SPIDER ILLUSTRATION

By

Elizabeth Wells

An Honors Project submitted to the University of Indianapolis Honors College in partial fulfillment of the requirements for a Baccalaureate degree "with distinction." Written under the direction of Dr. Marc Milne.

August 31, 2017.

Approved by:

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Marc Milne, Faculty Advisor

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Dr. James B. Williams, Interim Executive Director, Strain Honors College

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First Reader

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Second Reader

Abstract

The erigonine subfamily (family linyphiidae) currently consists of about 2,000 tiny (< 2mm) spiders. Little is known about their taxonomy and classification due to their small size and that female erigonines lack a taxonomic key to aid in species identification (Hormiga 2000). Therefore, in order to identify erigonine females, their epigyna (female reproductive structures) must be examined at 30-120x magnification using a dissecting microscope and compared against existing illustrations or photographs of known species (Sandlin 2011). Illustrations serve as efficient visual aids for identification because they are simplified and emphasize key parts of the animals. However, many erigonine illustrations are old (pre-1940's), poor in quality, and may be inaccurate (Blake 1892). To improve the ability of researchers to identify erigonines, females from eight species that currently possess insufficient material for proper identification were selected for illustration. Spider epigyna were then illustrated free-hand using pencil, pen, and a sketch pad while observing specimens under a dissecting microscope. Drawings were then edited in Photoshop to fix small errors and enhance the background. Upon completion, these illustrations were put on display on the LinEpig (short for "Linyphiidae epigyna") website hosted by the Field Museum of Chicago, where they currently accompany erigonine epigyna photographs taken by Nina Sandlin (Sandlin 2011).

Special thanks to …:

Dr. Marc Milne

Nina Sandlin and the Field Museum of Chicago

California Academy of Sciences

Museum of Comparative Zoology

Dr. Kevin Gribbins

Prof. James Viewegh

My Mother

Table of Contents

Statement of Purpose

The purpose of this project was to create clearer visual aids than were currently available for scientists and naturalists wishing to identify female dwarf spiders from the sub-family Erigoninae. My goal was to illustrate the reproductive structures of 5-10 female erigonine spiders, emphasizing the key characteristics that distinguish each spider. The species that I used for these illustrations were selected from collections from the Field Museum of Natural History, the California Academy of Sciences, the Museum of Comparative Zoology, and my advisor. These illustrations were first drawn in pencils and pens and then finished digitally in Photoshop. The illustrations are displayed on the website of the Field Museum of Natural History alongside photographs taken by Nina Sandlin.

Introduction

The Erigoninae is a subfamily of the Linyphiidae and consists of incredibly small sheet-web weaving spiders. These spiders range from 1-6mm, although most are approximately 2mm (Hormiga, 2000). They are so small that they are able to travel through the air by a process called ballooning, which involves releasing loops of silk that catch wind and lift the spider for aerial distribution (one may think of the spiders in Charolette's web for example). These spiders place their webs on the ground, usually under and on leaves, where they weave convex, sheet-shaped webs to catch their prey. Prey items are small and mostly consist of herbivorous insects, such as aphids and springtails.

Linyphiidae is the second most diverse spider family in the world and is the most diverse group in North America. There are about 4,533 species of linyphiid spiders, and Erigoninae is its largest subfamily within this taxa (World Spider Catalog, 2016). This subfamily consists of at least 2,000 species, 650 of which are in North America (Hormiga, 2000). However, while Linyphiidae itself has now been divided into 601 genera, classification within Erigoninae is highly debatable and in much need of revision (World Spider Catalog, 2016). As a result, many of these spiders' binominal nomenclatures change as revisions are made to their phylogenetic relationships.

Studies in spider taxonomy require collecting and then preserving spiders. Collection of this group of spiders is accomplished through both active and passive methods. The active methods include the use of hand tools, such as sweep nets, beat sheets, sifters, and aspirators. The passive methods include the use of traps, such as pitfall traps or Berlese funnels. Once the spiders have been caught, they are immediately stored in ethanol alcohol to kill and preserve the specimens (Cushing, 2005).

Spiders that are being evaluated for species identification are taken out of the storing alcohol and examined microscopically. For this type of analysis, there are also multiple preparatory techniques. A common technique is to place the spider in a dish of sand to stabilize the specimen and then submerge it in alcohol to keep it preserved, after which it is then placed under a dissecting microscope. This allows one to more easily observe the outer structure of the spider, as well as examine some internal structures that are visible through more transparent tissues of the specimen. To more closely examine the internal structure of the reproductive parts of female specimens, the spider's

epigynum may be placed in clove oil or a 10% KOH solution to digest the outer soft tissue exposing internal anatomical structures. For detailed analysis of external features, the use of a scanning electron microscope (SEM) may also be used (Hormiga, 2000). One of the advantages of the SEM is that it allows one to see more surface detail of the specimen. However, the processes necessary to prepare and view a specimen under the SEM may alter the specimen's shape. Further details, such as color of the specimen, cannot be visualized in this technique, which may be useful to identification of the spider.

Spider identification guides have clear descriptions of taxa, and species descriptions are often accompanied by illustrations of their reproductive structures as further aid for identification (e.g. Bishop, 1930). The reproductive organs are generally illustrated because these structures are highly specialized for each species of spider to prevent crossbreeding between species (Foelix, 1996). Thus, these structures allow for successful speciation and therefore accurately morphologically delineate species boundaries. The male reproductive organs are present on the spider's pedipalps (a structure present in both males and females but altered in males to store sperm), while the female's reproductive - structure is called the epigynum, where eggs are developed internally after mating (Foelix, 1996). Many identification guides have very simple illustrations without sufficient details, such as clear distinction of external form or internal organs (Figure 1). The simplicity of these drawings may lead the researcher to misidentify the species. This is especially seen in many older illustrations, such as *The Spider Fauna of the Upper Cayuga Lake Basin* (Blake, 1892). Other illustrative guides, such as *Studies in American Spiders: Genera Ceratinopsos, Ceratinopsidis and Tutaibo* (Bishop, 1930) show a combination of outline, stippling (making patterns through dots), and shading to give the reader a better understanding of the identification structures for that species (Figure 2). The most recent illustrative guides show a combination of pen and pencil techniques to outline and shade illustrations to create a realistic depiction of the structures in question

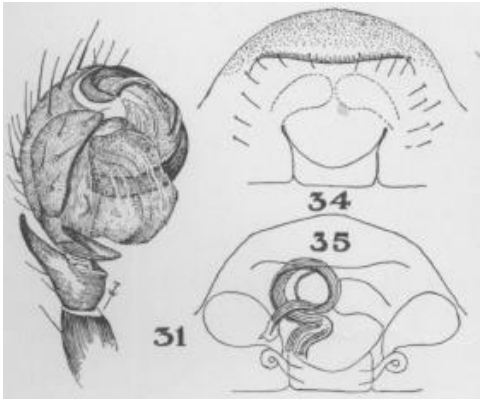

Figure 2. Bishop's (1930) illustration of Corniculara formosa

(e.g. Paquin and Duperre, 2003). Because of their accuracy and ability to point out minute details, these latest iterations of illustrations are the best method by which proper species identifications may be made.

Spider identification guides may also be accompanied by photographs. Like illustrations, photographs are useful for distinguishing between species. The process for photographing a spider is slightly similar to that of illustrating it. A spider is first placed in sand and alcohol and posed effectively. The spider is then cleaned from all debris before photographing and is afterwards edited in Photoshop. The final product allows one to see the form of the spider as well as color differentiation (Sandlin 2011). In the case of tiny spiders such as erigonines however, the photographs are blurry due to the need for such high magnification. The image quality may be so poor in some cases that it is almost impossible to distinguish species. Illustrations are then preferred to photographs because, if drawn well, they offer a clearer image and highlight the critical structures needed for identification. Multiple older illustrations of spiders exist that are still used today despite the availability of photographs, due to clarity and highlight of structures (Figure 3). In fact, this preference for illustrations extends to peer-reviewed scientific journals. For example, Zootaxa, a large, peer-reviewed, international journal for zoology publications (including those of

Figure 3. Crosby and Bishop's (1925) illustration of Ceratinella brunnea

arachnology) instructs authors that line drawings are preferred to photographs (Zootaxa, 2014).

Despite the limitations of photography, for many species of female erigonine spiders this is the only visual reference available. These images have recently been created by Nina Sandlin, a taxonomist at the Field Museum of Chicago. She has photographed more than 290 female erigonine species to date. She updates her images onto a one of a kind online database called LinEpig, (found on the website of the Field Museum of Chicago). Compared to other photographs of tiny spiders found in journals, the images on this database are of good quality. The images show distinctions in form, inner organs, and color. This allows them to be used by arachnologists around the world to identify females of these small, hard-to-identify spiders (Sandlin n.d). However, illustrations would greatly supplement this database due to the ability of illustrations to pull out minute details that photographs may miss.

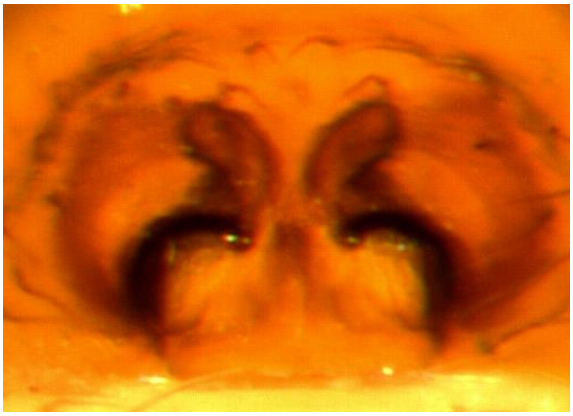

Figure 4. Sandlin's (2011) photograph of Ceraticelus atriceps

Method/Procedure

This project was overseen by my advisor, Dr. Marc Milne. In addition, I received some guidance from Prof. James Viewegh on my illustrations and from Dr. Kevin Gribbins about making a final product in Photoshop. Throughout the project, I

documented my progress via photograph starting with beginning sketches and finishing with the completed product.

I started the first stage of the project by figuring out which species' keys would most benefit from updated illustrations. This was done by Dr. Milne and Nina Sandlin (an erigonine expert at the Field Museum of Chicago) by examining the existing literature and illustrations of female erigonines. Once a list of needed species was obtained, I chose eight species to illustrate. I received these spiders through my professor's collection, and through loans from the California Academy of Science and the Museum of Comparative Zoology at Harvard. Upon receiving the loans, I took one spider at a time to pose and illustrate. To do this, I placed the spiders in shallow dishes with fine sand added to stabilize them and ethyl alcohol to keep them preserved. I then placed them under a dissecting microscope so that I could arrange and examine the specimens. I drew the epigynum of each spider in a sketchbook with pencil and pen. This part of the project took up the majority of my time and I often had to redraw and revise my illustrations until they were accurate representations. Dr. Milne helped me to assure this accuracy by assessing my illustrations and allowing me to use his microscope to examine the spiders under higher magnification than I possessed. To further assist my accuracy, he photographed the spiders at 120x magnification and I was then able to use both photographs and the actual specimen to create the illustrations.

Once the illustrations were completed by hand, I finished them digitally in Photoshop. For this part of the project, I transferred the illustrations into a digital format via a scanner. I then digitally removed the background (to create a blank white

background), added onto the image where anatomical parts of the spider were missing, fixed any errors, and otherwise finished the illustrations into a polished and final project. After digitally editing the illustrations, I sent the final images to Nina Sandlin at the Field Museum. There the images were published on the museum's website in the LinEpig ID gallery, where they accompany photographs Nina uses to help researchers with species identification. To display my completed project I created a poster containing all eight finished illustrations. This is accompanied by my sketchbook drawings, copies of my finished digital images, and photographs of my work in progress. In addition to presenting my work for Honors College, I presented my poster at the Indiana Academy of Science meeting in March 2016.

Analysis/Conclusion

I believe the work that I have created effectively depicts the key parts of each spider needed for identification. They have been created using illustration techniques generally used to create successful identification pieces (Paquin and Duperre, 2003). They are satisfactory to both my advisor and the museum for which they have been drawn and so require no further revision. Should the illustrations ever need to be revised however, it would be rather simple to switch out an image with an updated one. These illustrations are perhaps not my most aesthetically pleasing pieces, but are not meant to be and are certainly not the easiest to create. That being said, they have a beauty of their own that I find quite interesting. I therefore find this project to have been successful accomplished.

Reflection

I learned that drawing spiders is not as simple as it appears. At first I thought it might be like drawing animals that I am accustomed to. I have a great passion for drawing vertebrate animals and find myself able to form their shapes quite readily. Drawing spider epigyna is not like drawing vertebrates. It is more like drawing alien and almost abstract art, but in such a way that is still true and even essential to the animal's form and identity. This is something which I had never done and so this project required a rather large learning curve for me. I can say then that I have learned a lot by doing this project.

Not only have I learned how to draw erigonine spiders, but I also learned factual information and the science surrounding these organisms. I have done this by learning to capture and preserve spiders myself and to note the differences between species. I have learned about the taxonomy of erigonines and how difficult a task their classification is. I have been able to see how scientists go about identifying and classifying these species and how they aid each other through collaboration. Finally, I have had the opportunity to contribute to this collaboration by producing images that scientists will continue to use long after this project is completed.

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Appendices

Appendix A: CITI Training

COLLABORATIVE INSTITUTIONAL TRAINING INITIATIVE (CITI PROGRAM)

COURSEWORK REQUIREMENTS REPORT*

* NOTE: Scores on this Requirements Report reflect quiz completions at the time all requirements for the course were met. See list below for details. See separate Transcript Report for more recent quiz scores, including those on optional (supplemental) course elements.

- **Name:** Elizabeth Wells (ID: 4685642)
- **Email:** wellse@uindy.edu
- **Institution Affiliation:** University of Indianapolis (ID: 473)
- **Institution Unit:** Art
- **Phone:** 812-294-4105

- **Curriculum Group:** Human Research
- **Course Learner Group:** Group 3 Health Information Privacy and Security
- **Stage:** Stage 1 - Basic Course

- **Report ID:** 15519146
- **Completion Date:** 03/11/2015
- **Expiration Date:** 03/10/2017
- **Minimum Passing:** 75
- **Reported Score*:** 100

REQUIRED AND ELECTIVE MODULES ONLY	DATE COMPLETED
Belmont Report and CITI Course Introduction	03/11/15

For this Report to be valid, the learner identified above must have had a valid affiliation with the CITI Program subscribing institution identified above or have been a paid Independent Learner.

CITI Program
Email: citisupport@miami.edu
Phone: 305-243-7970
Web: https://www.citiprogram.org

COLLABORATIVE INSTITUTIONAL TRAINING INITIATIVE (CITI PROGRAM)

COURSEWORK TRANSCRIPT REPORT**

** NOTE: Scores on this Transcript Report reflect the most current quiz completions, including quizzes on optional (supplemental) elements of the course. See list below for details. See separate Requirements Report for the reported scores at the time all requirements for the course were met.

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REQUIRED, ELECTIVE, AND SUPPLEMENTAL MODULES	MOST RECENT
Belmont Report and CITI Course Introduction	03/11/15

For this Report to be valid, the learner identified above must have had a valid affiliation with the CITI Program subscribing institution identified above or have been a paid Independent Learner.

CITI Program
Email: citisupport@miami.edu
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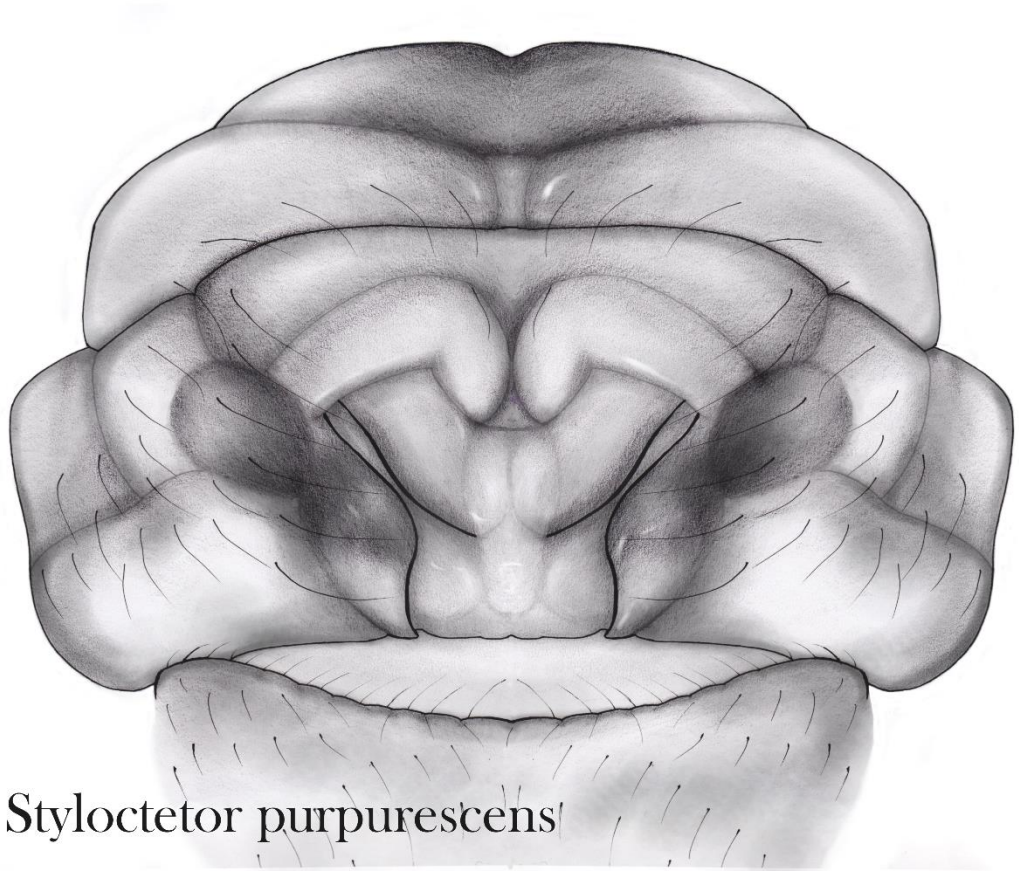
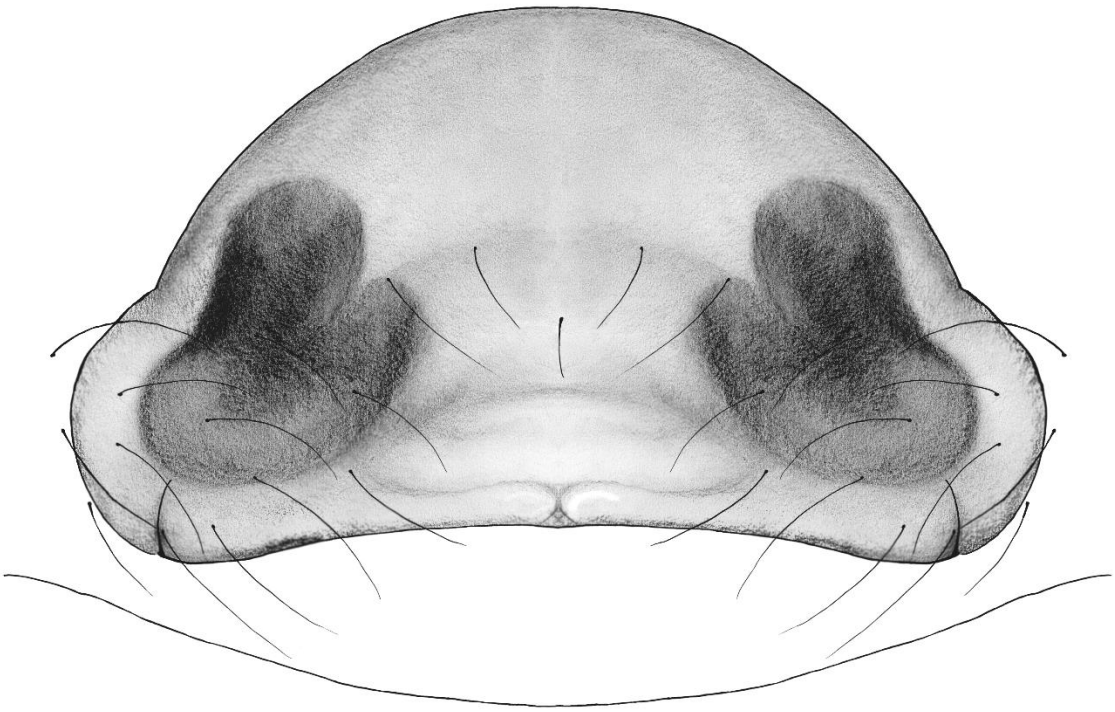
Web: https://www.citiprogram.org

Appendix B: Product Produced
Finished Digital Works





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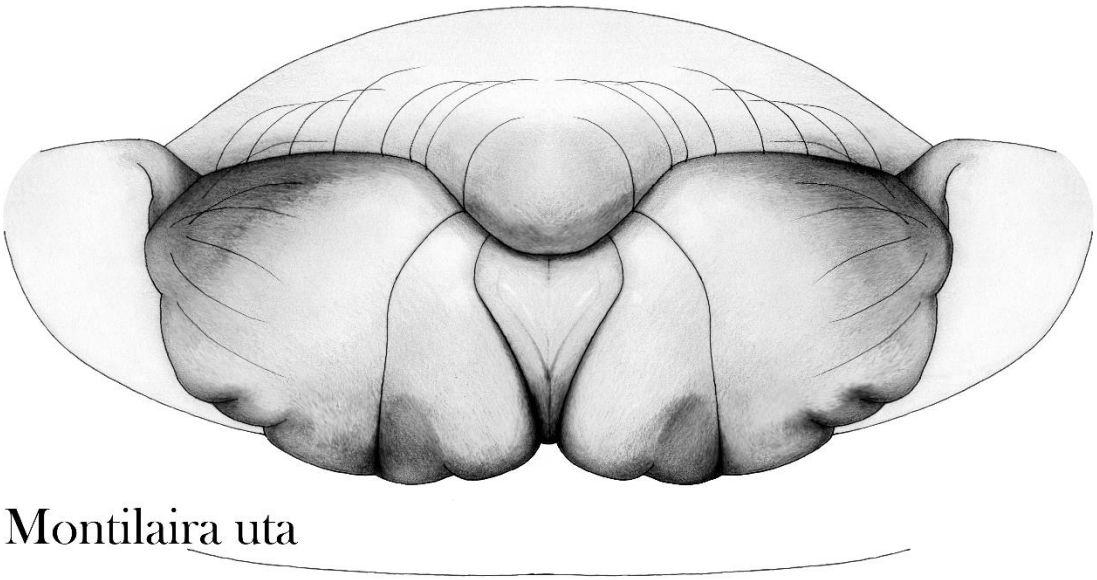

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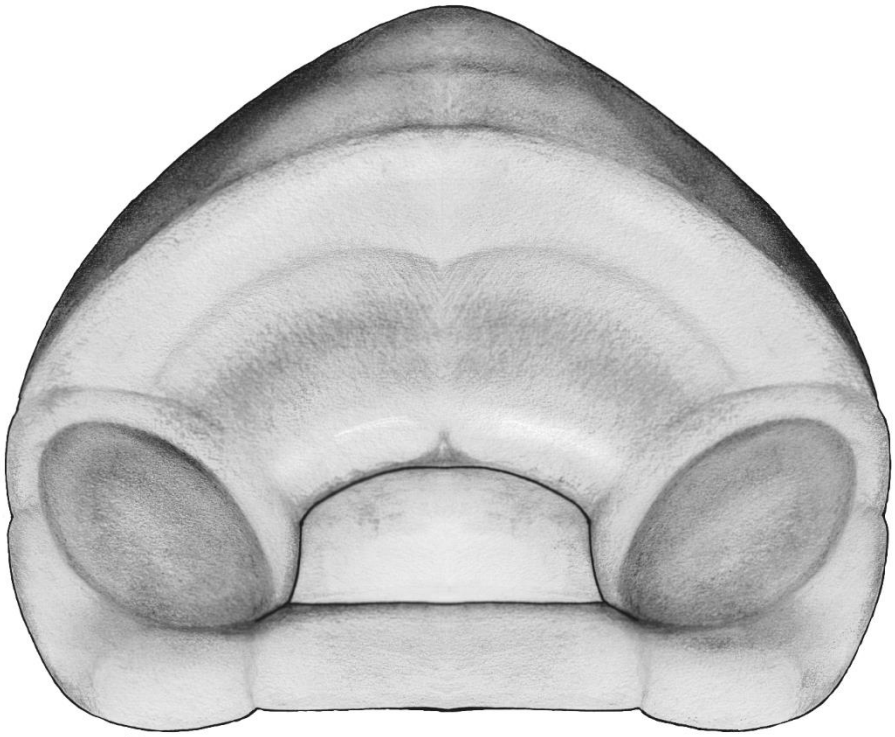

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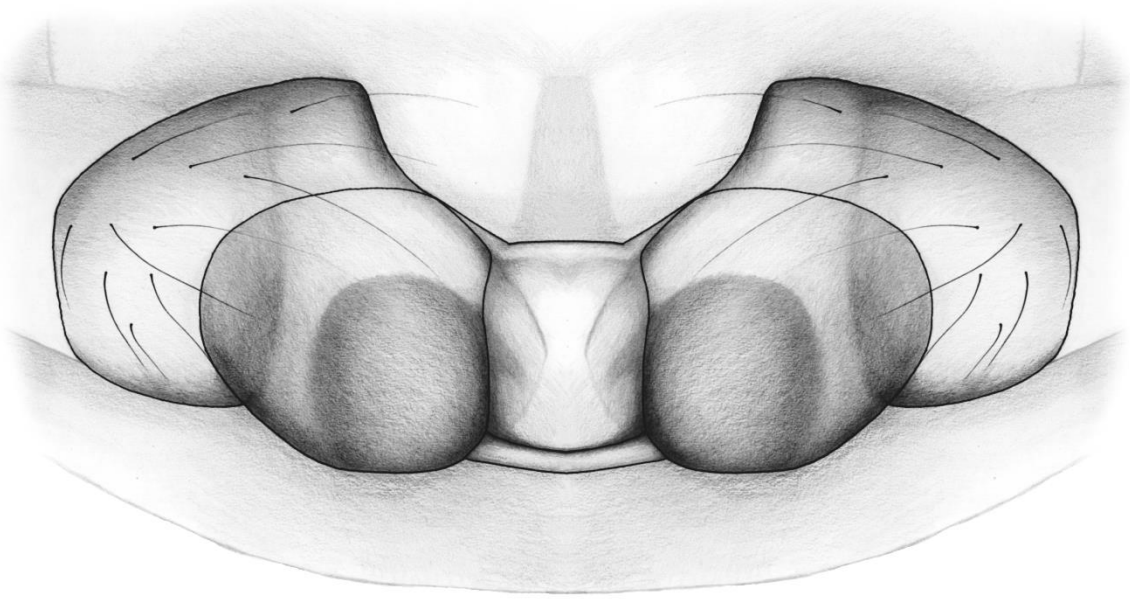

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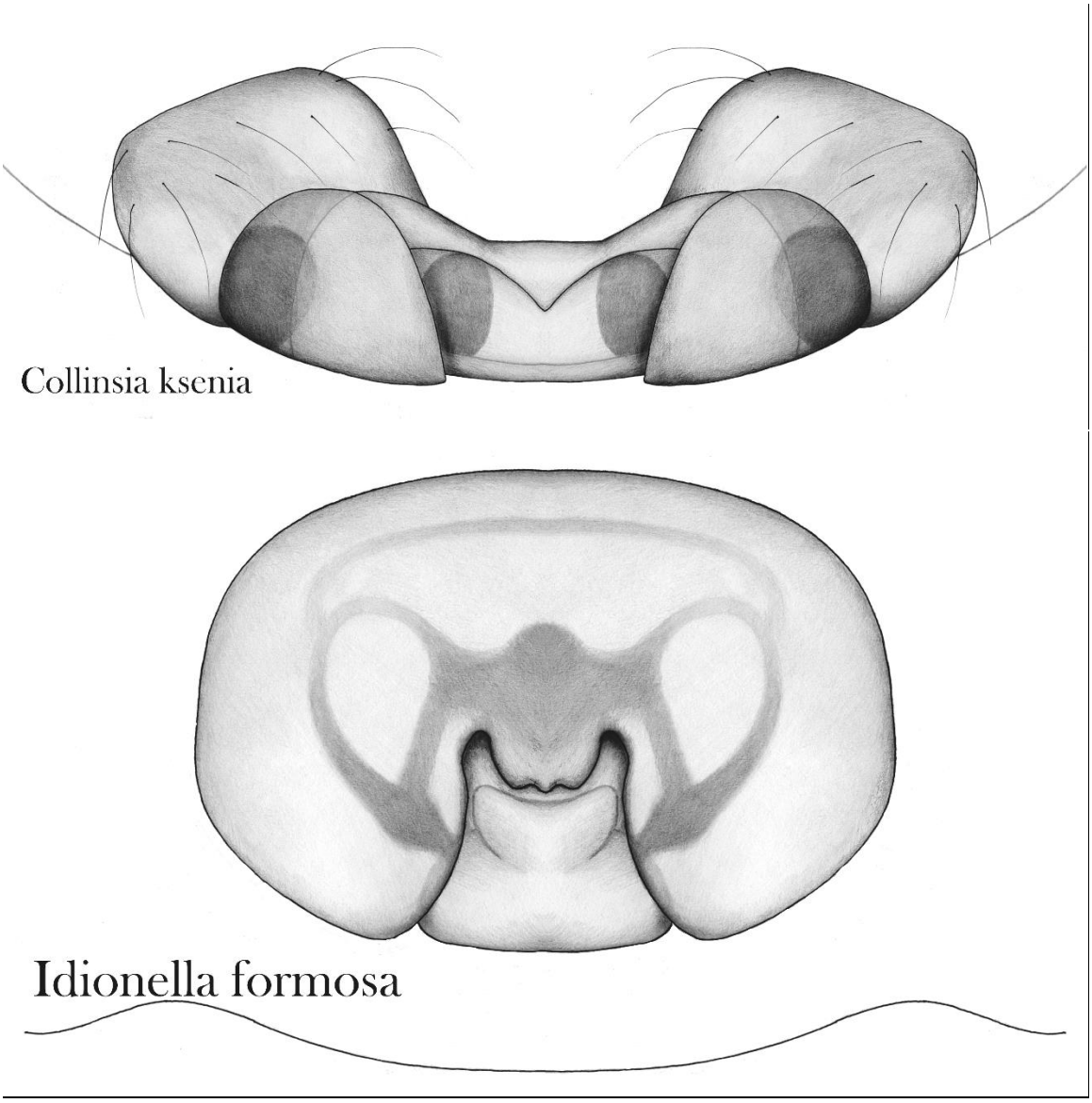
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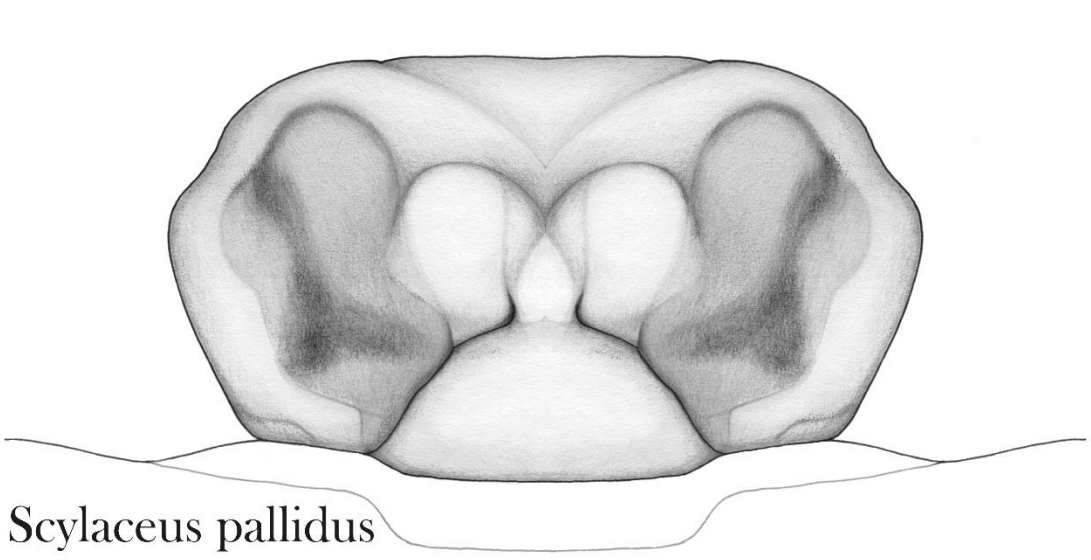
Idionella formosa



Poster

Illustrating some of the smallest spiders in the world: the erigonines

Elizabeth Wells and Marc Milne
Dept. of Biology, University of Indianapolis, Indianapolis IN 46227

Introduction

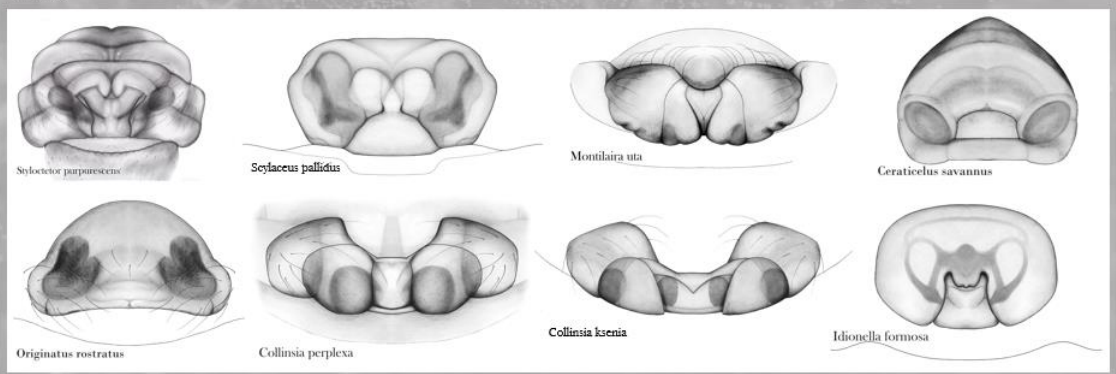
The erigonine subfamily (family linyphiidae) currently consists of about 2,000 tiny (< 2mm) spiders. Little is known about their taxonomy and classification due to their small size and female erigonines have no taxonomic key (Hormiga 2000). Therefore, in order to identify erigonine females, their epigyna (female reproductive structures) must be examined using a powerful dissecting microscope and compared against existing illustrations or photographs of known species (Sandlin 2011). Illustrations serve as efficient visual aids for identification because they are simplified and emphasize key parts. However, many erigonine illustrations are old (pre-1940's), poor in quality, and may be inaccurate (see Blake 1892; Fig. 1).

Fig. 1: Blake's (1892) illustration of Neophanes pallidus.

Methods

To improve the ability of researchers to identify erigonines, females from eight species that currently possess insufficient material for proper identification were selected for illustration. Spider epigyna were then illustrated free-hand using pencil, pen, and a sketch pad while observing specimens under a dissecting microscope. Drawings were then edited in Photoshop to fix small errors and enhance the background. Upon completion, these illustrations will be displayed on the LinEpig (short for "Linyphiidae epigyna") website hosted by the Field Museum of Chicago, where they will accompany erigonine epigyna photographs taken by Nina Sandlin (Sandlin 2011).

Works



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Acknowledgements

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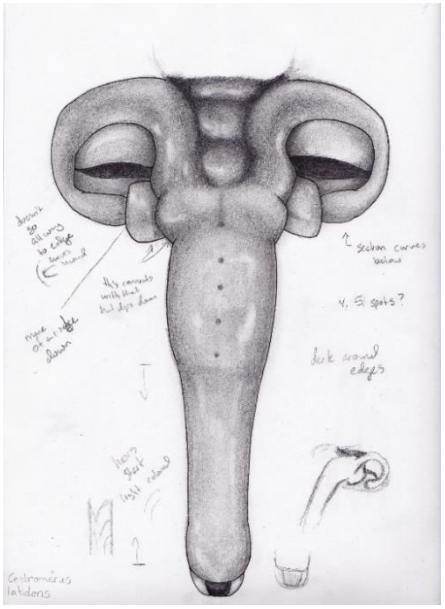
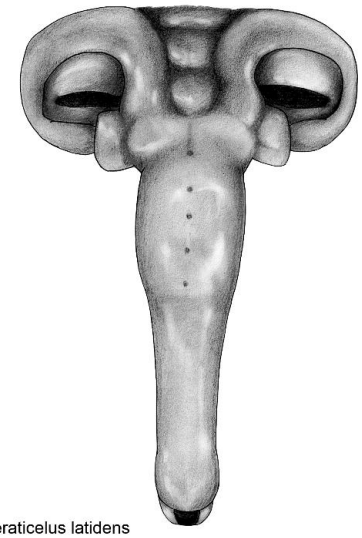
James Viewegh

Appendix C: Work Documentation

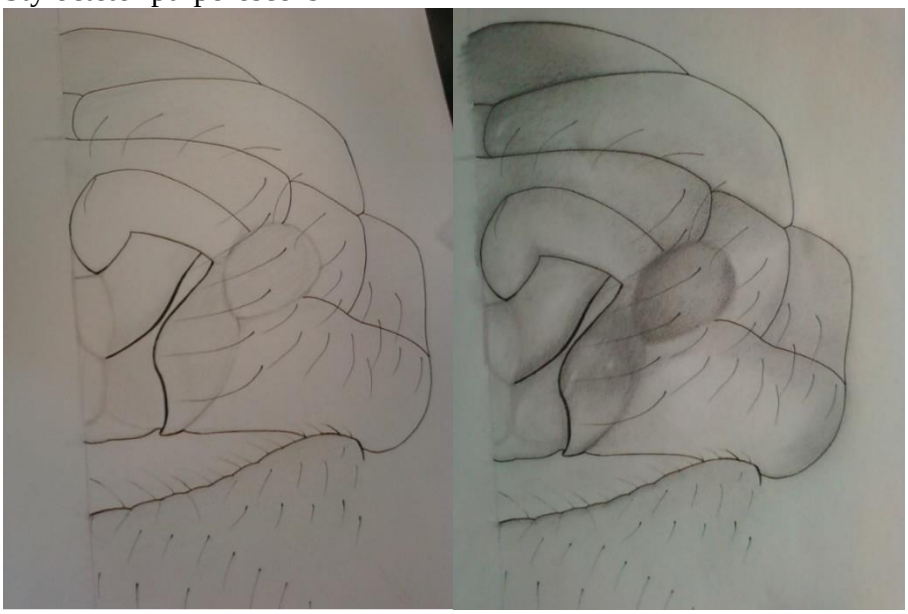
Practice

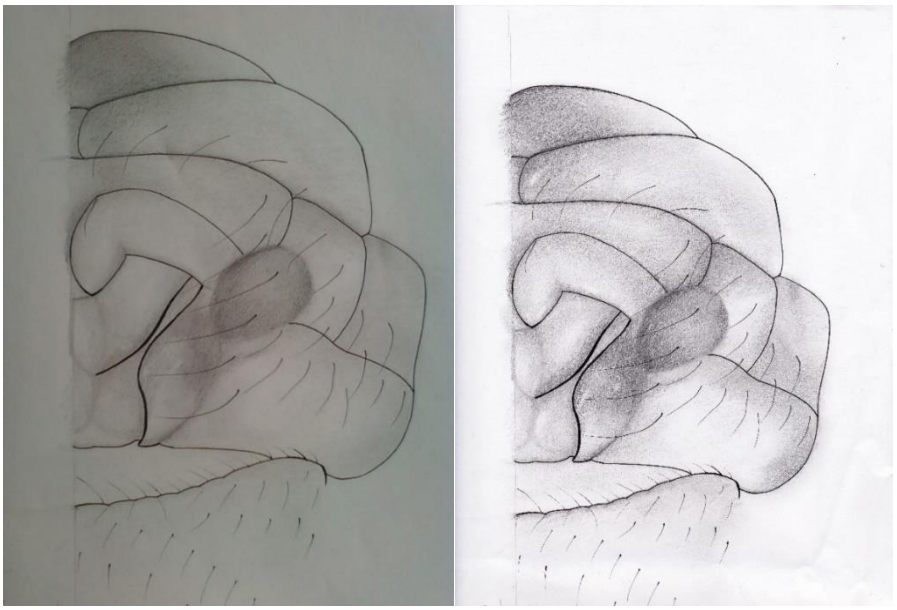




Ceraticelus latidens

Styloctetor purporescens





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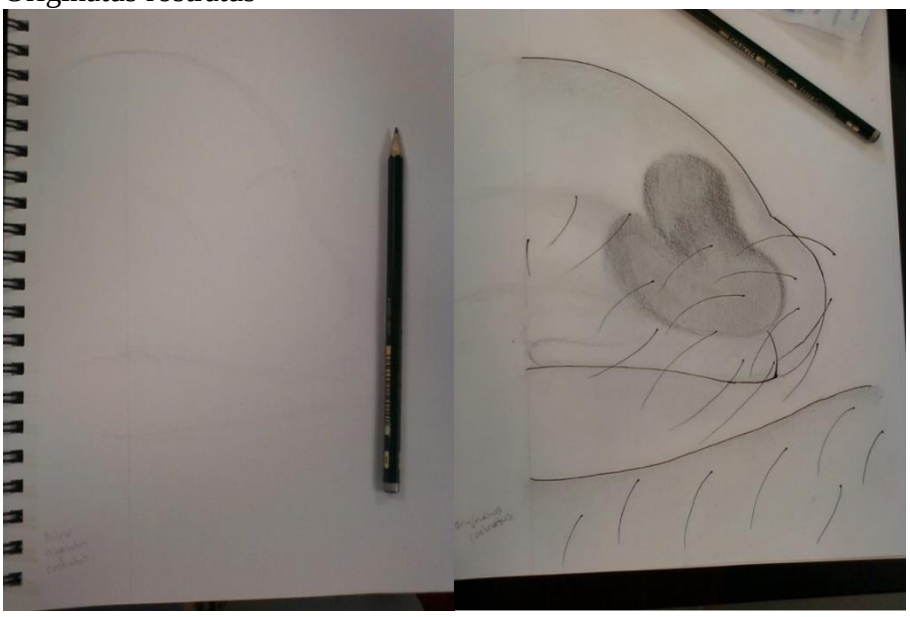

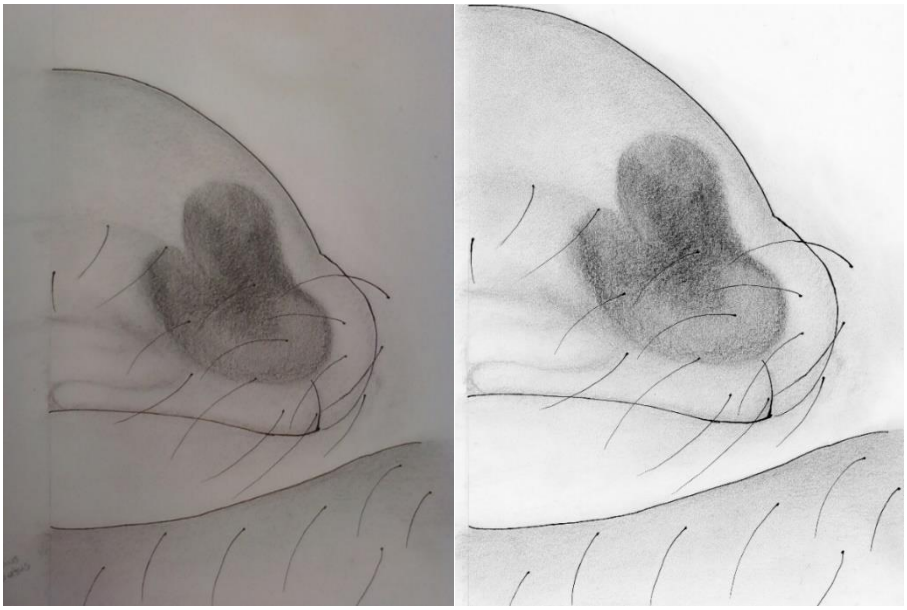

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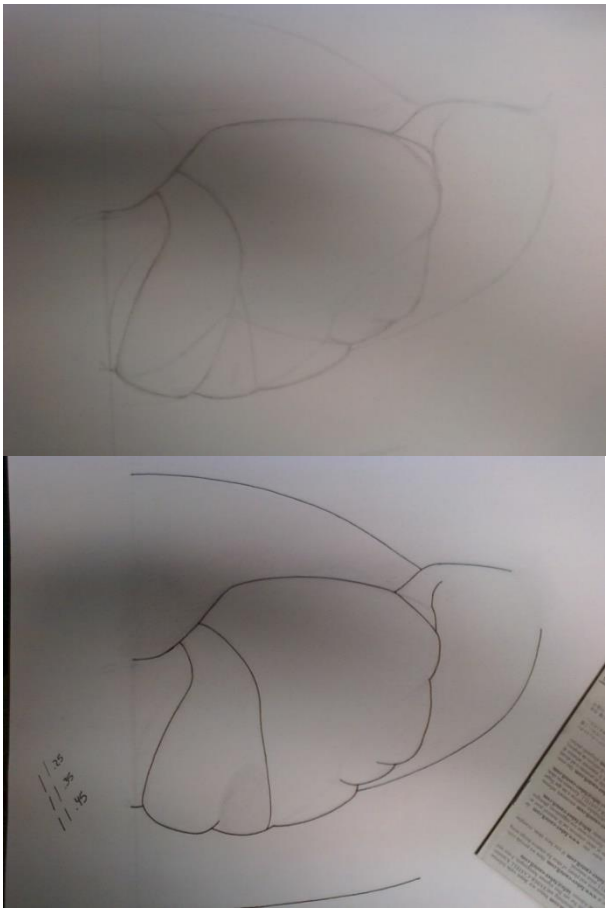

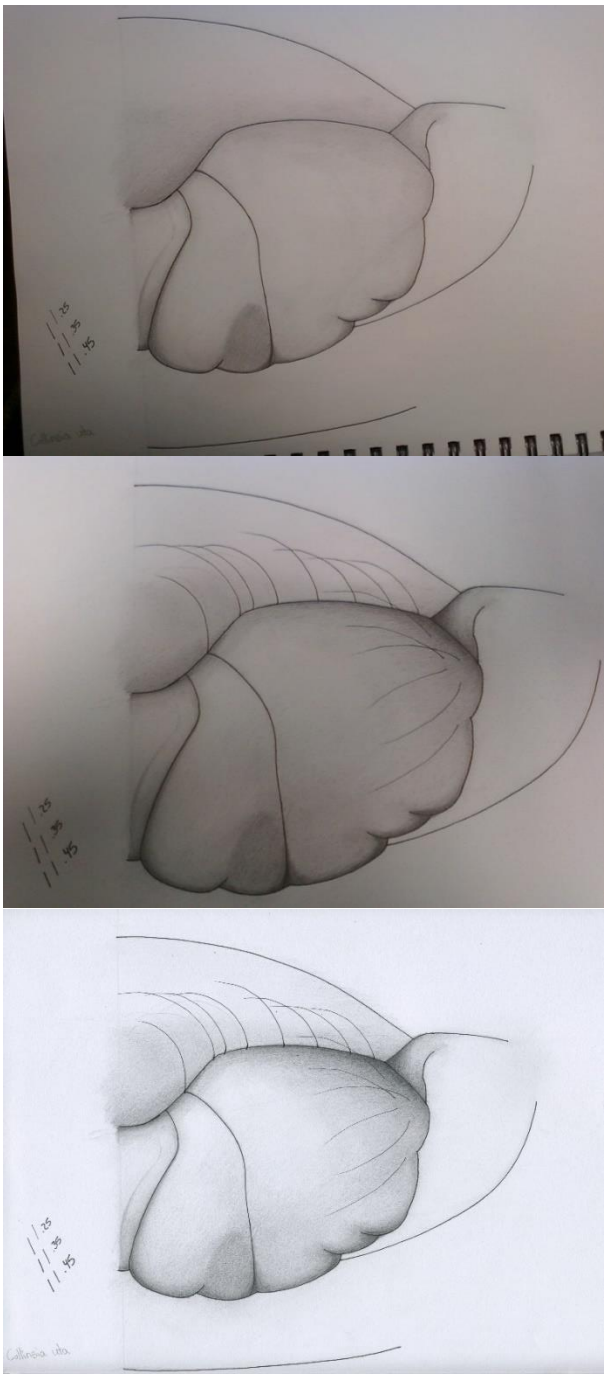

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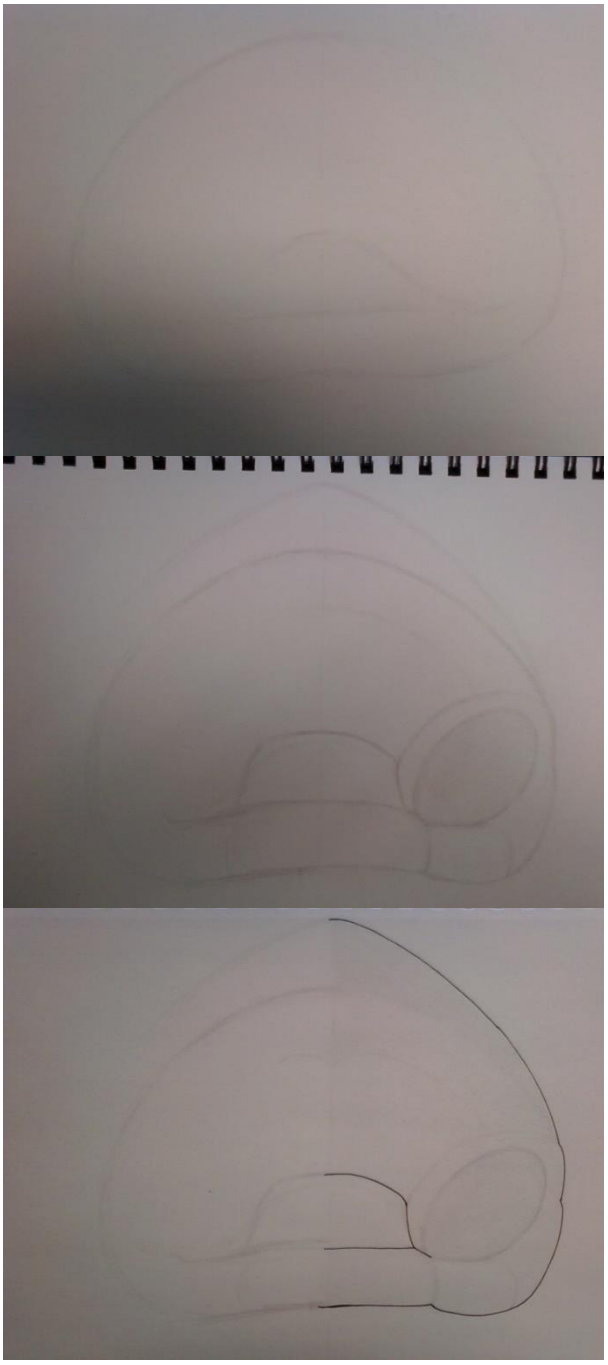

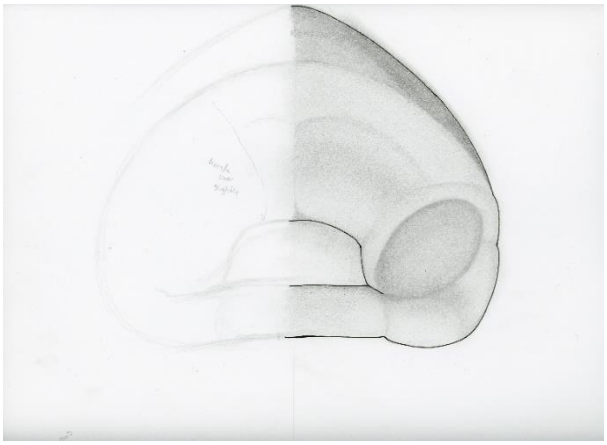

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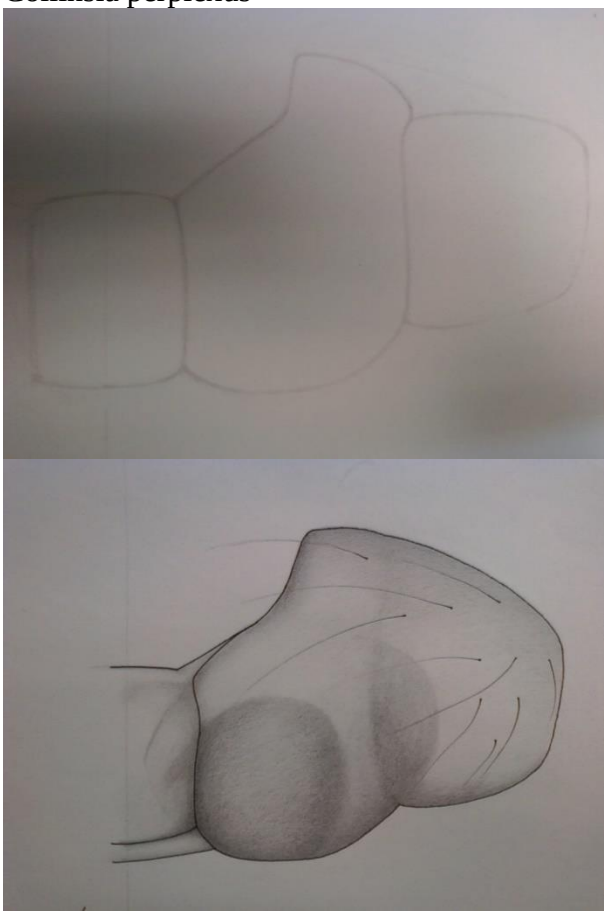
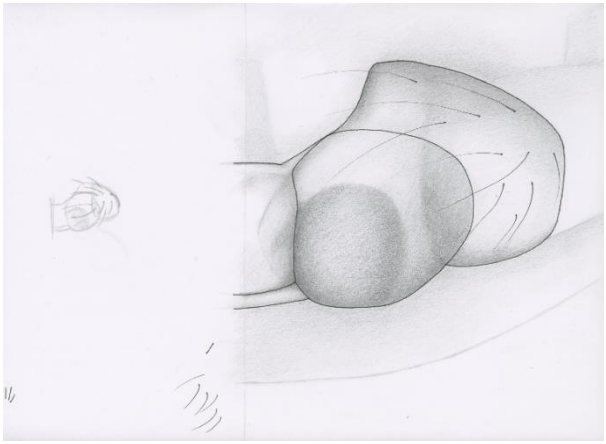
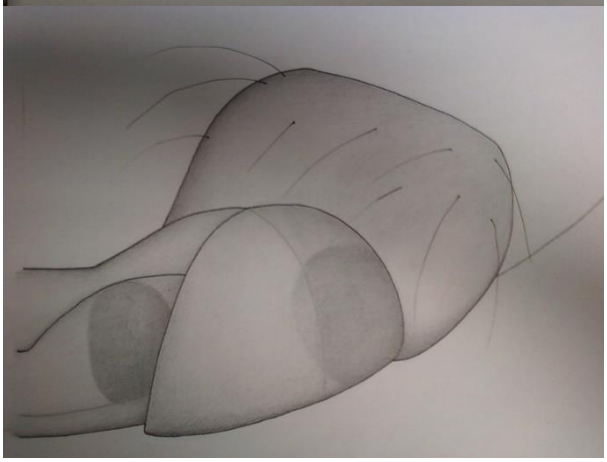
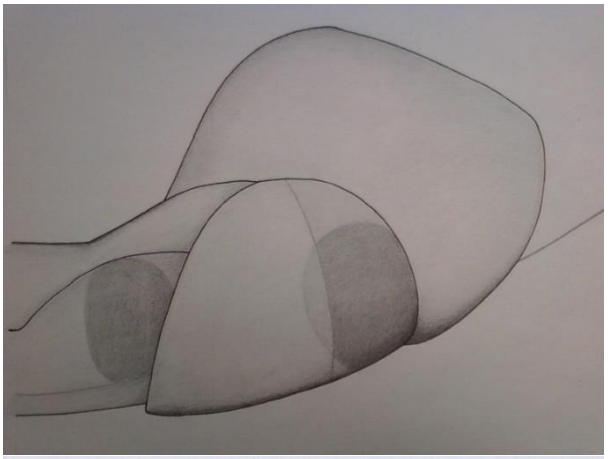
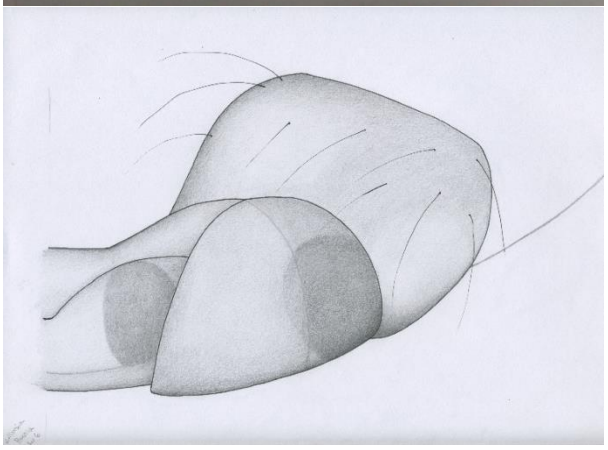




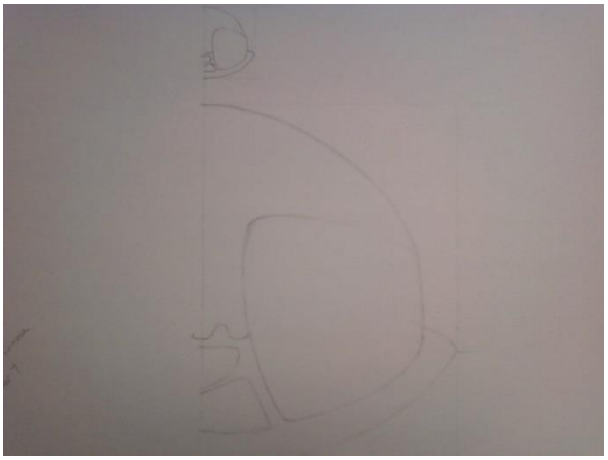
Collinsia ksenia

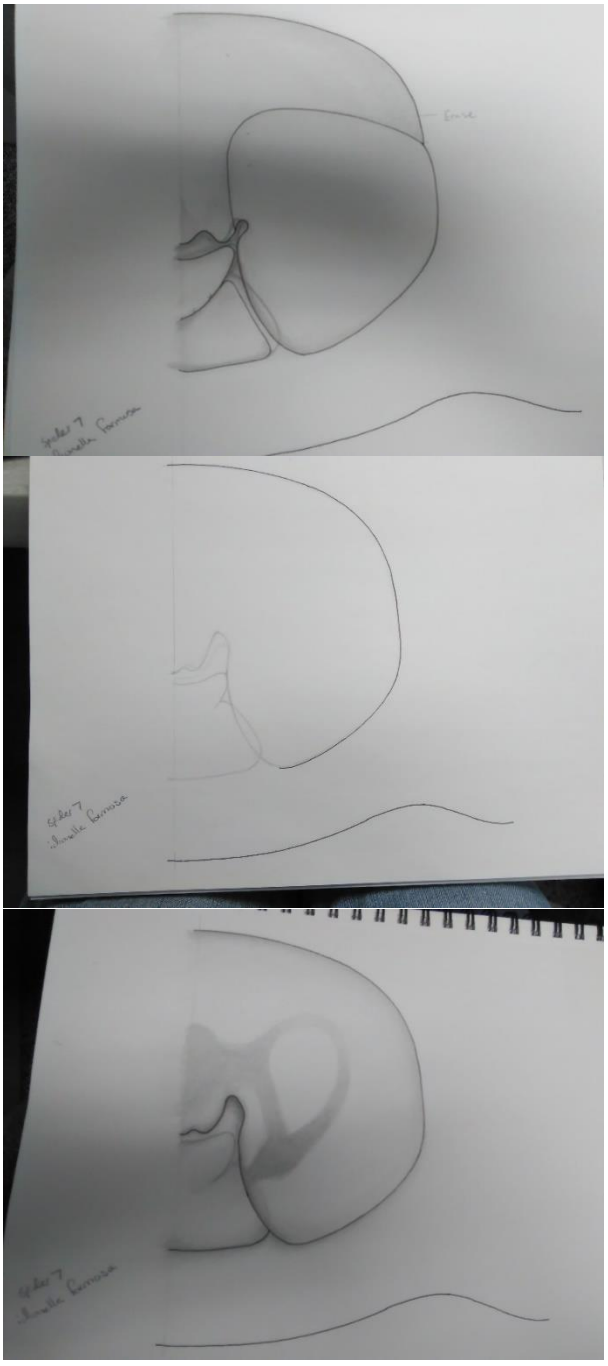


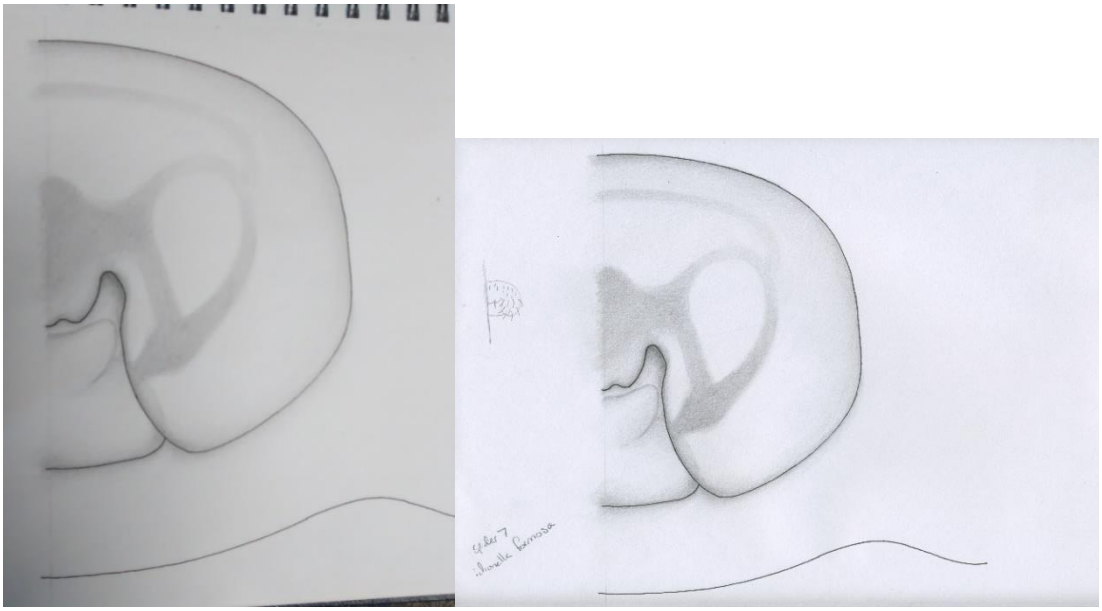




Idionella Formosa







Scylaceus pallidus