimpia	*maculosata*	Ennominae	-15.97	35.55	1800	2004-12-11	Lichenya Plateau Hut	R. J. Murphy
Xenimpia	sp.3	Ennominae	-15.94	35.50	840	2005-4-10	Likhubula Mission	H. S. Staude
Xenostega	sp.2	Ennominae	-16.03	35.52	694	2005-11-7	Mulanje Boma	H. S. Staude
Xenostega	sp.2	Ennominae	-15.98	35.65	1000	2008-04-07	Ruo River Valley	R. J. Murphy
Zamarada	*acosmeta*	Ennominae	-15.94	35.50	840	2005-4-10	Likhubula Mission	H. S. Staude
Zamarada	*bathyscaphes*	Ennominae	-15.94	35.50	840	2005-4-10	Likhubula Mission	H. S. Staude
Zamarada	*bathyscaphes*	Ennominae	-15.95	35.50	840	2008-04-07/ 2008-04-09	Likhubula Forest	R. J. Murphy
Zamarada	*crystallophana*	Ennominae	-15.95	35.50	840	2008-04-07/ 2008-04-09	Likhubula Forest	R. J. Murphy
Zamarada	*differens*	Ennominae	-15.94	35.50	840	2005-4-10	LikhubulaMission	H. S. Staude
Zamarada	*flavicaput*	Ennominae	-15.94	35.50	840	2005-4-10	Likhubula Mission	H. S. Staude
Zamarada	*gamma*	Ennominae	-15.94	35.50	840	2005-4-10	Likhubula Mission	H. S. Staude
Zamarada	*gamma*	Ennominae	-15.98	35.65	1000	2004-11-1	Ruo River Valley	R. J. Murphy
Zamarada	*gamma*	Ennominae	-15.95	35.50	840	2010-04-22	Likhubula Forest	R. J. Murphy

Zamarada	*glareosa*	Ennominae	-15.94	35.50	840	2005-4-10	Likhubula Mission	H. S. Staude
Zamarada	*metrioscaphes*	Ennominae	-15.97	35.55	1800	2004-12-12	Lichenya Plateau Hut	R. J. Murphy
Zamarada	*odontophora*	Ennominae	-15.94	35.50	840	2005-4-10	Likhubula Mission	H. S. Staude
Zamarada	*pinheyi*	Ennominae	-15.98	35.65	1000	2002-5-7/ 2004-10-5/ 2004-11-1	Ruo River Valley	R. J. Murphy
Zamarada	*plana*	Ennominae	-15.94	35.50	840	2005-4-10	Likhubula Mission	H. S. Staude
Zamarada	*pringlei*	Ennominae	-15.98	35.65	1000	2004-11-1	Ruo River Valley	R. J. Murphy
Zamarada	*prolata*	Ennominae	-16.03	35.52	694	2005-11-7/ 2009-6-6	Mulanje Boma	H. S. Staude
Zamarada	*prolata*	Ennominae	-15.98	35.65	1000	2004-11-1	Ruo River Valley	R. J. Murphy
Zamarada	*prolata*	Ennominae	-15.98	35.65	900	2008-09-24 Oct 2004 2008-10-28 Nov 2004	Ruo River Valley	R. J. Murphy
Zamarada	*psi*	Ennominae	-15.94	35.50	840	2005-4-10	Likhubula Mission	H. S. Staude
Zamarada	*rufilinearia*	Ennominae	-16.03	35.52	694	2005-11-7	Mulanje Boma	H. S. Staude
Zamarada	*scintillans*	Ennominae	-15.94	35.50	840	2005-4-10	Likhubula Mission	H. S. Staude
Zamarada	*scintillans*	Ennominae	-15.98	35.50	840	2008-04-07/ 2008-04-09	Likhubula Forest	R. J. Murphy
Zamarada	*seydeli*	Ennominae	-15.95	35.65	900	2008-09-24/ Oct 2004	Ruo River Valley	R. J. Murphy
Zamarada	sp.6	Ennominae	-16.03	35.52	694	2005-11-7	Mulanje Boma	H. S. Staude
Zamarada	sp.6	Ennominae	-15.98	35.65	1000	2004-11-1	Ruo River Valley	R. J. Murphy
Zamarada	*vulpina*	Ennominae	-15.94	35.50	840	2005-4-10	Likhubula Mission	H. S. Staude

Zamarada	*vulpina*	Ennominae	-15.98	35.65	1000	2004-11-1	Ruo River Valley	R. J. Murphy
Zamarada	*vulpina*	Ennominae	-16.10	35.62	605	2005-04-11	Tea Research Segregation Forest	R. J. Murphy
Zeuctoboarmia	*hyrax*	Ennominae	-15.94	35.50	840	2005-4-10	Likhubula Mission	H. S. Staude
Zeuctoboarmia	*hyrax*	Ennominae	-16.03	35.52	694	2005-11-7	Mulanje Boma	H. S. Staude
Acollesis	*mimetica*	Geometrinae	-16.03	35.52	694	2005-11-7	Mulanje Boma	H. S. Staude
Agathia	sp.1	Geometrinae	-15.98	35.65	900	Oct	Ruo River Valley	R. J. Murphy
Antharmostes	*papilio*	Geometrinae	-15.98	35.65	900	Oct	Ruo River Valley	R. J. Murphy
Antharmostes	sp.1	Geometrinae	-16.03	35.52	694	2005-11-7	Mulanje Boma	H. S. Staude
Antharmostes	sp.1	Geometrinae	-15.98	35.65	900	2008-04-08	Ruo River Valley	R. J. Murphy
Archichlora	*rectilineata*	Geometrinae	-16.08	35.73	1625	2005-02-08	Chisongele Forest	R. J. Murphy
Archichlora	sp.2	Geometrinae	-16.00	35.72	1625	2005-2-7	Chisongeli Forest	R. J. Murphy
Archichlora	*viridimacula*	Geometrinae	-16.10	35.62	605	2009-6-7	Tea Research Segregation Forest	H. S. Staude
Bathycolpodes	sp.2	Geometrinae	-16.03	35.52	694	2005-11-7	Mulanje Boma	H. S. Staude
Bathycolpodes	sp.2	Geometrinae	-15.98	35.65	900	2009-02-20/ 2009-02-23	Ruo River Valley	R. J. Murphy
Chlorissa	*albistrigulata*	Geometrinae	-15.98	35.65	900	2008-10-28 Nov 2004	Ruo River Valley	R. J. Murphy
Comibaena	*barnsi*	Geometrinae	-16.03	35.52	694	2005-11-7	Mulanje Boma	H. S. Staude
Comostolopis	*stillata*	Geometrinae	-15.98	35.65	900	2008-10-28 Nov 2004	Ruo River Valley	R. J. Murphy
Heterorachis	*lunatimargo* cf.	Geometrinae	-16.03	35.52	694	2005-11-7	Mulanje Boma	H. S. Staude
Heterorachis	*lunatimargo* cf.	Geometrinae	-15.98	35.65	900	2008-10-28 Nov 2004	Ruo River Valley	R. J. Murphy

Lophorrhachia	*burdoni*	Geometrinae	-16.03	35.52	694	2005-11-7	Mulanje Boma	H. S. Staude
Lophorrhachia	*burdoni*	Geometrinae	-15.98	35.65	900	2004-10-28	Ruo River Valley	R. J. Murphy
Lophostola	*annuligera*	Geometrinae	-16.03	35.52	694	2005-11-7	Mulanje Boma	H. S. Staude
Lophostola	*annuligera*	Geometrinae	-15.98	35.65	900	October 2004	Ruo River Valley	R. J. Murphy
Neromia	*phoenicosticta*	Geometrinae	-15.95	35.50	840	30-03-2005	Likhubula Forest	R. J. Murphy
Paragathia	*albimarginata*	Geometrinae	-15.98	35.65	900	October	Ruo River Valley	R. J. Murphy
Pingasa	sp.1	Geometrinae	-15.97	35.55	1800	2004-12-12	Lichenya Plateau Hut	R. J. Murphy
Prasinocyma	*semicincta* cf.	Geometrinae	-15.98	35.65	900	October 2008	Ruo River Valley	R. J. Murphy
Prasinocyma	*triangulata*	Geometrinae	-15.94	35.50	840	2005-4-10	Likhubula Mission	H. S. Staude
Thalassodes	*quadraria*	Geometrinae	-15.98	35.65	900	1997-06-15/ 2008-10-28 Nov 2004	Ruo River Valley	R. J. Murphy
Thalassodes	sp.1	Geometrinae	-16.03	35.52	694	2005-11-7	Mulanje Boma	H. S. Staude
Thetidia	*undulilinea*	Geometrinae	-16.03	35.52	694	2005-11-7	Mulanje Boma	H. S. Staude
Asthenotricha	*pycnoconia*	Larentiinae	-15.98	35.65	800	2004-9-26	Ruo River Valley	R. J. Murphy
Asthenotricha	*unipecten*	Larentiinae	-15.98	35.65	900	1997-06-15	Ruo River Valley	R. J. Murphy
Lobidiopteryx	sp.3	Larentiinae	-15.97	35.55	1800	2004-12-12	Lichenya Plateau Hut	R. J. Murphy
Mesocolpia	*lita*	Larentiinae	-15.91	35.50	2000	1999-7-9	Moiza	R. J. Murphy
Mimoclystia	*bergeri*	Larentiinae	-15.98	35.65	1000	2004-11-1	Ruo River Valley	R. J. Murphy
Piercia	*prasinaria*	Larentiinae	-16.03	35.52	694	2005-11-7	Mulanje Boma	H. S. Staude
Trimetopia	*aetheraria*	Larentiinae	-15.98	35.65	900	2005-04-02/ 2005-04-03	Ruo River Valley	R. J. Murphy

Xanthorhoe	*moderata*	Larentiinae	-15.97	35.55	1800	2004-12-13	Lichenya Plateau Hut	R. J. Murphy
Xanthorhoe	*poseata*	Larentiinae	-16.03	35.52	694	2009-6-6	Mulanje Boma	H. S. Staude
Xanthorhoe	*transjugata*	Larentiinae	-15.97	35.55	1800	2004-12-13	Lichenya Plateau Hut	R. J. Murphy
Xanthorhoe	*tuta*	Larentiinae	-15.97	35.55	1800	2004-12-11	Lichenya Plateau Hut	R. J. Murphy
Scopula	*bigeminata*	Sterrhinae	-15.98	35.65	900	2004-10-28	Ruo River Valley	R. J. Murphy
Scopula	*calcarata* cf.4	Sterrhinae	-15.98	35.65	900	2007-06-04	Ruo River Valley	R. J. Murphy
Chrysocraspeda	*leighata*	Sterrhinae	-15.97	35.65	900	2009-02-20/ 2009-02-23 2008-04-05/ 2008-04-07	Ruo River Valley	R. J. Murphy
Cyclophora	sp.3	Sterrhinae	-16.03	35.52	694	2005-11-7	Mulanje Boma	H. S. Staude
Problepsis	*latonaria*	Sterrhinae	-15.94	35.50	840	2005-4-10	Likhubula Mission	H. S. Staude
Rhodometra	*sacraria*	Sterrhinae	-16.02	35.54	1100	2009-6-7	Mulanje Crater	H. S. Staude
Rhodometra	*sacraria*	Sterrhinae	-15.98	35.65	900	2008-04-05/ 2008-04-07	Ruo River Valley	R. J. Murphy
Scopula	*elegans*	Sterrhinae	-16.10	35.62	605	2005-04-11	Tea Research Segregation Forest	H. S. Staude
Scopula	*fimbrilineata*	Sterrhinae	-15.98	35.65	900	1997-06-15	Ruo River Valley	R. J. Murphy
Scopula	*latitans*	Sterrhinae	-16.03	35.52	694	2005-11-7	Mulanje Boma	H. S. Staude
Scopula	*monteironis*	Sterrhinae	-16.03	35.52	694	2005-11-7	Mulanje Boma	H. S. Staude
Scopula	*monteironis*	Sterrhinae	-16.10	35.62	605	2009-6-7	Tea Research Segregation Forest	H. S. Staude
Scopula	*monteironis*	Sterrhinae	-15.97	35.65	900	2003-11-26/ 2004-9-26/ 2004-2-7/	Ruo River Valley	R. J. Murphy

						2004-10-5		
Scopula	*natalica*	Sterrhinae	-16.10	35.62	605	2009-6-7	Tea Research Segregation Forest	H. S. Staude
Scopula	*nigricosta*	Sterrhinae	-15.97	35.55	1800	2004-12-11	Lichenya Plateau Hut	R. J. Murphy
Scopula	*nigricosta*	Sterrhinae	-15.93	35.58	2000	2004-12-4	Sapitwa	R. J. Murphy
Scopula	*nigricosta*	Sterrhinae	-15.92	35.58	0	2004-12-5	Tuchila River Valley	R. J. Murphy
Scopula	*nigricosta*	Sterrhinae	-15.97	35.55	1800	2004-12-12	Lichenya Plateau Hut	R. J. Murphy
Scopula	*nigrinotata*	Sterrhinae	-15.94	35.50	840	2005-4-10	Likhubula Mission	H. S. Staude
Scopula	*nigrinotata*	Sterrhinae	-15.98	35.65	1000	2004-10-5	Ruo River Valley	R. J. Murphy
Scopula	*quintaria* cf.1	Sterrhinae	-16.10	35.62	605	2005-04-11	Tea Research Segregation Forest	R. J. Murphy
Scopula	*sincera*	Sterrhinae	-15.98	35.65	1000	2008-04-5	Ruo River Valley	R. J. Murphy
Scopula	sp.30	Sterrhinae	-15.94	35.50	840	2005-4-10	Likhubula Mission	H. S. Staude
Scopula	sp.30	Sterrhinae	-16.03	35.52	694	2005-11-7	Mulanje Boma	H. S. Staude
Scopula	sp.30	Sterrhinae	-15.98	35.65	1000	2004-10-5	Ruo River Valley	R. J. Murphy
Scopula	sp.31	Sterrhinae	-15.94	35.50	840	2005-4-10	Likhubula Mission	H. S. Staude
Scopula	*spoliata*	Sterrhinae	-16.03	35.52	694	2005-11-7	Mulanje Boma	H. S. Staude
Scopula	*sublobata*	Sterrhinae	-16.03	35.52	694	2005-11-7	Mulanje Boma	H. S. Staude
Scopula	*vestalis*	Sterrhinae	-15.94	35.50	840	2005-4-10	Likhubula Mission	H. S. Staude
Traminda	*obversata*	Sterrhinae	-16.02	35.52	694	2005-11-7	Mulanje Boma	H. S. Staude

The Mulanje Tiger Moth *Callioratis grandis* Prout, 1922, new status, a critically endangered species from Malaŵi (Lepidoptera: Geometridae: Diptychinae)

Hermann Staude[1], Julian Bayliss[2, 3] & Pasi Sihvonen[4]

[1]P.O. Box 398, Magaliesburg, 1791, SouthAfrica
E-mail: hermann@busmark.co.za
[2]Conservation Science Group, Department of Zoology, University of Cambridge, UK
[3]Mulanje Mountain Conservation Trust, P.O. Box 139, Mulanje, Malaŵi
E-mail: jlbayliss@yahoo.co.uk
[4] Research Funding Services, P.O. Box 33, FI-00014, University of Helsinki, Helsinki, Finland. E-mail: pasi.sihvonen@helsinki.fi

Abstract

Callioratis grandis Prout, 1922 new status (Geometridae: Diptychinae) is an extremely local species known only from the Likhubula Valley area on Mount Mulanje in Malaŵi. The species was formerly treated as a subspecies of *C. abraxas* Felder, 1874, as the distinct male was unknown before. It is here recognized as a distinct species (new status). *C. grandis* can be separated from the closely related *C. abraxas* by the male scent disseminating organs, male and female facies, male and female genitalia, LEK behaviour, early stages and DNA barcoding. These data are provided and illustrated for the first time. We consider *C. grandis* to be Critically Endangered (CE), using IUCN Red List criteria. The larva of *C. grandis* is monophagous, feeding in the wild exclusively on leaves of the Mulanje Cycad (*Encephalartos gratus* Prain, 1916 (Zamiaceae)), a vulnerable threatened 'living fossil' plant species that is restricted in its range.

The only known colony of *C. grandis*, with an area of occupation of less than 10 km^2 , is under threat from human population pressure and planned mining operations. The life history of *C. grandis* is described and illustrated. The known factors limiting the fundamental niche of the species are described.

Introduction

The genus *Callioratis* is now known to contain six species (Staude, 2001): *C. abraxas* Felder, 1874; *C. apicisecta* Prout, 1915; *C. millari* Hampson, 1905; *C. mayeri* Staude, 2001; *C. curlei* Staude, 2001; and *C. grandis* Prout, 1922, raised here from a subspecies of *C. abraxas* to species rank. The larvae of all known species of *Callioratis* feed on the leaves of cycads (Staude, 2001) and all probably sequester the toxin macrozamin from these plants, as is the case in the related *Zerenopsis lepida* (Donaldson & Bösenberg, 1995). *Callioratis* species have adapted to a diurnal lifestyle and display aposematic signals on their wings (Staude & Curle, 1997).

Prout (1922) described the subspecies *Callioratis abraxas grandis* on the basis of two females from Mount Mulanje, Malaŵi. He characterized this subspecies, apart from the larger size, by "...the terminal black spots of the hindwing larger anteriorly than posteriorly, ..." .This character is however inconsistent as some South African specimens of *Callioratis abraxas* display larger anterior terminal spots. The wingspan of *C. abraxas* adults can vary considerably, with specimens reared in captivity reaching a wingspan of 70 mm, almost that of the 84 mm of the ♀ type specimens of *C. grandis.* Based on the above information, Staude (2001) provisionally retained the subspecies, stating: "However, until specimens belonging to the Mulanje population have been reared, making a proper comparison possible, this taxon should be treated with caution." No further material was available on this taxon after its original description and the male was unknown.

Early in April 2005 Ray Murphy (Mzuzu, Malaŵi) rediscovered *C. grandis* 83 years after its description, by finding larvae of *C. grandis* on the Mulanje Cycad *Encephalartos gratus* growing in the grounds of the Likhubula Mission station on the slopes of Mount Mulanje. On 10 April 2005 Staude, Murphy and Bayliss visited the site. Many *C. grandis* females were flying around the cycads, and eggs and larvae were found on the leaves of *E. gratus.* Males were discovered for the first time, flying around a LEK tree in the mission gardens. Examination of the distinct males immediately revealed the specific status of the taxon.

Prompted by conservation concerns for the two living fossils, the *C. grandis* moth and the *E. gratus* cycad, and considering the difficulty in determining the population size of *C. grandis*, Bayliss and Staude designed a study to count the cycads and moth feeding damage at Likhubula, and tasked two students with the field work (C. Burrow and S. Martell). The results of this study were published by Bayliss *et al.*, 2009. The main findings were that *C. grandis* feeding damage on *E. gratus* leaves occurred mostly on mature cycads and that only 50,8% of the plants in the study area showed signs of feeding damage. The host plant seems to be threatened through habitat destruction and human population growth (Donaldson, 2009). The moth is extremely local, known only from the Likhubula Valley area on Mount Mulanje, Malaŵi.

In this paper we raise *C. abraxas grandis* Prout, 1922 to specific rank, provide for the first time diagnostic characters, description of the male, early stages and DNA barcodes. We describe additional observations on the male LEK. We also provide an assessment of the conservation status of *C. grandis*, using IUCN Red List Criteria (IUCN, 2010).

Materials and methods

Descriptions of early stages and behaviour are based on rearing notes, preserved material and photographic material in the Staude collection and observations of adult behaviour in the field at the Likhubula Mission Station (S15°56'16,8"/E35°30'11,3") by Bayliss and Staude.

Larvae and ova were collected by hand on the host-plant (*Encephalartos gratus*) and transported in white, plastic 35mm film canisters, containing some host-plant. Single larvae were reared initially in 60x40x30 mm clear plastic canisters and then in progressively larger canisters as the larvae grew. Larvae in captivity were switched to the leaves of *Encephalartos villosus* Lemaire, 1867, which were readily available. Some larvae were sleeved on the leaves of potted *E. villosus* plants. The canisters were kept closed in order to keep sufficient humidity in the containers (because of the dry climate where the laboratory is situated). Daily cleaning and airing was necessary in order to prevent mould from forming in the canisters. Food plant was kept fresh by placing the petiole in a glass vial containing previously boiled water and the entrance was sealed using "Prestik" putty. Larvae were initially reared in an unheated laboratory and later, when the ambient temperature dropped below 10°C, in a heated laboratory kept at approximately 20°C. Loose, compost-rich soil, pre-cooked in a microwave oven for 10 minutes and left to cool down, was provided for final instar larvae as a pupation substrate. Pupae were removed from the soil after 3 weeks and transferred to "ziplock" plastic bags hung up and breathed into weekly to provide some moisture. Ova, larvae and pupae were preserved in 70% ethanol in sealed glass vials.

Adults were collected in the field using a standard "Butterfly-type" hand net and were prepared in the standard way.

The genitalia and abdomen were prepared following Hardwick (1950). The male vesica was everted via the caecum that was cut open by placing the aedeagus inside a hypodermic syringe (Sihvonen, 2001). Morphological terms of the genitalia follow Klots (1970).

Institutional acronyms are as follows: BMNH = The Natural History Museum, London, United Kingdom; ZSM = Zoologische Staatssammlung, Munich, Germany; HSS = private collection of Hermann S. Staude, Magaliesburg, South

Africa. Specimen data are presented as they appear on the labels: a forward slash separates lines; a semicolon separates labels; and information enclosed by square brackets provides further details about the specimen or label. Author acronyms are as follows: H. S. Staude = (HSS); J. Bayliss = (JB); P. Sihvonen = (PS).

Voucher specimens from which tissue was extracted for DNA Barcoding were deposited in ZSM.

The unpublished raw data from the field survey counting larval damage on cycads, conducted at Likhubula (as reported in Bayliss *et al.*, 2009) were used to generate figures 35 & 36 and taken into account during the species fundamental niche hypothesis and IUCN Red listing assessment.

The assessment was conducted with the aid of the *Guidelines for Using the IUCN Red List Categories and Criteria* (IUCN Standards and Petitions Subcommittee, 2010).

Callioratis grandis **Prout, 1922 new status**
Callioratis abraxas grandis Prout, 1922, *Bull. Hill Mus. Witley* 1(2): 265.

Material

Type material examined:

Holotype ♀, [Malaŵi]: Type / HT; Mlanje, / Nyasaland; Joicey / Bequest / Brit. Mus. / 1934–120. (BMNH).
Paratypes (1♀). [Malaŵi]: Type ; Mlanje, / Nyasaland; Joicey / Bequest / Brit. Mus. / 1934–120. (BMNH).

Further material examined:

Males (8):

1♂ labelled: Malaŵi, Mnt. Mulanje,/ Likhubula mission,/ miombo/[on the label]riverine forest/ S15°56'26"/[on the label]E35°30'09"/ 840m, 10-04-2005,/ H. S. Staude; Malaŵi/ Mulanje/ Likhubula mission/ 35.30.090E 15.56.260S/ 10.IV.2005 840m/ H.S.Staude/ Hss d000.db 8321; GEOMETRIDAE/ DIPTYCHINAE/ *Callioratis*/ *grandis*/ H.S.Staude /[on the label] 16-06-2005/ Hss_d000.db 8321; genitalia ♂/ Prep. number 1693/ Pasi Sihvonen [blue rectangle label]; abdomen ♂/ Prep. number 1695/ Pasi Sihvonen [blue rectangle label] **2♂ labelled**: Malaŵi, Mnt. Mulanje,/ Likhubula mission,/ miombo/[on the label]riverine forest/ S15°56'26"/[on the label]E35°30'09"/ 840m, 10-04-2005,/

H.S. Staude; Malaŵi/ Mulanje/ Likhubula mission/ 35.30.090E 15.56.260S/ 10.IV.2005 840m/ H.S.Staude/ Hss d000.db 8321; GEOMETRIDAE/ DIPTYCHINAE/ *Callioratis*/ *grandis*/ H.S.Staude /[on the label] 16-06-2005/ Hss_d000.db 8321; **3♂ labelled**: Malaŵi, Mnt. Mulanje,/ Likhubula mission,/ miombo/[on the label]riverine forest/ S15°56'26"/[on the label]E35°30'09"/ 840m, 10-04-2005,/ R.J. Murphy; Malaŵi/ Mulanje/ Likhubula mission/ 35.30.090E 15.56.260S/ 10.IV.2005 840m/ R.J. Murphy/ Hss d000.db 8322; GEOMETRIDAE/ DIPTYCHINAE/ *Callioratis*/ *grandis*/ H.S.Staude /[on the label] 16-06-2005/ Hss_d000.db 8322; **1♂ labelled**: Malaŵi, Mnt. Mulanje,/ Likhubula mission,/ miombo/[on the label]riverine forest/ S15°56'26"/[on the label]E35°30'09"/ 840m, 02-04-2006 emerged,/ H.S. Staude; *ab larva* collected on *Encephalartos gratus* ZAMIACEAE, reared on *E. villosus*; Malaŵi/ Mulanje/ Likhubula mission/ 35.30.090E 15.56.260S/ 10.IV.2005 840m/ H.S.Staude/ Hss d000.db 13102; GEOMETRIDAE/ DIPTYCHINAE/ *Callioratis*/ *grandis*/ H.S.Staude /[on the label] 15-09-2008/ Hss_d000.db 13102 **[total 7 ♂'s in HSS]**.

1♂ labelled: Malaŵi, Mnt. Mulanje,/ Likhubula mission,/ miombo/[on the label]riverine forest/ S15°56'26"/[on the label]E35°30'09"/ 840m, 10-04-2005,/ H.S. Staude; Malaŵi/ Mulanje/ Likhubula mission/ 35.30.090E 15.56.260S/ 10.IV.2005 840m/ H.S.Staude/ Hss d000.db 8321; GEOMETRIDAE/ DIPTYCHINAE/ *Callioratis*/ *grandis*/ H.S.Staude /[on the label] 16-06-2005/ Hss_d000.db 8321; BC ZSM Lep00008 [green DNA barcode ID label] **[total 1 ♂in ZSM]**.

Females (15):

1♀ labelled: Malaŵi, Mnt. Mulanje,/ Likhubula mission,/ miombo/[on the label]riverine forest/ S15°56'26"/[on the label]E35°30'09"/ 840m, 10-04-2005,/ H.S. Staude; Malaŵi/ Mulanje/ Likhubula mission/ 35.30.090E 15.56.260S/ 10.IV.2005 840m/ H.S.Staude/ Hss d000.db 8321; GEOMETRIDAE/ DIPTYCHINAE/ *Callioratis*/ *grandis*/ H.S.Staude /[on the label] 16-06-2005/ Hss_d000.db 8321; DNA sample/ 00221/ Lepid Phyl; genitalia ♀/ Prep. number 1694/ Pasi Sihvonen [blue rectangle label]; abdomen / Prep. number 1696/ Pasi Sihvonen [blue rectangle label] **13♀ labelled**: Malaŵi, Mnt. Mulanje,/ Likhubula mission,/ miombo/[on the label]riverine forest/ S15°56'26"/[on the label]E35°30'09"/ 840m, 10-04-2005,/ H.S. Staude; Malaŵi/ Mulanje/ Likhubula mission/ 35.30.090E 15.56.260S/ 10.IV.2005 840m/ H.S.Staude/ Hss d000.db 8321; GEOMETRIDAE/ DIPTYCHINAE/ *Callioratis*/ *grandis*/ H.S. Staude / [on the label] 16-06-2005/ Hss_d000.db 8321; **[total 14 ♀'s in HSS]**.

1♀ labelled: Malaŵi, Mnt. Mulanje,/ Likhubula mission,/ miombo/[on the label]riverine forest/ S15°56'26"/[on the label]E35°30'09"/ 840m, 10-04-2005,/

H. S. Staude; Malaŵi/ Mulanje/ Likhubula mission/ 35.30.090E 15.56.260S/ 10.IV.2005 840m/ H.S.Staude/ Hss d000.db 8321; GEOMETRIDAE/ DIPTYCHINAE/ *Callioratis*/ *grandis*/ H.S.Staude /[on the label] 16-06-2005/ Hss_d000.db 8321; BC ZSM Lep00009 [green DNA barcode ID label]**[total 1 ♀ in ZSM]**.

Diagnosis

Sexually dimorphic, *Callioratis grandis* and *Callioratis abraxas* are similar (Figs 13-18). The following characters, among others, allow identification: Hindwing in both sexes of *C. grandis* substantially broader than in *C. abraxas,* inner margin-apex:base-termen ratio=0,81, *n*=19 in *C. grandis* (*C. abraxas* = 0,68, *n*=21). **Male**: *C. grandis* is considerably larger, forewing length is 36-38 mm, av. 36,5mm, *n*=7 (*C. grandis*♂ 22-29 mm, av. 26 mm, *n*=8); black streak in forewing base extends into inner margin (in *C. abraxas* the streak is interrupted before inner margin); scent disseminating organ differs markedly, androconial pocket formed by folding of hindwing, colour and distribution of setae and androconial scales being diagnostic (for comparison see Figs 19-24 and Staude, 1996); long and sharp projections of valva are curved (approximately straight in *C. abraxas*); valva wide and curved (narrower, straighter in *C. abraxas*); row of cornuti parallel with vesica (row of cornuti in about 45 degree angle with vesica in *C. abraxas*) (for comparison see Figs 25-28). **Female**: *C. grandis* is on average larger, forewing length 29-40 mm, av. 36 mm, *n*=13 (*C. abraxis* ♀ 24-38 mm av. 29,5 mm, *n*=14); the distal part of corpus bursae is short and approximately straight (long and curved in *C. abraxas*); the corpus bursae is elongated (pear-shaped in *C. abraxas*) (for comparison see Figs 29-32). **Larvae**: All larval stages distinctive; 2nd instar larvae bear some resemblance to *C. millari* and final instar larvae to *C. mayeri*; prominent dorsal black lines or spots between abdominal segments A1-A4 in 2nd instar similar to C. abraxas.

Morphology

Adult (Figs 15-21, 25-26, 29, 31)

Head. Base black, frons orange; antennae filiform in both sexes; labial palpi very short, not extending beyond proboscis, black with prominent orange scales covering two-thirds from base in both sexes; proboscis well developed, brown.

Thorax. Black with two orange stripes dorsally (both sexes); uniform black (male) or black with some orange ventrally (female).

Wings. Sexes distinctly dimorphic.

Forewing length. (♂ 36-38 mm, av. 36,5 mm, n=7) (♀ 29-40 mm, av. 36mm, n=13).

Hindwing ratio. Inner margin-apex:base-termen ratio=0,81(n=19), in both sexes.

Forewing of male. Upperside ground colour orange; sub-basal, antemedial and post-medial lines black, variable, very broad, merging along inner margin, never completely obfuscating ground colour and creating two distinct orange triangular patches, one basal and one medial, connected to costa, lines heavily suffused with ivory white scales, basal white suffusion never merging with medial suffusion, creating a black streak in forewing base extending to inner margin; terminal spots merged to form terminal line in most specimens towards apex. Underside uniformly suffused with ivory white scales except on veins and margins, the latter black with blotches of orange ground colour along termen in most specimens examined.

Hind wing of male. Upperside, black scales almost completely obfuscating orange ground colour in most specimens, suffused with ivory white scales centrally, partial suffusion creating greyish area towards but not reaching termen, black cilia in inner fold and extending over basal one-third of wing surface; underside as forewing underside but lacking terminal orange scales.

Wings of female. Ground colour of wings orange, in some specimens yellowish in costal area of forewing; sub-basal, antemedial and post-medial lines much thinner than in male and with white suffusion on lines much reduced; terminal spots variable in size and merged at apex of forewing; hindwing post-medial line evenly curved ending at apex of inner margin; discal spots round, small, reduced or absent or sometimes absent in one wing only in some specimens.

Abdomen. ♂ completely black; ♀ black dorsally, orange in genital area, orange with partial black suffusion ventrally.

Male androconial organ (Figs19-24). Scent disseminating organ on hindwing only; hindwing folded over onto underside along the inner margin to form androconial pocket; disseminating setae black, distributed along androconial pocket edge and on the basal one-third of the hindwing upperside; probable androconial scales occur inside the androconial pocket.

Tympanal organs. Large, round and well separated in both sexes. Ansa wide at base, then constricted before wide apex; lacinia with a wide, sclerotised plate where it meets the ansa. Abdominal segments of both sexes sclerotised but undifferentiated.

Male genitalia (Figs 25, 26). Uncus with wide base, lateral margins slightly concave, apical part sclerotised, setose, slightly elongated and tapering to a rather sharp apex. Gnathos arms narrow, slightly undulating, fused medially. Tegumen margin elongated medially. Juxta weakly sclerotised, having lateral, short lobes, one with a blunt, round apex, the other terminating in an acute apex. Dorsal part of valva (perhaps a derivative of juxta or labide?) taking the form of a prominent, long and narrow, inwardly curved projection, weakly setose and terminating in an acute apex. Ventral part of valva wide, curved, tapering smoothly to a blunt apex, costa and sacculus invaginated, forming distinct marginal areas. Vinculum arms and saccus narrow, the latter concave medially. From the dorsal part of genitalia (apparently from the base of valva) arise two asymmetrical membranous sacs, one small, the other about the size of valva, containing numerous long and narrow setae. Aedeagus a long, straight tube, caecum very short, apex slightly elongated. Vesica taking the form of a simple sac, slightly enlarged at base, containing a long and narrow, sclerotised ridge apparently serving as base for attachment of numerous, needle-like cornuti; ridge positioned in the same direction as vesica; cornuti apparently detaching during copulation as they are found in high numbers inside the bursa copulatrix of the female.

Female genitalia (Figs 29, 31). Papillae anales soft, setose. Apophyses posteriores long, narrow, weakly enlarged at tip; apophyses anteriores blunt-ended, only about 1/3 length of apophyses posteriores. Lamella postvaginalis membranous; lamella antevaginalis granulose, weakly setose, invaginated medially, forming a sclerotised cup. Ductus bursae a short, ventrally sclerotised channel. Ductus seminalis opening ventrally from a membranous section between ductus bursae and distal part of the corpus bursae. Distal part of corpus bursae short, comparatively straight, grooved longitudinally throughout. Corpus bursae elongated, medially constricted thus having two sacs; the posterior sac is weakly grooved and fairly well sclerotized, retaining its shape, anterior sac is thin and membranous. Dorsal wall of corpus bursae with short spines. Signum in ventrolateral wall, large, slightly elongated, outer margin stellate, medial part round, inner surface with many thorn-like sclerotisations.

Immature stages (Figs 1-6)

Ovum (Figs 1, 2). Shell transluscent; bright yellow when laid, becoming gradually darker as larva develops inside, black before hatching; circular in dorsal view, dome-shaped with flat bottom in profile. Surface finely sculptured with irregular circular grooves; emergence hole of larva large, circular, spanning almost all of dorsal area.

1st instar larva (Fig. 2). Displaying a full complement of well-developed white primary setae that are on average slightly shorter than the body diameter; general body colour orange; head orange, black dorsally; anal shield yellow; a brownish patch on dorsal half of prothorax; dark reddish lines dorsally between prothorax and A1-A5; setal base colour undifferentiated from general body colour; primary setae white, relatively short; well developed prolegs on A5, A6 and A10, semi-developed prolegs lacking crotchets on A4.

2nd *instar larva* (Fig. 3). Head brownish-orange with two prominent dorsal black spots bordering similar black spots on prothorax; ground colour of prothorax and abdomen variable, creamy white to yellow becoming more orange-brown towards head; black dorsolateral dividing lines just below SD1 setae; three prominent dorsal black lines or spots between abdominal segments A1-A4, smaller black spots between other segments present in some larvae only; all setal bases now black, giving larvae a spotty appearance, a broken brown lateral line just above spiracles; relatively short secondary setae now present, primary and secondary setae white.

3rd *instar larva* (Fig. 4). Ground colour now almost uniform deep orange, anal shield dark brown, dorsolateral lines much broader, merging with brown lateral line.

4th *instar larva* (Fig. 5). Dorsolateral lines now merging dorsally dividing dorsal ground colour area into several patches, again variable between individuals.

Final instar larva (Fig. 6) Ground colour now red; dorsal merging of dorsolateral lines complete in most individuals, rendering upper half of larvae black, lower half red. Larvae grow to 65 mm in length before pupation.

Pupa. Dark brown, 24 x 14 mm, a pair of 1.4 mm long cremastral hooks present, not merged at base of cremaster.

DNA Barcoding (Fig. 33)

Analysis of the barcode fragment (COI 5', >500 bp) of two specimens each of *Callioratis grandis* (gr), *Callioratis mayeri* (may) and *Callioratis abraxas* (ab) revealed the following genetic distances (minimum pairwise distance, Kimura 2 parameter):

gr - ab: 1.89%
may - ab: 2.23 %
may - gr: 2.18 %

Intraspecific variation (pairwise maximum distance, Kimura 2 parameter) was 0.0 % in both *C. abraxas* (*n* = 2) and *C. grandis* (*n* = 2), 0.15 % in *C. mayeri* (*n* = 2). Source: BOLD database (http://www.barcodinglife.com/views/login.php; cf. Ratnasingham &Hebert, 2007).

Life History and Behaviour

Ovum (Fig. 1). Egg cluster on average containing 27 ova (*n*=12), cluster randomly shaped and eggs not touching each other. Eggs are laid by day on the underside of leaflets.

1st instar larva (Fig. 2). Larvae only partially consume eggshell and feed by trenching along veins, consuming the inner, but not the outer leaf cuticle.

2nd instar larva (Fig. 3). Larvae feed on the underside of the leaflet, producing irregular oval patches not penetrating the leaflet upper cuticle. These patches are quite distinctive and can be observed on the leaves long after the larvae have left.

3rd & 4th instar larva (Figs 4-5). Feeding occurs on the edge of leaflets; larvae no longer cause patches on the underside.

Final-instar larva (Fig. 6). These became sluggish, and one individual died when left in an unheated lab during winter in South Africa, where temperatures plummeted below 5˚C. The sluggish larvae recovered quickly when moved to a heated room. Final-instar larvae burrow into loose soil and spin a flimsy cocoon, incorporating the surrounding debris. *Larval stages took up to four months to complete in captivity in South Africa.*

Pupa. Rigid, does not wriggle when disturbed.

Imago (Figs 7-8). Adults of *C. grandis* are diurnal. Females widely patrol surrounding areas in the vicinity of cycads and visit nectar sources; they are active from early in the morning until dusk. One female was observed landing on a cycad and then walking up and down the underside of the leaflets with her proboscis touching the surface of the underside of the cycad frond. Males exhibit LEK forming behaviour.

LEK and mating behaviour (Figs 11-12). Staude (1996) described LEK formation in *C. abraxas*, whereas the first account for the present species is by Bayliss *et al.* (2009). Subsequent observations revealed the following: the LEK appears to be composed of approximately 10 males. Trees chosen for the LEK are relatively tall (above 6 m), prominent specimens with cycads growing below. Open protruding branches are preferentially chosen by males. Several LEK trees, of different tree species, were found. It is thought that the height of the tree is the most important factor; however, this requires confirmation as does the local density of individual LEKs. The males seem to rest there and gently open and close their wings, presumably gradually releasing pheromones. Occasionally they take flight but do not go far from the LEK and return fairly quickly, within a few minutes.

When a female approaches the LEK, males start to beat their wings vigorously, presumably releasing pheromones, but do not leave their position. Females land amongst the males in the LEK. After copulation has commenced the pair drop out of the LEK to a lower/neighbouring branch, with the female transporting the passive male. Mating lasts for approximately 30 minutes.

One LEK was observed for approximately a month. After a heavy storm the LEK had disappeared, although females were still flying. It is presumed that several small LEKs (of approximately 10 males each) exist in the area of the cycads.

Phenology. The species appears to be univoltine with an extended single brood. Adults as well as ova and all larval stages were found to be present in mid-April, 2nd instar to final instar larvae were still found on the cycads in mid-June. No signs of any life stages were found in October. This may indicate that adults probably have a long and extended flight period from March to May.

Ecology

Predators & parasitoids

Females were observed that had been killed and trapped by crab spiders in one of the cycads. None of the *C. grandis* larvae collected in the wild were parasitized, although Bristly flies (Tachinidae) have been found to parasitize *C. abraxas* larvae (Staude, pers. obs.).

Larval host-plants (Fig. 10)

Ova and all larval instars of *C. grandis* have been found on the leaves of the Mulanje Cycad (*Encephalartos gratus*) in the wild (Staude, 2008). Larvae of all instars were observed by day on the underside of leaflets. Unlike in other *Callioratis* species, ova were found on hardened, more mature leaves of *E. gratus.* Bayliss *et al.* (2009) found larval damage on *E. gratus* to be much greater on more mature plants. Larvae were switched to leaves of *Encephalartos villosus* in captivity, which were readily accepted. No larvae of *C. grandis* have been found to utilize secondary host-plants in the wild. In the lab, final instar larvae were offered leaves of *Diospyros whyteana* (Hiern.) (Ebenaceae), which were accepted as a secondary host-plant by *Callioratis abraxas* (Staude, 2001) together with leaves of *E. villosus* but larvae of *C. grandis* did not feed on the *D. whyteana*, suggesting that this species does not readily utilize secondary host-plants. *Encephalartos gratus* is the only cycad growing in the area where *C. grandis* occurs and therefore appears to be its only host-plant.

Distribution (Figs 34-36)

Callioratis grandis and/or signs of its presence (feeding damage on leaves) were found only in a small area in the Likhubula Valley, on the slopes of Mount Mulanje, Malaŵi where the host-plant grows. The presence of the moth can easily be established by searching for the typical feeding damage on the leaves of the host-plant, which persists for several years. Despite careful examination of plants growing in the town of Chitakali, Mulanje and surrounding areas nearby, no signs of *C. grandis* were found. These plants in the surrounding areas are mature plants that have been there for many years, and may represent relict individuals of a much wider natural distribution of *E. gratus* in this area, where the plant is now largely confined to the Likhubula valley. The fact that *C. grandis* has not migrated to these plants may indicate its extreme reluctance to disperse or that there are simply not enough of these plants to maintain a local population of the moth. Plants growing in adjacent Mozambique were also examined and no signs of the presence of *C. grandis* were found, although the majority of these individuals were planted. However, *E. gratus* is known to occur in small populations across northern Mozambique. Those found in and around the northern Mozambique towns of Mlanje and Gurue (Namuli) were searched for moth damage but none was found. Bayliss *et al*. (2009) surveyed all *E. gratus* plants occurring in the Likhubula Valley and found 532 individuals. Of these plants 50,8% showed evidence of *C. grandis* feeding damage (Fig. 36), and a highly significant relationship was found between the incidence of *C. grandis* damage and *E. gratus* specimens being mature.

Species niche

Factors limiting the fundamental niche of this species include its dependence on older mature *Encephalartos* host-plants; larval temperature tolerance of not less than 5ºC; suitably high trees for LEK formation in the vicinity of its host-plant; and the species' apparent low dispersal rate.

Callioratis grandis does not seem to be limited to a particular surrounding vegetation type as it thrives in the Likhubula Mission's garden which, apart from a high concentration of *E. gratus*, consists mostly of exotic plants. This is a well groomed garden subjected to common gardening practices.

It is not understood why the species does not seem to occur in the surrounding areas and adjacent Mozambique.

Conservation

Threats

The Mount Mulanje conservation area, in particular the main mountain plateau, is threatened by bauxite mining. The main plateau, at about 2000 m, is on top of a granite massif with sheer cliff walls surrounding, making it very difficult to build an access road to the plateau, and to this day the only access is by foot. The Likhubula Valley (Fig. 9) is by far the easiest route to access this plateau and would be the best route for a road needed to extract the bauxite ore, should mining plans go ahead. There is, therefore, a high probability that a road could be built through the only known habitat of *C. grandis* in order to gain access to the plateau. This could easily drive the species to extinction.

The burgeoning human population living within the area of occupancy of the species poses a more immediate threat. Although it does not seem that specimens of *E. gratus* are being targeted, felling of potential LEK trees and clearance of bush for crops are continual. The authors noticed a visible deterioration of the habitat of *C. grandis* between 2005 and 2009. A recent visit to the area in June 2011 clearly showed signs of further encroachment and fire damage to host-plants. The human population in the valley will increase dramatically if bauxite mining operations go ahead, further adding to the severity of the above threats. It is feared that this observed continual decline in the quality of the habitat would lead to the extinction of *C. grandis* if the current trends continue.

There is an urgent need for the implementation of a *Mulanje Tiger Moth Conservation Management Programme*, which should include: Immediate steps to be taken to stop the current trend of habitat deterioration; ongoing monitoring of the health of the colonies of *C. grandis* and *E. gratus*; continued monitoring and managing of farming and other invasive human practices; further scientific research into the ecological requirements of the moth and its host-plant; an educational programme educating the local population and people in general about this unique moth and its 'living fossil' cycad host. A translocation programme should also be considered for those cycads in local populations that currently do not have evidence of the moth being present.

IUCN red list assessment

Donaldson (2009) classified the host-plant *E. gratus* as vulnerable A4cd. We have made an assessment, following the IUCN Red List Categories and Criteria version 3.1 (2001), on the Red List status of *C. grandis*, based on evidence presented in this article. We found *C. grandis* to be **Critically Endangered**. The species should be classified as **(CR)B1ab(i,ii,iii)+2ab(i,ii,iii)** on the following grounds: The IUCN criteria EOO (Fig. 35) and AOO (Fig. 36) are smaller than the allowable maximum; only a single colony is known; there is an observed continuing decline in the quality of the only habitat, which will likely lead to the extinction of the species if allowed to continue.

Acknowledgements

The authors would like to thank Ray Murphy for immediately reporting the re-discovery of the moth to us in 2005. Jonathan Ball for advice and discussions on the use of IUCN Red List Criteria and for comments on the manuscript. Louél Staude for her assistance in the plate layouts. Camilla Burrow and Sarah Martell for their role in collecting the raw data gathered during their cycad field work. Axel Hausmann for assistance in evaluation and citation of DNA barcoding data. Alf Curle for comments on the species' early stages. The Mulanje Mountain Conservation Trust for permission to work in the area and for the use of their facilities, specifically Carl Bruessow (Director) and David Nangoma (Biodiversity Officer). Rick and Barbara Illingworth for their kind hospitality and permission to work on their farm. The staff of the Likhubula Mission Station for their kind hospitality and for permission to work and camp in their garden. Doug Kroon for, as always, scrutinizing the final manuscript.

References

BAYLISS, J., BURROW, C., MARTELL, S. & STAUDE, H.S. 2009. An ecological study between two living fossils in Malaŵi – the Mulanje Tiger Moth (*Callioratis grandis*) and the Mulanje Cycad (*Encephalartos gratus*). *African Journal of Ecology* **48:** 472-480.

DONALDSON, J.S. 2009. *Encephalartos gratus*. *In*: IUCN 2010, IUCN Red List of Threatened Species. Version 2010.4. <www.iucnredlist.org>. Downloaded on 26 May 2011.http://www.iucnredlist.org/apps/redlist/details/41916/0

DONALDSON, J.S. & BÖSENBERG, J.D. 1995. Life history and host range of the leopard magpie moth, *Zerenopsis leopardina* Felder (Lepidoptera: Geometridae). *African Entomology* **3** (2): 103–110.

FELDER, R. 1874. *In:* FELDER, C., FELDER, R. & ROGENHOFER, A., *Reise öst. Fregatte Novara* (Zool.) **2** (Abt.2): pl. 100, Figs17,18.

HAMPSON, G.F. 1905. The Moths of South Africa (Part III). *Annals of the South African Museum* **3**(9): 389–438.

HARDWICK, D.F. 1950. Preparation of slide mounts of lepidopterous genitalia. *Canadian Entomologist* **82:** 231–235.

IUCN Standards and Petitions Subcommittee 2010. Guidelines for Using the IUCN Red List Categories and Criteria. Version 8.1. Prepared by the Standards and Petitions Subcommittee in March 2010. Downloadable from http://intranet.iucn.org/webfiles/doc/SSC/RedList/RedListGuidelines.pdf

KLOTS, A.B. 1970. Lepidoptera. *In*: TUXEN, S.L. (ed.), *Taxonomists' glossary of genitalia in insects*. Copenhagen, Munksgaard, pp. 115-130.

PROUT, L.B. 1915. New Genera and Species of African Geometridae. *Novitates zoologicae* **22**: 311–385.

PROUT, L.B. 1922. Some New Geometridae and Dioptidae in the Joicey Collection. *Bull. Hill Mus. Witley* **1**(2): 252–269.

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

SIHVONEN, P., 2001. Everted vesicae of the *Timandra griseata* group: methodology and differential features (Geometridae, Sterrhinae). *Nota Lepidopterologica* **24:** 57– 63.

STAUDE, H.S. 1996. Observations on LEK Behaviour and the description of Male Scent Disseminating Structures of *Callioratis abraxas* Felder, 1874 (Lepidoptera: Geometridae). *Metamorphosis* **7**(3):121–126.

STAUDE, H.S. 2001. A revision of the genus *Callioratis* Felder (Lepidoptera: Geometridae: Diptychinae). *Metamorphosis* **12**(4):121–156.

STAUDE, H.S. 2008. An annotated report on 115 further host-plant associations for African Loopers (Lepidoptera: Geometridae). *Metamorphosis* **19**(4):193-209.

STAUDE, H.S. & CURLE, A.I. 1997. A Classification of Visual-signals Emanating from the Wings of Afrotropical Lepidoptera. *Metamorphosis Occasional Supplement* **3**: 156–182.

One fine day in the Mulanje Crater

Hermann Staude[1] & Julian Bayliss[2]

[1] hermann@busmark.co.za
[2] jlbayliss@yahoo.co.uk

The morning broke serenely, as mornings usually do in winter in this part of the world. The slight mist burning away in front of our eyes unveiled one of the most spectacular views inAfrica, the Mulanje Crater (see back cover), part of the larger Mulanje massif covering 650 km^2 and the second highest mountain range in southern Africa after the Drakensberg. *"What would you like to do today"* Julian asked Hermann. *"I would love to get into that forest over there surrounded by sheer cliffs, is there a way into that? perhaps we are lucky and we will find the elusive* Pitthea neavei*"* was Hermann's reply.

It was one of Julian's last days in Malaŵi as his contract was ending after almost 6 years as consultant ecologist to the Mulanje Mountain Conservation Trust (www.mountmulanje.org.mw). Hermann flew up from South Africa to see him off and to check on the Mulanje Tiger Moth (*Callioratis grandis*) colony at Likhubula, which we visited the day before finding good numbers of larvae on the cycads. The previous day we had also visited the Tea Segregation Plots. This is a very interesting place. Years back strips were cut into an area of the last remaining lowland forest and these were planted with various tea cultivars for experimental purposes. These experiments are long finished and the forest was allowed to take over again. Now you have a very diverse forest intermixed with tea trees gone wild. All of the surrounding forests and bush outside of the Tea Segregation Plots have since been cleared for agriculture. Today this forest is an island of 'natural forest' in a sea of transformed agricultural land. Many lowland forest butterflies, not normally seen in the area were seen flying all over these plots. Particularly common were *Aterica galene, Euphaedra neophron, Euryphura achlys, Scopula monteironis* and various *Neptis* spp.

We were having a cup of Mulanje's finest tea on Julian's verandah. Julian explained that this was called the Mulanje 'Crater', so called because being surrounded by sheer granite giving it the impression of being a crater. It was however formed by erosion, not by volcanic eruption nor by something big dropping in from outer space. You can check out the spectacular formation on Google Earth by typing S16°00'44,8"/E35°32'55,6" into the search browser. The way in was by boulder hopping up the river flowing out of it into the Lauderdale tea estate. This was early June and the river was relatively low making this exercise a little easier. Rick Illingworth (Assistant Managing Director of Eastern

Produce) kindly gave us permission to drive through his tea plantations to near the crater entrance.

Butterflies were everywhere, the *Cyrestis camillus* were particularly attractive floating over neatly trimmed tea. One could stay for hours just watching all the butterflies flying along the forest edge over the tea but we were anxious to get going as the crater beckoned.

A little way into the crater we came across a number of *Acraea egina* males and females. While handling a male Hermann noticed that it was exuding a yellow fluid from the hindwing termen (Fig. 1). Closer inspection revealed black pocket-like swellings on the veins from which the fluid emanated. Many acraeas exude a defensive fluid when handled but neither of us had ever seen such fluid pockets situated at the hindwing termen, nor did we recall ever having read about this in the literature either. We wondered if this had ever been recorded before? Why would these pockets evolve on the wing termen? Why not on the body where the butterfly is most vulnerable as is the case with most acraeas? Perhaps this fluid exudate was not a defensive mechanism? Perhaps a pheromone?

Further into the crater we came upon a large open area made up of solid granite (Fig. 7). At the head there was a small waterfall with the water cascading into a pool. The river then split into a multitude of small rivulets each finding its way across the huge rocky surface. This was a perfect place from which to watch all the Lepidoptera flying along the forest edge and into this natural clearing. Many charaxes and other butterflies were congregating here, using the overhanging branches as territory to defend. As much as we searched everywhere for *Pitthea neavei,* as elusive it remained and we never saw this lovely diurnal geometrid. We fished a dead geometrid, floating down one of the rivulets, from the water. It turned out to be what probably is an undescribed species resembling a species Martin Krüger had recently described from Zimbabwe called *Odontopera stevensoni*.

Julian noticed some, perhaps a dozen or so, *Hypolimnas* roosting under a rock overhang (Fig. 2). Closer inspection revealed that this 'roost' consisted of two species, *Hypolimnas anthedon wahlbergi* and *H. deceptor*. We found two more such roosts each containing both species. This was around midday, strange we thought, again wondering if this had previously been recorded for these species, whether it was known that both species roost together and what the purpose of this strange behaviour could be?

Further on in a grassy area we came across a number of liptenine mating communes. One sometimes finds these strange groups of mating *Pentila pauli* *nyassana*. Hermann remembers seeing a group of over twenty mating pairs all perched on a single stem of a sparse growing bush near Kitwe, Zambia. Julian found some of the much scarcer *Teriomima puella* flying around as well. Upon investigation he found a mating commune consisting of both the *Pentila pauli nyassana* and *Teriomima puella* (Fig. 5). We pondered on this phenomenon. Again this is something that needs to be investigated. Why do these butterflies form these mating communes? Is this pheromone related and if so why then is more than one species involved? Is it easier for these butterflies to find mates when they congregate like that but is it worth it given the obvious risk of such conspicuous displays? Perhaps their aposematism is enough to protect them from predators?

On the look-out for more of these mating communes, Hermann came across a number of Dancing Acraeas (*Telchinia serena*), all perched on what looked like a grass stem from afar (Fig. 4). Closer inspection revealed that these were all dead butterflies, some already dried up. They had all got stuck on sticky seeds. We wondered how that happened? Perhaps one got stuck on the seeds and the commotion lured the others, each one in turn getting stuck on the seeds - quite bizarre! We did not ponder on what was happening here. It was quite clear that the seeds were probably sticky so that passing mammals could transport them to another location and the butterflies were simply victims. We did however wonder how often this happens? Does it happen to other species? Has anyone seen this before?

While boulder hopping on the river Julian almost stepped on a mating pair of arctiids (*Karschiola holoclera*). This was fascinating to watch. The male was very much aware of our presence. In an attempt to shield the female from danger he was constantly turning himself towards the camera, vigorously beating his forewings all the time. It was really difficult to get a shot in with the wing surfaces of both moths in view. In the end Hermann managed one shot (Fig. 3). This pretty moth is possibly exclusively diurnal as all the specimens that Hermann has ever come across were collected by day and he has never found one at light traps. The late Neville Duke observed that the males fly very fast during the day and are exceedingly difficult to capture. Typical of diurnal moths the male has well developed sex disseminating organs on the hindwing. We are unaware of anyone ever having observed the mating behaviour of this species. It would certainly be fascinating to do a study on the biology of this species.

There were quite a lot of *Oxyanthus* trees growing under the forest canopy. *Scopula* of the *Cartaletis* Group use these trees as their host-plants. These moths have become diurnal and are much larger and look very different from their nocturnal relatives in the genus *Scopula*. So much so that for many years these were not recognized as being part of *Scopula*. In fact they were placed in a different subfamily. Pasi Sihvonen first realized that they were part of the genus *Scopula* when he revised the subfamily a couple of years ago. Modern molecular studies have since verified the position. The larvae of these moths are aposematic and very conspicuous on their host-plants. Hermann found some of these larvae (Fig. 6) on the *Oxyanthus*. These looked very different from the *Scopula monteironis* larvae he had bred from the Manguzi Forest, South Africa. On Mount Mulanje two species of these diurnal *Scopula* are known, *S. monteironis* and *S. nigricosta.* Hermann was very excited, these could be the larvae of the rare *S. nigricosta* or perhaps this was another species. It was unlikely to be *S. nigricosta* though as it has only been found much higher up in the forests of the plateau and not down here on the lower slopes of the mountain. These larvae were later reared to adulthood and the adults turned out to be typical *S. monteironis*. Perhaps the Mulanje specimens represent a species distinct from typical coastal *S. monteironis*? Or perhaps the unique larvae are just a local form? Pasi and Hermann are in the process of revising the African Scopulini - a ten-year project. Perhaps they will find some answers to the above question together with many others regarding the *Cartaletis* complex.

As the shadows became longer, we reluctantly made our way out of the Mulanje Crater. Later that evening, with beer in hand at the Mulanje Country Club, we reflected on all we had witnessed that day. The few observations that we had made only that day and the questions that we had to ask would take years of dedicated ecological study to elucidate. We marvelled at how much there still is out there to discover, you only have to open your eyes and look! It is incredible to think that so few people realize that this wonderful world of discovery lies at our feet, beckoning us to enter. Perhaps Johnny Nash was referring to us when he sang: *"There are more questions than answers - pictures in my mind that do not show.....”*

Sponsor & Honorary Life Members of LepSoc

The following members, apart from their significant contributions to the Society as individuals, have also chosen to be sponsor members for 2010 and have through their generosity provided significant financial support which is much appreciated:

Sponsor Members

Dr Jonathan Ball
Justin Bode
Yolande Bode
Charles Botha
Kevin Cockburn
Dr Bennie Coetzer
Steve Collins
Alf Curle
Martin Curle
Jeremy Dobson
Dr Dave Edge
Owen Garvie
Tim Gilbert
Glynis Hardy
Graham Henning
John Joannou
Duncan MacFadyen (E. Oppenheimer & Son)
Dave McDermott
Ernest Pringle
Harald Selb
Peter Sharland
Hermann Staude
Reinier Terblanche
Steve Woodhall

Honorary Life Members

Dr Stephen Henning
Dr Douglas Kroon
Clive Quickelberge
Prof. Mark Williams

Any member can volunteer to become a sponsor member on an annual basis and make a contribution of R600. As the Society does need all the financial support it can get it is hoped that more members will elect to become sponsor members in the future. Donations to the Society will also be most welcome.

Figure 1. Ova (HSS)

Figure 2. 1st instar larvae (JB)

Figure 3. 2nd instar larvae (HSS)

PLATE NO. 2 – *Callioratis grandis* life history

Figure 4. 3rd instar larva (HSS)

Figure 5. 4th instar larva (HSS)

Figure 6. Final instar larva (HSS)

Figure 7. live ♂ imago (HSS)

Figure 8. live ♀ imago (HSS)

PLATE NO. 4 – *Callioratis grandis* habitat

Figure 9. Likhabula Valley, Mount Mulanje, Malawi (HSS)

Figure 10. Host plant *Encephalartos gratus in* situ, Likhabula Valley (HSS)

Figure 11. LEK tree top, arrows indicate position of seven males in the LEK (JB)

Figure 12. LEK tree with cycad below, Likhabula Mission gardens (HSS)

PLATE NO. 6 – *Callioratis grandis* & *C. abraxas* adults


Figure 13. *C. abraxas* ♂ imago upperside (HSS)


Figure 14. *C. abraxas* ♀ imago upperside (HSS)


Figure 15. *C. grandis* ♂ imago upperside (HSS)


Figure 16. *C. grandis* ♀ imago upperside (HSS)


Figure 17. *C. grandis* ♂ imago underside (HSS)


Figure 18. *C. grandis* ♀ imago underside (HSS)

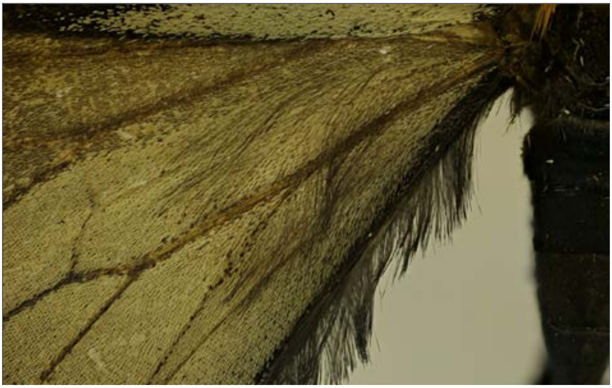

Figure 19. *C. grandis* ♂ scent disseminating setae, hindwing upperside (HSS)

Figure 20. *C. grandis* ♂ scent disseminating setae & androchonial fold, hindwing underside (HSS)

Figure 21. *C. grandis* ♂ androconial fold, partially opened to show androconial scales (HSS)

PLATE NO. 8 – *Callioratis grandis* male scent disseminating structures

Figure 22. *C. abraxas* ♂ androconial scales (HSS)

Figure 23. *C. abraxas* ♂ scent disseminating setae, hindwing upperside (HSS)

Figure 24. *C. abraxas* ♂ androconial patch, forewing underside (HSS)

Figure 25. *C. grandis* ♂ male genitalia
(slide PS1693) (PS)

Figure 26. *C. grandis* ♂ aedeagus and cornutus enlarged (PS1693) (PS)

Figure 27. *C. abraxas* ♂ genitalia (PS1691) (PS)

Figure 28. *C. abraxas* ♂ aedeagus and cornutus enlarged (PS1691) (PS)

PLATE NO. 10 – *Callioratis* ♀ genitalia, diagnostic characters are indicated.

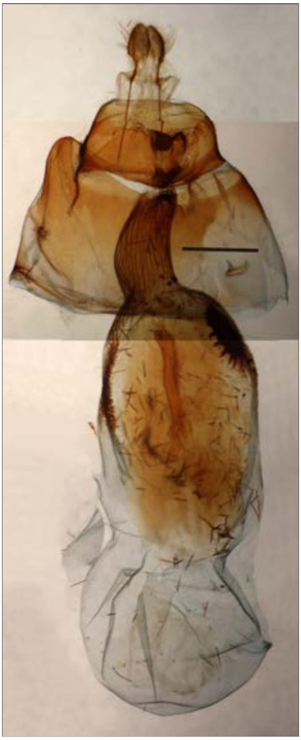

Figure 29. *C. grandis* ♀ genitalia (PS1694) (PS)

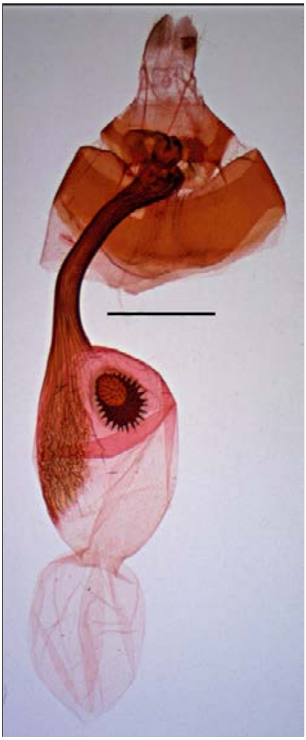

Figure 30. *C. abraxas* ♀ genitalia (HSS)

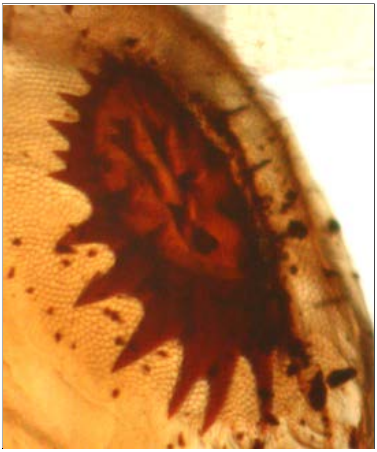

Figure 31. *C. grandis* ♀ signum (PS1694) (PS)

Figure 32. *C. abraxas* ♀ signum (PS1692) (PS)

PLATE NO. 11

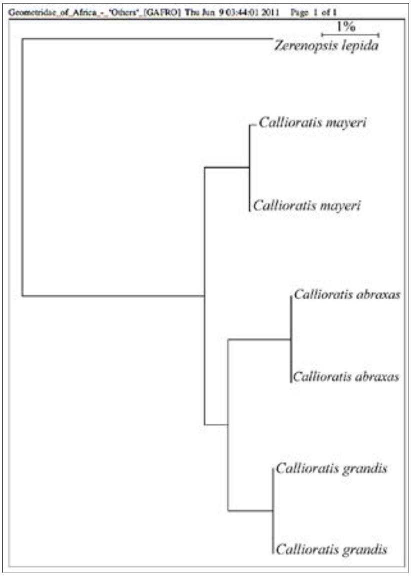

Figure 33. *Callioratis* Taxon ID Tree (Source: BOLD database)

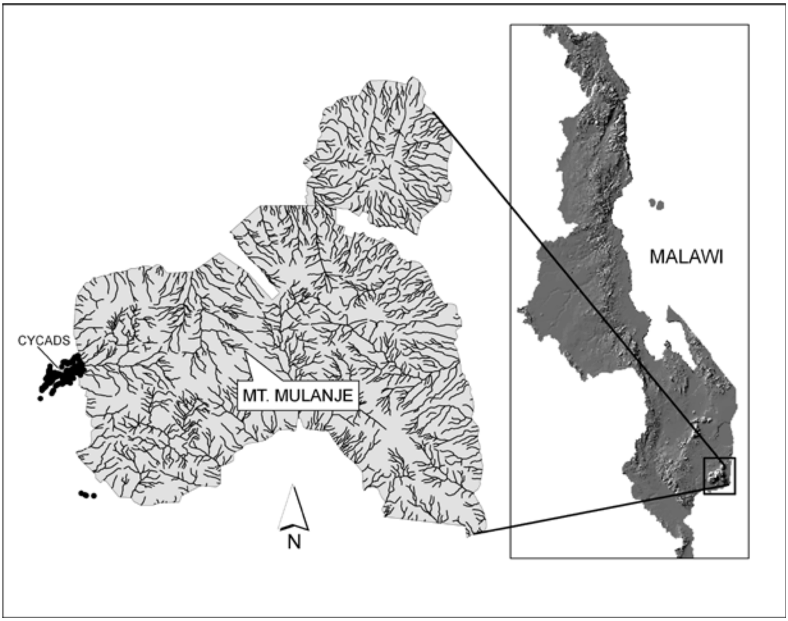

Figure 34. Host plant *E. gratus* Malaŵi distribution in relation to Mount Mulanje Conservation Area (JB)

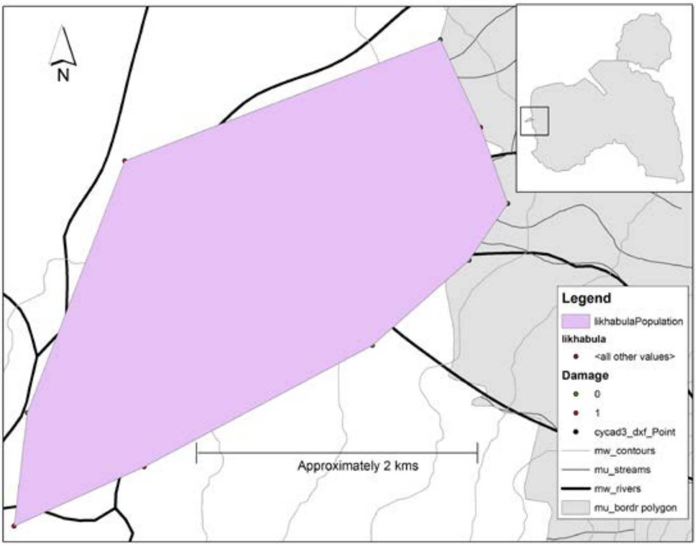

Figure 35. *Callioratis grandis* ‘extent of occurrence’ (JB)

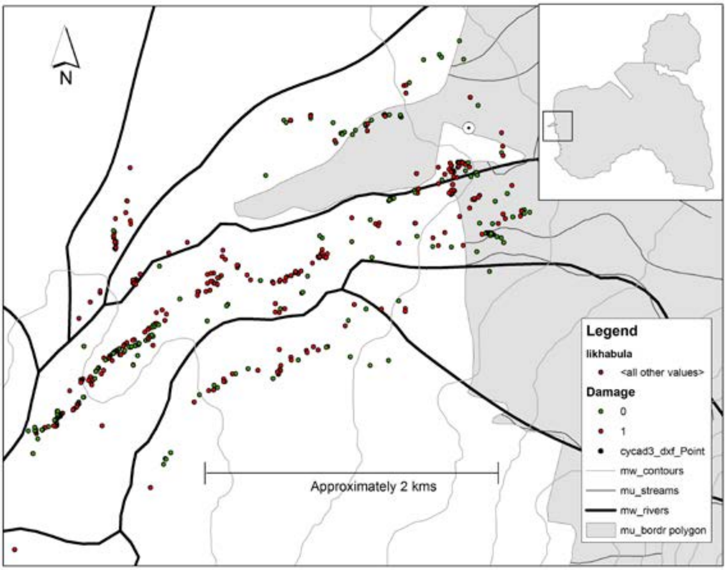

Figure 36. *Encephalartos gratus* ‘distribution’ and evidence of *Callioratis grandis* feeding damage indicating the ‘area of occupancy’ (JB)

PLATE NO. 13

Figure 37. *Acraea egina areca* ♂ showing liquid exuding from the hindwing termen (HSS)

Figure 38. *Hypolimnas anthedon wahlbergi* & *H. deceptor* in communal roost (HSS)

PLATE NO. 14

Figure 39. *Karschiola holoclera* mating pair (HSS)

Figure 40. *Telchinia serena* group stuck to sticky seeds (HSS)

PLATE NO. 15

Figure 41. *Pentila pauli nyassana* & *Teriomima puella* mating pairs in mating commune (HSS)

Figure 42. *Scopula monteironis* 'Malawi' larva (HSS)

PLATE NO. 16

Figure 43. Mount Mulanje Crater, the clearing along the river (HSS)

Figure 44. Mount Mulanje Crater (HSS)