



## Dear gelechioid aficionados,

The latest issue of I.N.G.A. is out again. This time it provides you with a great aficionado bio from Daniel J. Bruzzese and many interesting articles. For instance, you can learn more about how to make amazing illustrations of gelechioids and their genitalia, and dive deep into the phylogenetic and biogeographical patterns in Elachistinae. In addition, read more about Lepidoptera course 2019 from page 26.

As always, we welcome any contributions from the community to be published in the coming issues and greatly thank Daniel J. Bruzzese, Terry Harrison, Peter Huemer, Lauri Kaila, Ole Karsholt, Sjaak (J.C.) Koster and Jürg Schmid for providing articles and images for the current issue.

Hope you enjoy the newsletter!

*I.N.G.A. team*



*Read more  
about the story  
of the  
taxonomic  
revision of  
Megacraspedus  
from page 5*



Cover image and other photos of *Megacraspedus* are kindly provided by Jürg Schmid

# Gelechioid Aficionado:

*Daniel J. Bruzzese*

*dbruzzes@nd.edu*

I'm a PhD student in the Feder lab at Notre Dame (IN, USA). I study the process of speciation, specifically looking at how an internal symbiont, *Wolbachia*, can create barriers to reproduction and lineage diversification in the tephritid fly genus, *Rhagoletis*. I began researching the process of speciation though during my master's research on a gelechioid moth family. In a joint program at the Chicago Botanic Garden (IL, USA), and Northwestern University (IL, USA), I studied how hostplants contribute to the diversification of Momphidae.



Momphidae is a family with approximately 120 named species, characterized by their small size and narrow forewings with raised scale tufts (Nieukerken et al. 2011). I first became interested in *Mompha* because of their rich diversity of hostplant use. *Mompha* larvae feed on seven plant families and can mine, bore, or gall on flowers, fruits, leaves, shoot tips, stems, and roots (Hodges 1998; Powell 1980; Koster and Sinev 2003; Wagner et al. 2004). By studying shifts to new host plant niches in momphids, I hoped to better understand how multiple axes of the hostplant resource (hostplant family, plant tissue type and larval feeding mode) contribute to the diversification of momphids and more broadly, phytophagous insects.

My coauthors (David Wagner, Terry Harrison, Tania Jogesh, Rick Overson, Norman Wickett, Robert Raguso, and Krissa Skogen) and I generated the first phylogeny of North American momphids. We found that shifts to new hostplant feeding niches have played an important role in the diversification of these microlepidoptera. We identified four major clades: 1) an Onagraceae flower and fruit-feeding clade, 2) a Melastomataceae galling clade, 3) an Onagraceae and Rubiaceae leafmining clade, and 4) a heterogeneous clade associated with multiple hostplant families, plant tissues, and larval feeding modes.

We also found that a great number of species-level lineages remain undescribed (56 species - level taxa). There are many undescribed momphids found boring on Onagraceae in the American Southwest, leafmining on Onagraceae in the Canadian Rockies, and feeding on Melastomataceae in the Neotropics. I encourage everyone to collect and rear momphid larvae to contribute to understanding the diversity of this family!



**Figure 1. *Mompha pecosella* complex. Collected as larva in West Texas from *Oenothera capillifolia* flower buds. This figure is adapted from figure 1 in (Bruzzese et al. 2018) Photo credit: Terry Harrison.**

For more information I invite everyone to read our manuscript (Bruzzese et al.), which is currently under review. You can view our preprint (not peer-reviewed) here: <https://www.biorxiv.org/content/early/2018/11/08/466052>

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## Taxonomic revision of *Megacraspedus* – more than just a paper...

*Peter Huemer<sup>1</sup> and Ole Karsholt<sup>2</sup>*

1. Tiroler Landesmuseen Betriebsges.m.b.H., Hall, Austria

[p.huemer@tiroler-landesmuseen.at](mailto:p.huemer@tiroler-landesmuseen.at)

2. Zoological Museum, Natural History Museum of Denmark, Copenhagen, Denmark

[okarsholt@snm.ku.dk](mailto:okarsholt@snm.ku.dk)

Yes, we have written many papers, revisions, monographs and books, and yes, each of them had their own story. But none of our previous publications has cost us as much power, energy and endurance as the revision of the genus *Megacraspedus*. It's probably no coincidence that none of our great predecessors or current active colleagues have been more deeply involved with this genus. They all probably had a dull foreboding of the problems to be expected. In fact, the book cover of the voluminous monograph (278 pp.) recently published in Zookeys speaks for itself and should therefore be quoted:

*„Gelechiidae are among the megadiverse families of Lepidoptera with about 4700 species described worldwide, but their actual number is estimated to double. The revision of the Palearctic genus Megacraspedus Zeller, 1839 underlines this assumption. A total of 85 species are defined, including 44 new taxa. Twenty-two [recte twenty-seven!] previously unnamed species originate from the seemingly well-studied Europe. The authors furthermore establish 4 new generic and 13 species synonyms, and 5 new combinations. Species delimitation is basically based on morphological characters and genetic data of the DNA barcode. However, only 35 species are known from both*

*sexes, while of 46 species, the females are unrecorded. The partly inconspicuous morphology and an up to 14% intraspecific genetic divergence, so far unknown in Lepidoptera, occasionally make the identification difficult. The strong tendency to brachyptery or flightlessness in the female sex results in increased isolation of mountain populations and is reflected in a complex phylogeography with deep barcode splits.”*

Indeed, species of *Megacraspedus* are often very difficult to identify, and classical morphology in many cases reaches its limits. A general lack of material, difficulties in locating and organizing type material, huge gaps in biology and ecology knowledge, and often incongruent molecular data have been real hurdles to the taxonomic decisions to be made. On the other hand, *Megacraspedus* is a fascinating and obviously (in the Palearctic) much more diverse group of Gelechiidae than previously suspected, and on a European scale it was probably the least studied genus of Lepidoptera to be revised for a long time. It is significant that so many Lepidoptera species were not described in a single work from this continent since 1887. Although not all problems, such as the unexplained intraspecific genetic diversity of some taxa, have been resolved, we hope that the revision is still an important contribution to Old World Gelechiidae.

Last but not least, a personal note (PH) ...

It took 5 years to complete this work and ultimately put it on paper. Not least a new and challenging professional environment of the co-authors resulted in an increasing lack of time resources, which also affected the original ambitious time line. For the new head of the Natural History Collections of the Tyrolean Provincial Museums, tasks such as relocating several million objects to a new domicile simply had priority. Thus, the patience and the former optimism of both authors was sometimes strained to the utmost. Anyone who has written such a comprehensive revision knows the various challenges, even without the problems mentioned above. The fact that the authors finally managed to finish what sometimes seemed almost impossible was mainly due to some personal attributes. The authors get along well together for a long time, ready to take compromises and willing to accept sometimes less than 100%. Last but not least, a friendship that has lasted for decades has helped to overcome any crisis sentiment. Thank you Ole!



Ole Karsholt (left) and Peter Huemer (right)

Original publication:

HUEMER, P. & O. KARSHOLT (2018): Revision of the genus *Megacraspedus* Zeller, 1839, a challenging taxonomic tightrope of species delimitation (Lepidoptera, Gelechiidae). — Zookeys, 800: 1-278. <https://doi.org/10.3897/zookeys.800.26292> (29 Nov 2018)



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# The illustrating of Microlepidoptera in color and the genitalia apparatus in black and white line drawings

*Sjaak (J.C.) Koster*

*Naturalis Biodiversity Center*

*Postbus 9517, 2300 RA Leiden, The Netherlands*

*sjaak.koster@naturalis.nl*



## Introduction

### Watercolors of Microlepidoptera

It was in the 70ties of the last century that I seriously started with the study of Microlepidoptera. The main problem in those days was the lack of proper literature, or better said, the lack of literature with good images of the species. As with many of the amateur-entomologists in those days, I started with the butterflies and moths, but later I also collected the larger Microlepidoptera like Crambidae and Tortricidae. I soon found out that for a proper determination you did not just need good images of the adults, but also good pictures of the genitalia. Most of the publications in those days used black and white photos for the adults and often also for the genitalia.

The first publication with color images that I started using was British Pyralid and Plume Moths (Beirne, 1954). This was later followed by the two volumes of the British Tortricoid Moths (Bradley et al., 1973, 1975) with pretty good color illustrations, but with only a few images of the genitalia. After that, more and more books with color images became available e.g. in the series Fauna Entomologica Scandinavica with volume 6 on Elachistidae (Traugott-Olsen & Schmidt Nielsen, 1977), volume 13 on Scythrididae (Bengtsson, 1984) and volume 23 on Nepticulidae and Opostegidae (Johansson, et al., 1990). In these volumes the magnification of the actual size of the moths is much larger as in the other mentioned publications. This greatly increased the value for the user. The watercolor images of the Nepticulidae and Opostegidae by Roland Johansson were especially magnificent. In the UK they did not lag behind, and in 1976 the first volume of The Moths and Butterflies of Great Britain and Ireland was released (Heath ed., 1976) containing Micropterigidae – Heliozelidae. To date eight volumes have been published in this series. The color images in these volumes are good, but rather small for the Microlepidoptera. Another very noteworthy series started with the publication of volume one of Microlepidoptera Palaearctica in 1965 on Crambidae (Blesziński, 1965) with beautiful and more enlarged color images by František Gregor.

My first entomological publication dates from 1990 in which I described the differences between the two species of *Ocnerostoma* (Lepidoptera, Yponomeutidae) (Koster, 1990) that occur in the Netherlands. The pictures of both adults were photos in black and white, but the genitalia were line drawings. These photos did not really bother me, because both species have gray-white wings without markings. My next publication was in 1991 and concerned the differences between the three species

of *Pancalia* (Lepidoptera, Cosmopterigidae) (Koster, 1991), also from the Netherlands. Not all the available material was suitable for taking pictures because specimens were rather worn or badly set. I decided to depict the adults in line drawings. A lot of work resulted in rather monotonous illustrations for such very nice colored species. This has to be changed, but how?

I explained my concerns to Ernst Traugott-Olsen, who made the fine watercolors for his book on Elachistidae. I had met him, and also Bengtsson and Johansson, for the first time during the VIIIth SEL Congress in Helsinki, Finland in 1992. He promised to teach me how to make these watercolors when we would meet again at the IXth SEL Congress in Lednice, Czech Republic. So he did. It was a good demonstration he performed, and it gave me an idea about what I needed for this job. Afterwards I also asked Bengt Bengtsson and Roland Johansson about their “secrets” of how to figure Microlepidoptera in watercolors. Also František Gregor joined this congress, and he was very open about his way of making watercolors and provided me with several very useful tips.

Back home I started to practice what I had seen and heard from these people. My first trial was *Mompha sturnipennela*, a rather dull colored species with some whitish markings on the forewing. It took me six watercolors from the same specimen before I reached a result that I thought was good enough for publishing. Instead of depicting the complete specimen as most of the above mentioned authors did, I followed the way of František Gregor who always depicts only the right wings of a specimen. It saves a lot of time, as you can imagine.

In 1996 I used watercolors for the first time in a joint publication with Sergey Sinev on the *Mompha divisella* group (Koster & Sinev, 1996). This effort was followed later by a series of other publications. It is a very time-consuming job to depict all the species in watercolors.

In the past it was not easy to get good images by photos, but nowadays with the digital cameras, this job is much easier to accomplish (Grinter, 2014). I have to admit that I will use a camera frequently in my forthcoming publications, especially now that I have gained access to the following equipment of our museum: An AxioCam digital camera attached to a motorized Zeiss SteREO Discovery V12 microscope, using the Module Extended Focus in the Carl Zeiss AxioVision software to prepare a picture in full focus from a Z-stack of about 10 to 25 individual photos. However, even then you need undamaged and well set specimens for a proper image. With badly set or worn specimens, I prefer to make a watercolor because I can also use at least the left wings of a specimen or the wings of more specimens of the same species to produce a proper image for one pair of wings. If more than one specimen is used to accomplish a proper image, this has to be clearly mentioned as a remark in the description of the species.

#### Line drawings of the genitalia

Depicting the genitalia by line drawings is a more common habit by many entomologists. I don't know when the first line drawings were made, but one of the earliest publications was the series of books on the genitalia of the Lepidoptera of the British Islands (Pierce, 1909, 1914; Pierce & Metcalfe, 1922, 1935). When I started dissecting specimens I have used several volumes of this series to



Sjaak (J.C.) Koster

determine the species I had collected. Nowadays it has become a common practice to also provide images of the genitalia for determination of Microlepidoptera in publications. It was and still is done by photographs, but very often line drawings are used. Compared to watercolors, line drawings seem much easier to make. Technically this is correct, but the time and skills for making a good drawing are often underestimated. I remember a rather hilarious presentation from Klaus Sattler in the XVth SEL Congress in Erkner, Germany where he showed a photo of a male genitalia he called the “trampled mouse”. The next image he presented was the drawing of this genitalia in which the artist gives his own impression, and this increased the confusion even more.

Currently, the DNA barcode is often given in the description of new species. Also beautiful photos of the adults are attached, but the photos or drawings of the genitalia are not always sufficient to separate species. Authors should take into account that not all material is eligible for DNA research and not everyone has access to a DNA laboratory.

For the entomologist who wants to make genitalia drawings, it is a requirement that he or she has a full knowledge of the complete structure of the genitalia. I have seen very nice drawings of genitalia that were not well cleaned and the unremoved scales were displayed very accurately or spermatophores in the corpus bursae were drawn. Such details must be ignored. On the other hand, especially in the male genitalia, many parts or structures are paired and will show little differences due to their enclosure in Euparal and the cover glass. Just draw what you see, and do not try to make a perfect symmetrical genitalia drawing by your own imagination. Believe me, this happens. Therefore, in my opinion, it is mandatory to mention the number of the genitalia slide of your drawing in the publication so people are able to later check the original slide.

## **Materials**

### Watercolor

For the substrate I use simple white paper/cardboard with a paper weight of 300 gm, size A5, length 210 mm, width 148 mm. Of course the use of watercolor paper is also possible, and for any detailed work, you need hot-pressed paper with a very fine texture.

For the watercolor I use the watercolor paints from Winsor & Newton or Talens (a Dutch brand of similar quality). It is sold in pans or tubes. For my watercolors I use 15 pans of the colors: Chinese white, yellow light, yellow ochre, Winsor red, permanent sap green, cerulean blue, Prussian blue, violet, light oxide red, burnt umber, sepia modern, Payne’s grey or neutral, indigo, raw sienna and burnt sienna. Some colors are used very often like Chinese white, sepia modern, neutral and yellow ochre, others are rarely used like cerulean blue, Prussian blue and light oxide red. I refill the empty pans with the same watercolor paint from tubes. Two jars filled with water are used for rough and fine cleaning of the used brushes. For mixing the right color I use two old saucers as palettes. The stereomicroscope, with low magnification at 16x, and a piece of paper to show the colors after mixing are also important (figs. 1-2).

I use brushes in different sizes, all made of sable hair. For mixing colors I use brushes no. 3 or 4. For the actual painting I use brushes of different sizes starting with no. 1, the largest, and painting most

of the details with no. 3/0 or 5/0. For extremely detailed work, like palps or antennae, I use size no. 10/0 (fig. 3).

A pencil, hardness grading HB, is used for drawing the sketch prior to the watercolor and also for drawing the fringes. A ruler is needed for measurements and for drawing the guide lines. Other necessary items include an eraser and a piece of fine sandpaper to sharpen the pencils (fig. 4). A box of watercolor pencils is used for coloring the fringes (fig. 5).

Line drawings

For the substrate I use a similar white paper/cardboard as for the water colors, 300 gm weight, size A4, length 297 mm, width 210 mm. A pencil, hardness grading HB, is used for drawing the genitalia and a black Rothring Rapidograph technical pen, 0.13 mm, to put the drawing in ink. Similarly, an eraser and a piece of fine sandpaper to sharpen the pencil are needed (fig. 4).



Fig. 1. The requirements for making a watercolor.



Fig. 3. Brushes of different sizes, the three at the top are rectangular cut off.

Fig. 2. The box with the pans of the used colors.



Fig. 4. Pencils hardness grading HB and 4H, Rothring Rapidograph technical pen 0.13 mm black, eraser, ruler, fine sandpaper.

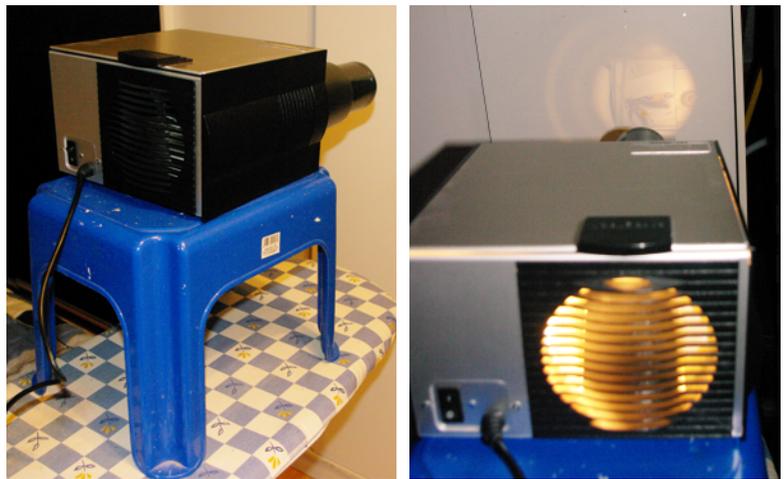


Fig. 5. Watercolor pencils.

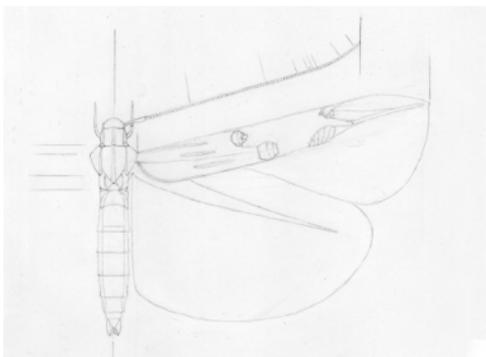
## Methods

### Watercolor

I do not have the skills to paint a moth by just looking at it. The outlines and wing details of the subject have to be drawn first. To achieve this I use an epidiascope to project a photo of the specimen directly on the paper used for the watercolor (fig. 6-7). Prior to this I have put two lines on the paper indicating the exact forewing length of the specimen, but with a 20x magnification. I use three sizes for the magnification of the watercolors. For small specimens I use 20x, and for larger specimens I use a magnification of 15x or even 10x, if necessary, for the largest specimens.



**Figs. 6 & 7. Epidiascope (left). Epidiascope projects the photo of the object to be painted (right).**



**Fig. 8. Drawing of the *Cosmopterix spec.***

particular case it concerned a *Cosmopterix spec. nov.* from Madagascar (fig. 8).

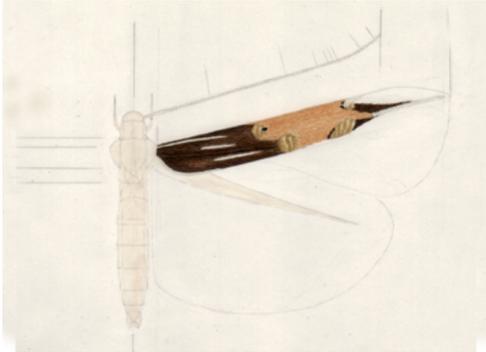
3. The pencil image is now erased so far that the lines are still just visible. After this, the erased part is covered with a layer of white watercolor paint without the section of the fringes of the fore and the hindwings. This underlay of white paint is applied to make it possible to correct minor errors (fig. 9).

4. I always start with the ground color of the forewing, in this case very dark brown. The color for this watercolor is made on the saucer using a mixture of sepia modern and some white. The paint is applied in small even spots with brush no. 0 or no. 3/0, often with a right-cut point. The latter brush is used if the forewing is roughly scaled and the individual scales are clearly visible. In the case of the *Cosmopterix* used here, it is not important because the

1. The proper size of the projected subject on the paper will be adjusted by sliding the epidiascope back and forth and fine tuning its lens. As soon as I get a sharp picture, I carefully trace the contours and details with the pencil.
2. Many parts of the specimen are measured carefully, including the length of the head, thorax, and abdomen and the width of the head, thorax, tegulae, and abdomen. These measurements are put on the paper as guide lines. The image is drawn using the guide lines and the stereomicroscope. When the specimen is worn and I have more material of the same species, I also will use these to get a proper picture. In this



**Fig. 9. Drawing covered with a layer of white watercolor paint.**



**Fig. 10. The forewing has been painted.**

forewing is smoothly scaled. The dark brown sections of the forewing have a reddish gloss; therefore, the brown sections are now provided with little red stripes between the dark brown spots. After this the dark brown sections are now completed by using the dark brown watercolor mixture. By making the edges of the wing and the section at the fold darker, it will give more depth and a more natural image. Then the orange section is painted, also with darkened edges. The four tubercular golden spots are next, the color gold can be obtained by mixing yellow ochre with some permanent sap green. Making the edges darker create a tubercular shape by using a 3/0 brush (fig. 10).

5. The next step is to paint the head and thorax tegulae, and appendages in a similar way as the forewing. The antenna with the white frontal line and white rings are important features for identification and therefore painted with a 5/0 or 10/0 brush. Other part are done with a 3/0 brush (fig. 11).



**Fig. 12. The hindwing and the abdomen have been painted.**

6. Hereafter, the hindwing and the abdomen are painted with a 3/0 brush (fig. 12).

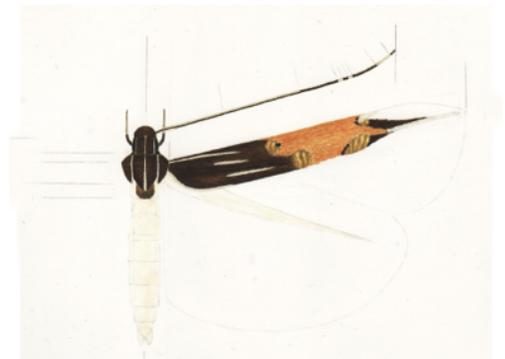
7. Now the fringes of fore and hindwing are drawn with the pencil (fig. 13).

8. The color of the fringe is applied with a watercolor pencil of the right color or a mixture of more than one pencil. The usually darker fringes around the tip of the wing are darkened by the very dark brown paint of the forewing using a 0/5 brush. All remaining

pencil lines are now erased and the image is ready (fig. 14).

### Line drawings

The drawing of genitalia initially does not differ much from a watercolor. The outlines of the genitalia apparatus have to be drawn first. These outline drawings of the genitalia are made with a compound microscope using the camera lucida method. For this purpose a strong light source (slide projector) is used for the illumination on the mirror of the microscope. A prism is placed on top of the microscope eyepiece to bend the projection 90° and project the subject on the drawing paper (An inspection mirror bend under an angle of 45° and attached



**Fig. 11. The head, thorax and tegulae and their appendages are now displayed.**



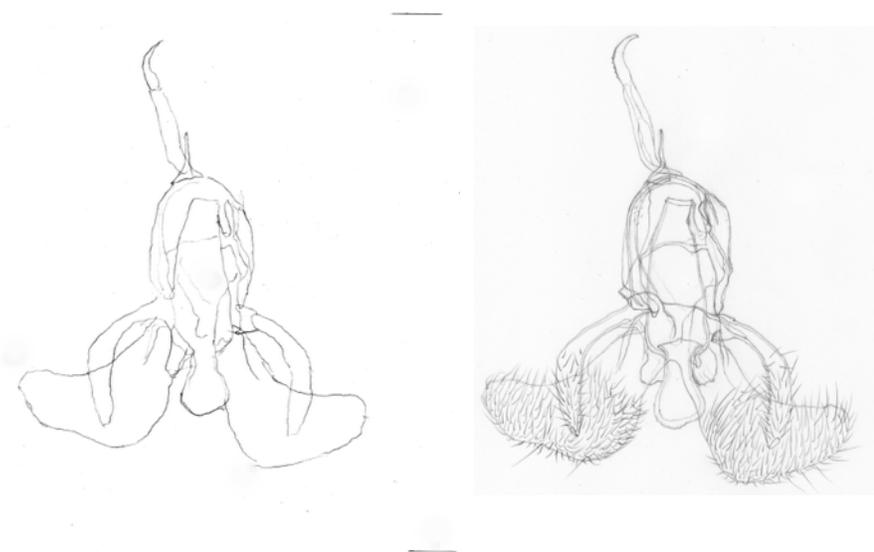
**Fig. 13. The fringes of fore- and hindwing are drawn by pencil.**



**Fig. 14. The fringes are colored and pencil aid lines erased.**

and down to get a clear view of all the structures. When the tracing has been completed, turn the projected object a little to the left or to the right away from the drawing. Select a structure, e.g., the tip of the uncus or a valva, and mark this on the paper. Slide the object exactly 1 mm up or down by the mechanical stage and mark the same part of the genitalia again. Now you have the correct magnification in mm, and here at the right side of the paper you will find these marks. This can be used later for the scale bar (fig. 16).

2. Now we have a roughly outlined image of the genitalia. This pencil image is now erased so far that the lines are still just visible. With help of the microscope the drawing is now redrawn and completed with the smaller details, hairs and setae (fig. 17).



**Figs. 16 & 17. The sketch of the genitalia apparatus with on the right the markings for the scale bar (left). The genital apparatus is now accurately drawn in pencil (right).**

to the tube of the microscope is also possible). All outlines are drawn by pencil and these will later be set in Indian ink.

1. A drawing paper in the format A4 is attached to a vertical object. The rough size of the drawing is adjusted by setting the correct magnification of the microscope. The desired size can be achieved by sliding the microscope back and forth until the desired size of the object to be drawn has been reached (fig. 15). After this all parts of the genitalia will be carefully traced by the pencil. Keep in mind that with small or very small objects, you have to vary the focus a little up

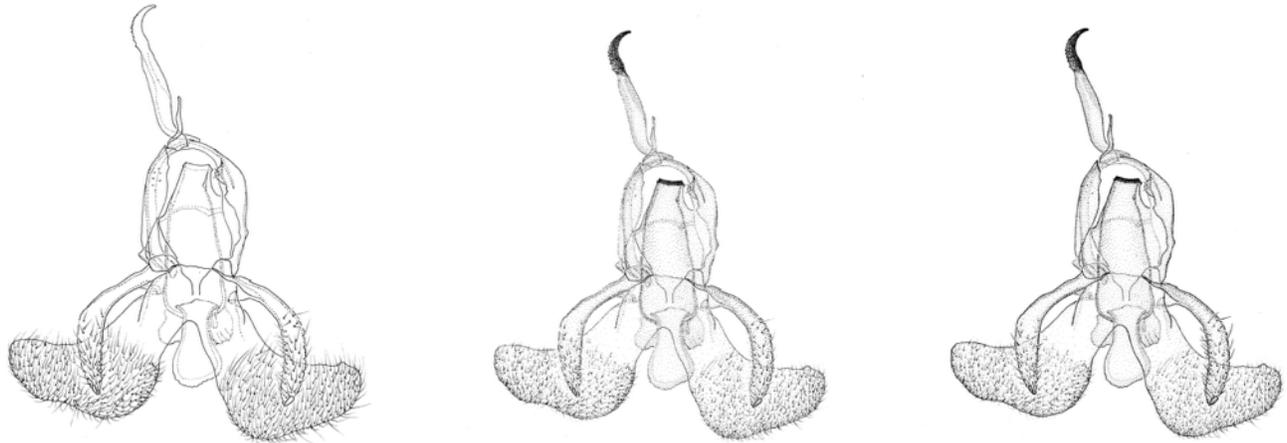


**Fig. 15. The microscope with the prism on top and the light source (slide projector).**

3. The next step is to draw all the lines in Indian ink. Be careful, as only the upper parts get solid lines, and all other lines are represented by dotted lines. The genitalia apparatus is a three dimensional object, and it is more or less flattened after it was embedded on the genitalia slide, but the individual parts are still recognizable. Displaying the lines of the underlying parts in dotted lines gives more clarity to the individual parts. It gives the image a more or less three-dimensional appearance (fig. 18).

4. All the image lines are now in Indian ink. However, compared to the original it looks unfinished for it lacks the sclerotization of the original apparatus. We will simulate this by applying dots. The stronger the sclerotization the higher the amount of dots. When the application of the dots has completed, the entire drawing is now erased to remove all residues of the pencil. The drawing will lose its sharpness and this makes the entire drawing somewhat vague (fig. 19).

5. To create more contrast, all the continuous lines are once again covered with Indian ink. This is a very delicate job and must be done with great care to avoid double lines (fig. 20).



**Figs. 18, 19 & 20. The pencil lines have been replaced by lines in Indian ink (left). The degree of sclerotization is represented by the density of the dots (middle). All the continuous lines have been drawn in Indian ink again (right).**

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# On phylogenetic and biogeographical patterns in Elachistinae

*Lauri Kaila*

*Luomus, Finnish Museum of Natural History,  
P.O.Box 17, FI-00014 University of Helsinki, Finland  
Lauri.Kaila@Helsinki.fi*

## On phylogeny and classification

I have for years strived to study the taxonomy of Elachistinae on a world-wide basis, and also attempted to create a phylogenetic framework for the subfamily down to species group-level. My first taxonomic papers were published in 1992 and on phylogeny in 1999. This work was more recently redone with a considerably larger taxon and character coverage (Kaila & Sugisima 2011). On the basis of these studies, the now-delineated subfamily Elachistinae was first divided into three (Kaila 1999a) and, subsequently, four (with *Urodeta* Stainton added in the latter study) well-defined groups that were considered to be the only valid genera. Thus, four genera are included now: *Urodeta*, *Perittia*, *Stephensia* and *Elachista* – out of over 50 generic names available. A simplified cladogram of their interrelationships is presented in Fig. 1.

There are also a few stray genera that have been impossible to include in these studies, and whose placement in Elachistinae is not yet verified. Some of these classificatory decisions may need explanation, especially the wide concepts of *Elachista* and *Perittia*. Here I attempt to briefly explain my rationale that ended in this result.

The decision for the inclusive concept of *Elachista* was to maintain stability where it was possible, in particular to enable the retaining of the species-rich ‘whites’ (= subgenus *Aphelosetia*) with 200 known species in this genus, among them some of the best-known species such as *Elachista argentella* (Clerck). Because of uncertainties in the phylogeny among *Aphelosetia* and two small genera, *Dibrachia* and *Hemiproposa*, as regards to the newly developed subgenera *Atachia* and *Elachista*, these were also included in *Elachista* for stability’s sake; two Nearctic species also seem intermediate between *Aphelosetia* and *Dibrachia*. In Fig. 1 these subfamilies are presented as a trichotomy to highlight their unclear interrelationships. At the same time some other well-known genera were sunk as synonyms of *Elachista*, most notably *Cosmiotes*. At present Elachistinae includes a total of 785 valid species (L. Kaila, in prep.).

Earlier, the generic classification could be said to have consisted roughly of two elements: an European tradition with a few genera thought more or less distinct based on species of this somewhat



Lauri Kaila

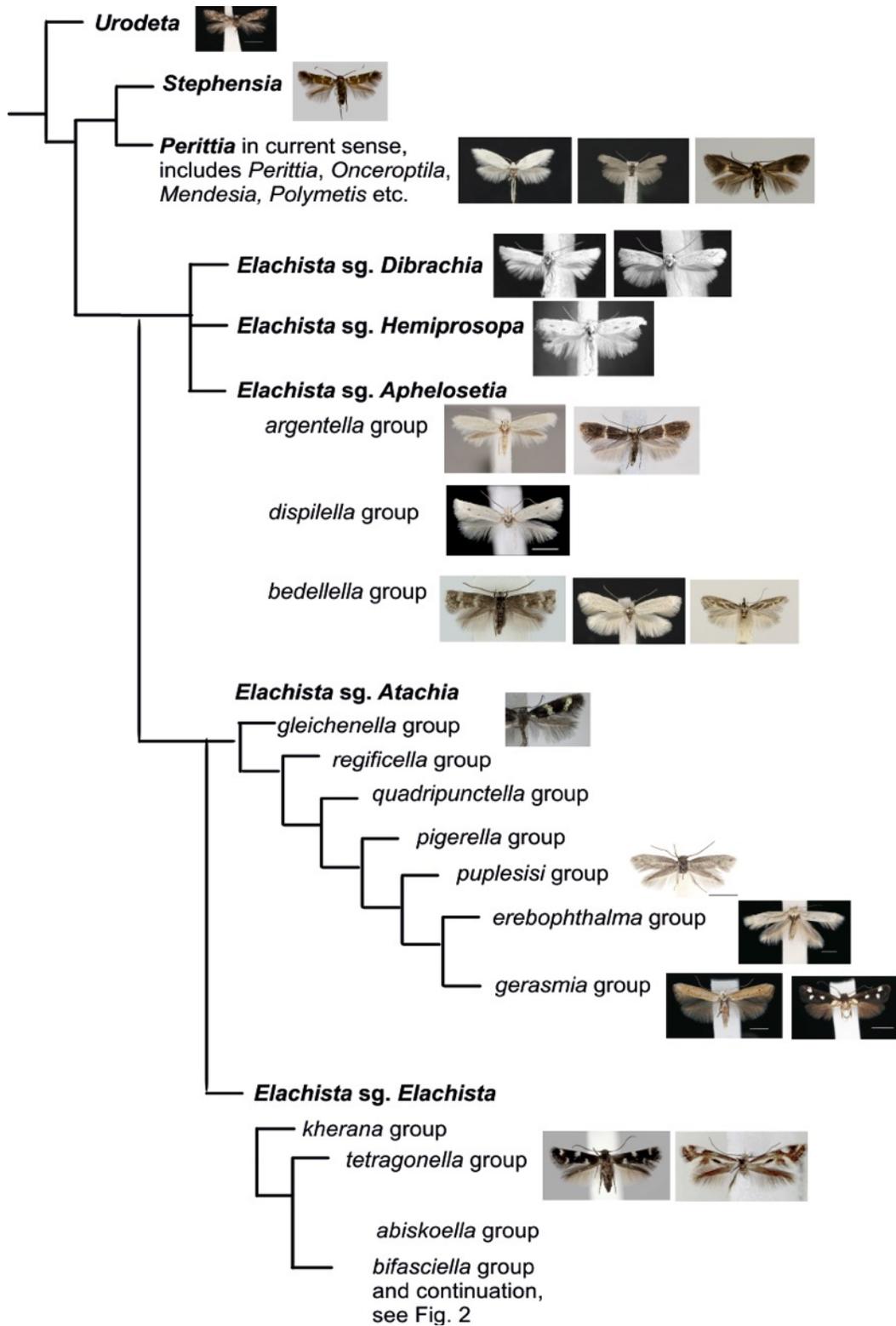


Fig. 1. A simplified phylogeny of the main groupings of Elachistinae, following Kaila & Sugisima (2011). In that work, however, the subgenera *Apheloseitia*, *Dibrachia* and *Hemiprosopa* were resolved. The basis for that was so weak that in the present figure their relationships are presented as a trichotomy.

better known region, and a miscellanea of “exotic” names with rather little attraction to anyone, or attempts to connect them to the established system. The basis of the European system, still (or again) surprisingly well up-to-date, was laid in the works of Henry T. Stainton and Heinrich Frey during the 1900s. Many of the now synonymized genera come, not surprisingly, from the non-European taxa. However, to understand the phylogeny of the subfamily in its entirety these taxa are of course vital. Let us take some examples.

The genus *Cosmiotes* was established by the American microlepidopterist Brackenbridge Clemens (1860). Annette Braun (1948) delineated this genus in her revision of North American Elachistidae based on their genitalia. Since then, the genus has been considered well-defined and distinct from other elachistines. But to have any convergence with reality, the phylogenetic hypothesis of mine (1999) predicted that there should be or have been a series of unknown intermediates between

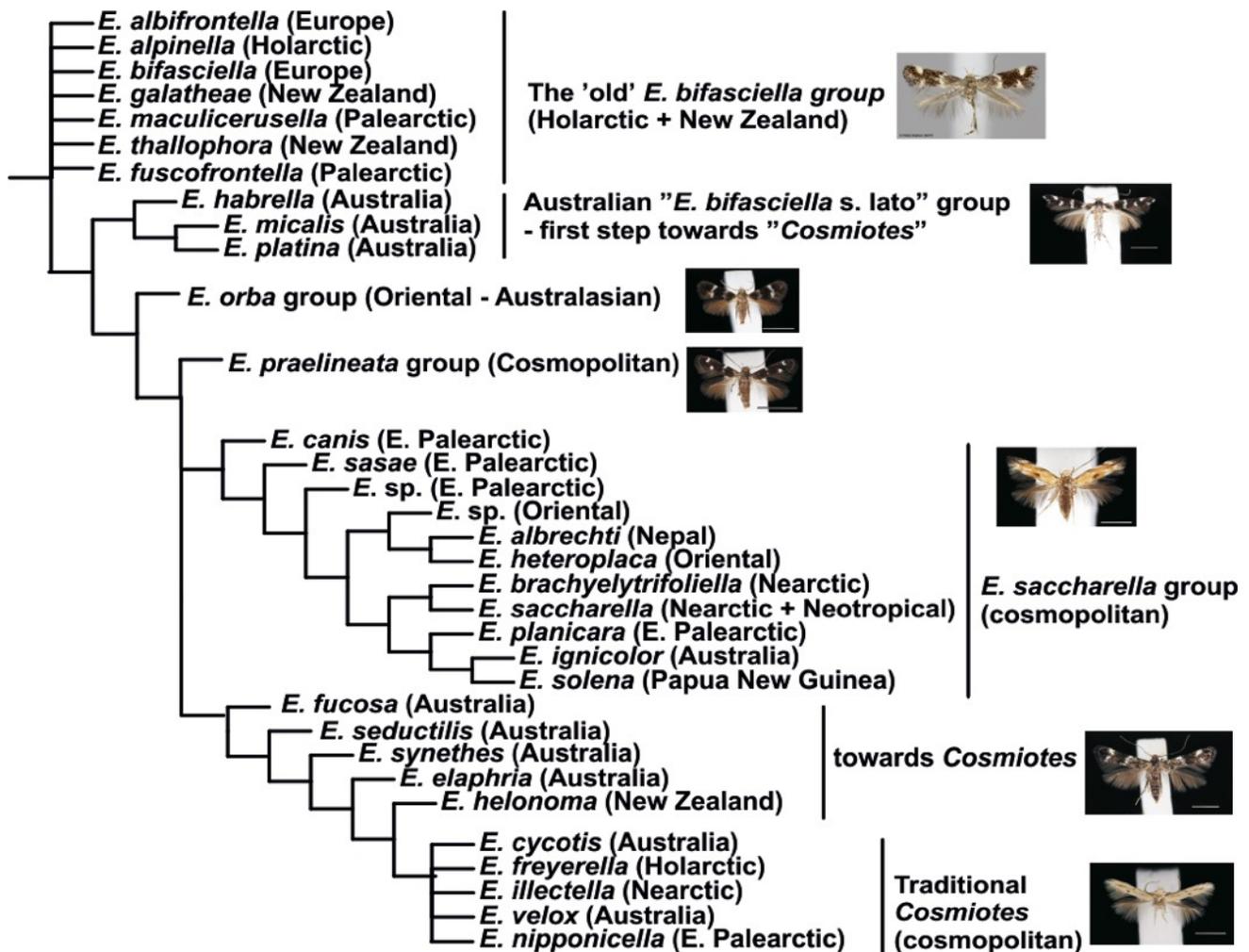


Fig. 2. Phylogeny of the apical part of the subgenus *Elachista*. The part shown was historically divided into several genera, as well as species and groupings with unknown affinities. Quite a few of species included in this picture are very recent discoveries.

typical *Cosmiotes* and the nominate group of *Elachista*, the *E. bifasciella* group. To my elation such a set of taxa in entirety was found to live and thrive in Australia after the fauna of this continent was surveyed (Kaila 2011), and their intermediate relationship was demonstrated by the revised phylogeny by Kaila and Sugisima (2011) (Fig. 2). Neither *Cosmiotes* nor the *Elachista bifasciella* group could be delineated unambiguously any longer. Merging these genera appeared even more plausible than on the basis of the earlier hypothesis.

Traugott-Olsen and Nielsen (1977) established the genus *Biselachista* for a group of species with certain characteristics in genitalia and 'typical wing pattern' in their break-through book on North-European Elachistidae. On the basis of the phylogenetic analyses, this genus also falls within *Elachista* is merged with the *E. biatomella* group without any differential traits. As a side remark, the oldest generic name for this group would be *Platyphyllis* Meyrick (1932) if splitting of *Elachista* to such level was re-considered.

Another example. There is a conglomerate of species that have been assigned to the genera *Perittia*, *Mendesia* and *Polymetis* in Europe, *Onceroptila* in North America, *Swezeyula* in Hawaii, and *Zemiocrita* in South America, and other genera for newly discovered species such as *Perittoides ochrella* Sinev, and so on. During the 1990's a plethora of other genera were erected to denote single or at most a handful of species. When a global perspective was taken with the inclusion of tens of previously unknown species, it appeared that practically none of the differentiating characters of these genera hold, and with current data available the recognition of only one genus seems the most reasonable choice, which likely also best maintains nomenclatural stability.

In the phylogenetic studies a seemingly heterogeneous miscellanea of species and species groups that are odd-looking, each in their own way, but surprisingly appear to form a monophyletic entity. It consists of the former New World genus *Dicranoctetes*, Papuan *Eupneusta*, Oriental *Ptilodoxa* as well some morphologically very peculiar species and species complexes that are not easy to connect with Elachistinae unless examined character by character. They may have upturned wing tips, longitudinal stripes on forewings, a flattened head, and very complicated genitalia. Of these the *albrechti* and *heteroplaca* groups consist of only a few described species, but many more are known in collections. All species with known life history feed on bamboos. Knowing the vast diversity of bamboos, these groups may eventually prove to be very species rich if focused collecting, especially rearing of larvae, was undertaken in the Oriental region. Although, that may be challenging as potential occurrence areas may be difficult to reach. Species belonging to this/these group(s) are known from Nepal in the west to the Solomon Islands in the east. This group is denoted as the *E. saccharella* group (Fig. 2). While species of *Elachista* are nearly universally grass or sedge feeders, there are two intriguing exceptions: members of the Oriental-Australian *E. orba* complex feed on monocot plants belonging to Commelinales and Zingiberales, and one Australian species feeds on a plant belonging to Iridaceae.

## On Biogeography

Elachistine moths have a reputation of being rather poor in their dispersal ability. On a small scale, in the Finnish archipelago their diversity tends to be smaller than one could expect when compared with other small moths, e.g., coleophorids or nepticulids. In contrast to this belief, it seems surprising that the *Elachista freyerella* group ("traditional *Cosmiotes*" in Fig. 2) is cosmopolitan, and even the

remote islands surrounding New Zealand host species of this group. Moreover, these species are morphologically very similar to each other, and their barcodes do not show large interspecific differences either. These traits combined might suggest that this group is rather young – also supported by their placement in the phylogenetic tree (Fig. 2). The greatest species diversity of the *freyerella* group occurs in Australia (Kaila 2011).

Within the subgenus *Apheloseitia* both the large *E. bedellella* and *dispilella* groups are exclusively Old World, largely Palearctic with single species occurring in South Africa. On the other hand, the presumably more “primitive” *E. argentella* group from which the two other groups likely evolved, is Holarctic, with a large diversity in North America. The whole subgenus as well as the Holarctic subgenera *Hemiprosopa* and *Dibrachia* are absent in Oriental Palearctis, Australasia and South America.

The somewhat heterogeneous subgenus *Atachia* contains several small groups, such as the Holarctic *gleichnella* group and Palearctic *regificella* group. The Australian *Elachista* fauna is dominated by the subordinate *gerasmia* group with over 100 species currently known, and surely much more to be discovered. A few species are also known to occur in New Zealand and New Caledonia.

The subgenus *Elachista* is cosmopolitan. It is now divided into several informal species groups. Several of them would have one or more generic names available, but others not. Division of this subgenus into smaller formally recognized (sub)genera would lead to a proliferation of names, with no end given the likely continuing discovery of new taxa that do not fit into any of the now known groups. This would hardly serve any purpose. I will not list in detail all these, but briefly elaborate a few. The *E. tetragonella* group, including the so-called genus *Biselachista*, with 60 species, is predominantly Holarctic with a few species in the Oriental region and one species likely belonging to this group in northern Australia. The informal *E. bifasciella* group with about 150 known species is almost solely Holarctic with an intriguing exception: some species live in New Zealand. These species are externally close to each other but dissimilar to others, which suggest that they are descendants of one colonization event.

The heterogeneous genus *Perittia* is also cosmopolitan, but seems to be most species-rich in South America; morphological diversity is perhaps richest in South Africa. With current knowledge little can be suggested about the biogeographical pattern of its subgroups. However, many South American species seem close to each other, and seem to form at least two endemic radiations. The former *Perittia* in strict sense is Holarctic. Species that can be considered very roughly to belong to the former *Mendesia* – *Polymetis* (etc.) genus group have been recorded from Australia, South Africa, western Palearctic and Nearctic region. In addition, there are species, for instance in southern and eastern Palearctic region, each of which seems neither close to each other nor to the larger entities.

The genus *Urodeta* was long known by one species only, *U. hibernella* (= *cisticolella*) whose affinities within Gelechioidea remained unknown or of conjectural nature. After studies on morphology it appeared most likely to belong to Elachistinae; molecular studies also support this placement (Kaila et al. 2011, Heikkilä et al. 2014). Later it has appeared that this genus is likely quite large with many species overlooked due to their modest appearance – even in elachistine standards. Most of the recent *Urodeta* discoveries are from tropical Africa (De Prins & Sruoga 2012).

## Historical Biogeography

Many groups of organisms have been suggested or shown to exhibit a Gondwanan distribution pattern, meaning that members of these groups are distributed in or their current descendants originated from Southernmost Africa, Southernmost America and Tasmania, the underlying hypothesis being that they originate from ancient Antarctic or areas connected with it. The biogeographic pattern seen today would be a relict from this ancient distribution. One of the most famous examples of this kind of distribution is the plant genus *Nothofagus*. A similar pattern has also been observed in some insect groups. But, is there any indication of such in Elachistinae? If there were, that would necessitate the subfamily to be at least 140 million years old as Africa and South America were separated then. Around the same time also Madagascar+India were separated from the continent formed of the current Antarctic and Australia. Australia, Antarctic, New Zealand and southern South America were separated around 95-30 million years ago. In Elachistinae, there is no convincing case to suggest a history that would conform with these tectonic events. If any, the genus *Perittia* might show something like that with the largest diversity in Cape region in southernmost Africa and southern South America. Being a cosmopolitan genus with unclear phylogenetic structure this pattern lacks convincing support.

Laurasian distribution means that taxa have originated in an area nowadays situated in northern hemisphere. There is indeed an observable pattern that many elachistinae groups have highest numbers of species in the Holarctic region, or occur solely there. This does not, however, necessarily mean that they would have originated there. Their absence from southern continents such as South America and Australia, as is the case of *Aphelosetia*, *Dibrachia* and *Hemiprosopa*, appears to suggest a northern origin for these. But as a summary, dispersal and extinctions during extensive periods over time might after all be the simplest explanation for much of the biogeography as now observed.

## Climate and species group patterns

One factor seems to affect the diversity of various groups. The *E. bifasciella* group with a current total of 150 species is nearly entirely boreomontane (Kaila 1999b, Kaila 2015). In contrast, the *bedellella* and *dispilella* groups of sg. *Aphelosetia* with a total of 100 species are most species-rich in semi-arid regions with Mediterranean climate. The Australian *gerasmia* group is entirely confined to coastal and montane areas around the continent (Fig. 3).

## Acknowledgements

I wish to thank Pekka Malinen for permission to use several habitus images, and Richard Brown and Maria Heikkilä for linguistic revision.

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**Fig. 3. Map of records of Australian Elachistinae (after Kaila 2011). Almost all species known prefer moist areas along coasts and montane areas. This may to some extent, but not entirely, follow the general occurrence area of their main host plant genera. Only one known species, *E. fucosa* Meyrick, is a dry habitat species that seems distributed through the arid inland of the continent.**



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# Digitizing data and images of Gelechioidea by Lepidoptera Network (LepNet)

*Richard Brown and Sangmi Lee*

Databasing of specimen data in biological collections in North America has received considerable attention during recent years. The National Science Foundation (NSF) initiated the "Advancing Digitization of Biodiversity Collections" (ADBC) Program in 2010 to expand the resource of digital data and to improve data accessibility to researchers. As part of this program, the Integrated Digitized Biocollections (iDigBio) was established as a coordinating center to implement a cloud-based infrastructure and web portal.

The Lepidoptera of North America Network (LepNet) received funding from NSF in 2016 as a Thematic Collections Network (TCN) to mobilize occurrence data and images of moths and butterflies in 26 core collections and six partner collections. The four-year project has a goal of digitizing 1.7 million specimen records and integrating these with more than 1 million existing records. A second goal is to produce 81,000 high resolution images as species exemplars and >160,00 images with lower resolution.

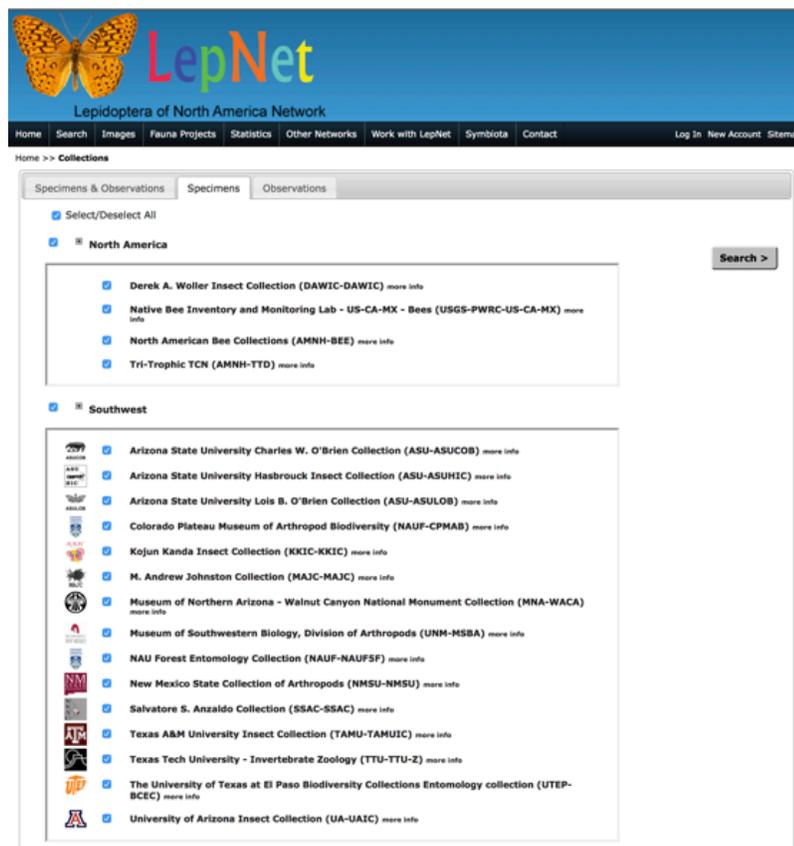
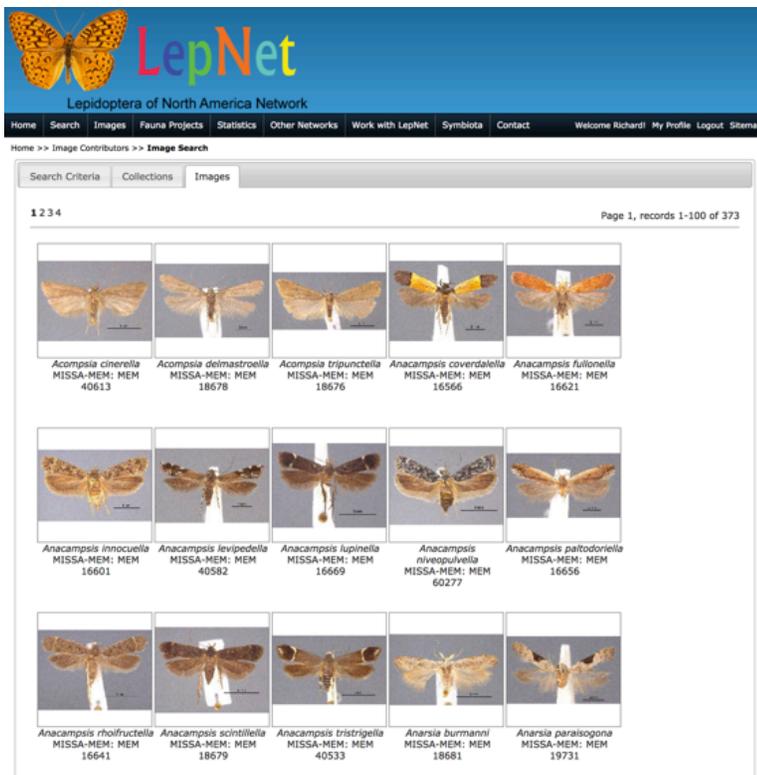


Fig. 1. Search page for specimens in collections.

Because the funding level was not sufficient to digitize all Lepidoptera in the 26 core collections, each collection prioritized taxa for digitizing.

LepNet and other TCN's are using an integrated Symbiota software portal, <http://symbiota4.acis.ufl.edu/scan/lepnet/portal/index.php>. Symbiota provides tools that allow direct input of specimen data and images from institutions as well as to aggregate data from other software platforms, e.g., Arctos, Specify, etc. Symbiota serves as the data back-bone that allows users to generate maps and species lists for selected localities. All images and data are available on data portals of the LepNet, iDigBio, and Global Biodiversity Information Facility (GBIF).

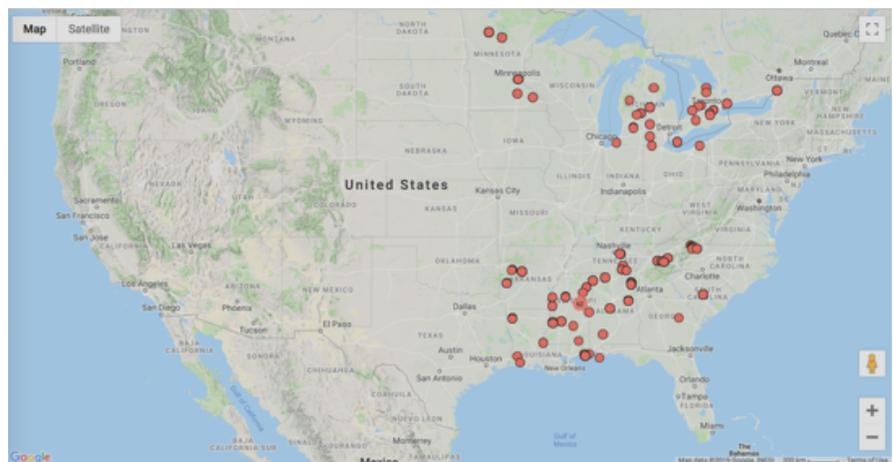
To conduct a search of collections in Symbiota, an option is provided for



**Fig. 2. Gallery of Gelechiidae obtained with search of images.**

with deselection of collections in Hawaii and other locations. Occurrence csv files were downloaded by selecting the icon in upper right corner of the dataset at the top of the page. The downloaded file was formatted to delete non-essential data fields and remaining data were sorted to eliminate unidentified species, entries from outside America north of Mexico, and entries without locality data.

As of December 10, 2018, Symbiota includes 41,425 occurrence records and 690 images of identified adult specimens of Gelechioidea from America north of Mexico. Gelechiidae and Depressariidae included 24,927 and 6,015 of these records, respectively. Additional records will be added by participating collections during the next two years.



**Fig. 3. Distribution map of *Dichomeris ligulella*. Selection of each distribution point will yield occurrence data.**

specimens, observations, or both. All collections are selected by default, but an option is provided for deselecting any or all of the collections or geographical regions (Fig. 1). Deselecting all collections can be followed by selection of a single or few collections of interest. A search of selected collections provides a new page for entering the family or scientific name as well as other criteria, including locality, collector and specimen. The specimen criteria provide an option to limit the search to only specimens with images (thumbnails also can be obtained by selecting images in the top menu, Fig. 2). Distribution is provided for species as Google maps (Fig. 3) or Google Earth maps.

A search was conducted for specimen data and images (excluding observations) for each of the 16 families of Gelechioidea that occur in continental United States and Canada

## 2019 Lepidoptera Course Announcement



The 2019 Lep course will be held August 1-10 at the Southwestern Research Station (SWRS) in the Chirichahua Mountains of Southeastern Arizona (a 2 1/2 hour drive from Tucson), USA. With its extensive series of Sky-Island mountain ranges, SE Arizona is a hot spot for the highest Lepidoptera diversity in North America. With low desert scrub oak and mixed oak-pine woodland, lush riparian, juniper, Douglas fir, and mountain meadow habitats all within a 40 minute drive from the station, the SWRS is an ideal location from which to sample this diversity of both habitats and species.

The emphasis of the Lep Course is to train graduate students, post-docs, faculty, and serious citizen-scientists in the classification and identification of adult Lepidoptera and their larvae. The course includes lectures, field trips and labs. Topics to be covered include an extensive introduction into adult and larval morphology with a focus on taxonomically important traits, extensive field work on both adults and larvae, collecting and curatorial techniques, genitalia dissections, larval classification, and general issues in Lepidoptera systematics, ecology, and evolution.

Instructors will include Chris Grinter, Sangmi Lee, Richard Brown, Ray Nagle, Jennifer Bundy, Bruce Walsh, Ron Rutowski, John Brown, and James Fordyce.

Updates and further information is available online at <http://www.lepcourse.com/>

Applications to the Lep Course can be made in the future at the following site: <https://www.amnh.org/our-research/southwestern-research-station/education/lepidoptera-course>

# Farewell Letter from Mari to Gelechioid Aficionados

Sometimes life doesn't go as planned. When I decided to become a biologist in the nineties, I believed that I would continue doing that until I retire. Clearly, I was a bit naive, but I had strong passion towards biology and research, and I was confident that no matter what challenges I would face, I could always solve them.

Over two decades later, I finally realized that my career as a professional lepidopterist has reached its end. I have felt overly tired and frustrated for some time now, and working on my beloved leps has mainly made me feel sad. It was undoubtedly the most difficult decision of my life to admit to myself that I need a new direction.

I called myself as a method geek after obtaining my PhD due to various methods I used in my studies. I decided to return to the same path, but this time BIN, ABGD, TCS and GMYC have been replaced by Python, AI, SQL and AWS. My aim is to become a data scientist. I learn new things every day and enjoy it tremendously.

I will continue as an amateur lepidopterist and will always be a gelechioid aficionado, but because I probably won't see many of you again, I would like to thank you all. Thank you so much for all the great memories and experiences I have gained during these years. I have been privileged to meet so many great people, learn so many interesting things and have so many exciting discussions.

I guess I have always been a bit bold and I would like to use that shameless boldness to make one last wish for the whole global gelechioid and lepidopterist community. The sad fact is that many gelechioids, lepidopterans and insects in general are under a great threat, and at the same time, the number of people working on them is decreasing. This combination makes every (gelechioid) aficionado a valuable jewel, and it makes no difference whether they are women or men, professionals or amateurs, novice or established, collectors or observers, employing morphological characters, barcodes, genomes or all of them. I wish everyone would remember this because gelechioids and other lepidopterans desperately need all the friends they can get!

Sincerely yours,

*Mari Kekkonen* (the Finn with just one 'a')



***I.N.G.A. newsletter  
looks for new enthusiastic  
editors!***

*Please contact any of the team members for  
further information.*

# Recent Publications on Gelechioidea

Compiled by Maria Heikkilä

Articles dealing with pest or biocontrol issues are not included.

## 2017 additions

Please, see I.N.G.A. issue n. 7 for other articles published in 2017: [http://mississippientomologicalmuseum.org.msstate.edu/Researchtaxapages/Lepidoptera/Gelechioidea/INGA/INGA\\_issues/INGA\\_7\\_2018.pdf](http://mississippientomologicalmuseum.org.msstate.edu/Researchtaxapages/Lepidoptera/Gelechioidea/INGA/INGA_issues/INGA_7_2018.pdf)

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### Editorial team of this issue

Dr. Richard Brown (articles, news etc.)  
RBrown @ entomology.msstate.edu

Dr. Maria Heikkilä (publication list etc.)  
a.a.maria.heikkila @ gmail.com

Dr. Mari Kekkonen (layout)  
m.e.kekkonen @ gmail.com

Dr. Sangmi Lee (articles, news etc.)  
microlepi @ hotmail.com

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ISSN: 2328-370X (online)