Much of the world's biological collections are locked away in cabinets, cases and jars, largely inaccessible to the public. This past March, at the Annual Entomological Society Eastern Branch Meeting, we brought our local digitization community together, particularly people actively digitizing entomological collections. These "digitizers" exist as members of our regional museums, universities, and private facilities, and they work tirelessly to "free" the collections stored within these institutions. Please follow us on this educational journey in which we learn what "Digitization Entomology" means today and what it may mean in for our future.

**Our opening talk, titled "Digitizing the Frost Entomological Museum, Lessons Learned and Given", was a personal account of Dr. Andy Dean's digitization efforts**. The Frost collection, part of the Department of Entomology in Penn State University, is a very large public collection with approximately 1 million specimens present and 4,000 + annual visitors. The museum has 65,000 specimen from the Beatty Collection alone. This collection, from the mid-1900s, is largely Northeastern and Mexican Odonates (dragonflies and damselflies). It is one of strongest larval and exuviae collection from George Beatty's massive rearing attempts, and is useful in trying to match larvae to adult stage odonates. The Frost Museum is also famous for their massive Pennsylvanian spider collection; with over 1,000 vials dating back to the 1880s. Current digitization efforts have been funded by InvertEBase, two NSF DBI grants to replace cabinets and equipment, and an NSF EE DigGrant. Lessons that Andy shared with us are invaluable for those who are interested in pursuing a digitization project;

**Lesson 1-Digitization and Collections Improvement are best done together**

The digitization process exposes specimens to risks, therefore maintenance during the process reduces negative impacts of handling.

**Lesson 2-Digitization of insects is HARD**

Some work is easier to digitize than others. Andy discussed how his past MorphBank digitization work with natural history collections of poison ivy differed greatly in ease of digitization. 2D leaf specimens are easy to image because they are flat, but digitization of 3-D insects with pin boxes is difficult.

**Lesson 3-Digitization of insects can be easy!**

The second lesson is not a reason to not digitize insects! Through the aid of workshops, workflows, and shared experiences, digitization is possible. The Frost Museum has settled upon 3 major types of digitization efforts;

Pinned Specimens-Can be digitized using Darwin Core +Spreadsheets. Databasing is vital. Workflow=Line specimens, spreadsheet transcription. Open, refine, correct and improve what's in the spreadsheet. 127,000 occurrences @ SCAN Symbiota Collections of Arthropods Network disseminated through IDIGBIO and GBIV

Wet Specimens and dragonfly envelopes-Can be digitized using point and shoot methods + people power

Dump specimens out, image vial image specimens onto grid, image slice into fields and transcribe the labels

Slide Specimens-The Frost Museum maintains the world's largest collection of sucking lice (15,000 slides)

**Lesson 4-Digitization is the best way to learn about a collection and set priorities for the futur**e.

By digitizing, we learn the strengths, weaknesses and extent of the collection itself in addition to regional collections as a whole. What questions can and still can't be answered by the specimens in the Frost Museum? Where do we take students on field trips?

**Lesson 5-Digitization inspires and catalyzes research**

Digitization allows us to answer profound and compelling questions. For example, while digitizing odonate larvae and field notes at the museum student Emily Sandel was inspired to do more. Based on her own work , and classical studies done by GH and AF Beatty (Edaphic Factors in Pennsylvania Odonata) , she has recently submitted her research "Temporal differentiation in environmental niche modeling of Nearctic Narrow-winged damselflies -PeerJ in revision .

**Lesson 6-Digitization connects people to collections and to science**

When connecting people to collections they saw a surge of interest and students who want to know the best practices and how to contribute specimens to the Frost Museum.

**Lesson 7-Digitization contributes to addressing global causes such as declines in biodiversity**

Once we know more about a collection, how can we better contribute to greater insect biology studies?

**Lesson 8-Digitization is transformative as a process** in digitizing a collection, new tools and ideas arise such as pollinator ID tools, Invasive species management and applied systems biology. Ventures

**Our next talk, "Using Specimens from the past to understand the living world through digitization" shows the other side of digitization. Dr. Jessica Ware, from Rutgers-Newark University, utilizes digital data to answer large-scale scientific questions.** As an expert odontologist, Jessica studies the evolution of dragonflies (3000 species) and damselflies (3000 species).Of particular interest to her is the question "How do dragonflies fly"? Previously described as perchers, fliers, migrators, and homebodies, these fascinating insects spend some more than 50% of their time "on the wing". Some species, like *Pantala flavescens*, can go many kilometers at a time, while others only go 11 meters their entire life. With different flight strategies, they have adapted different wing structures, with flight wing venation largely affecting wing camber, lift, and ultimately flight patterns. Additionally, density, pattern, and stiffness of wing veins and margins influence overall maneuverability.

In answering questions about dragonfly flight, Jessica has turned to digitization of several invaluable dragonfly collections; Florida State(150,000 specimens),Smithsonian Museum (200,000 specimens), and her own Ware Lab collection (4,000 specimens).For Jessica's graduate work (2007) she manually measured 85 specimens, forewings only, which amounted to 7 months of work. This was time-consuming and less digitization was completed. These digitization efforts have since evolved and are now collectively called the TOWD Project Target Odonata Wing Digitization Project (2019). The result? An automatic species identification system plus rapid extraction of wing information and patterns where 206 specimens can be digitized with only 2-3 minutes of work per specimen. With automatic species identification for dragonfly species her team hopes to develop software using veins to identify species with an app.

**Workflow**

1-Excise dragonfly wings

2-Position onto template and organize data of importance

3-Forewing-hindwing-pattern, color

4-Extract data using protocol

5-Storing images through CYBER NSF database to house images

**The TOWD Project aims to complete digitization for 400+ North American Odonates**

This new and improved process involves progress tracking for 11 odonata families and an enthusiastic team of undergraduate wing scanners at Rutgers-Newark.

Are Wing Ratios Important?

-Coding-Aspect ratios; how elongate is the wing compared to its overall area?

-Measure aerodynamic efficiency of a wing comparing ratios where perchers and flyers will vary

-High-long and narrow, Low-short and broad.

-More data on aspect ratios and better interpretations needed

Is Wing Loading Important?

-Body mass/wing area

-Certain life history strategies of odonates may be influenced by wing loading. For example, tandem egg oviposition may affect wing loading because there will be a mass shift as females fly attached to males during flight to the water.

-More data is needed across families to understand if tandem versus solo ovipositing species have significantly different wing loading.

The results so far show that there is a significant difference in wing loading (p value .002945) and in wing ratios (p-value .001819) between perchers and flyer forewings. Hindwings were found to be less significant. To conclude, Jessica touched upon the importance of specimen labels in understanding natural history of odonates. Without these labels, we risk losing important information about range, habitat, phenology, and the diversification of lentic and lotic species. Specimen label data, in addition to automatic feature extraction data can shift our speciation rates and our molecular interpretations. Humans only have so much time and precision, digitization is the way of the future.

**If you are hoping to gain advanced knowledge of the many resources available for digitization, join us as we delve into Deborah Paul's talk "Digitizing Collections Worldwide in support of 22nd century Entomology".**

Deb is an expert digitizer who believes in the worldwide initiative for faster, better, and newer data mobilization. Once upon a time, we removed an insect from its environment. How do we reconstruct the insect and the ecosystem in which it was removed? We must give it a "new set of wings", and link this data to new tools and new databases.

In this talk, Deb discusses worldwide digitization, and the skills, metrics, and literacy data needed in 4 main areas. She then addresses the three main points:

1) Local to global change story in practice

2) Policy collecting citation workflows access

3) How to contribute and be prepared

**Worldwide, Digitization is occurring:** DISSCO European Collection is the largest ever formal agreement between natural science collection facilities .It involves 115 national facilities, with 21 countries as part of this agreement, and by 2024 it will involve the EU Consortia.

There are countless workshops and digitization events that promote community building, such as ADBC. Many resources exist for digitization data mobilization and data use, but sometimes you find that people will put anything and their dog in the date field. Not all data is listed in a useful manner, but if we teach students how to standardize it, we improve its usefulness. At workshops, students can learn useful skill sets such as georeferencing for research use, integrated geospatial training paradigm for biocollections (GRU),data aggregation renewal skills needed and knowledge gaps, capacity building needs, software, standards, data cleaning and management, spreadsheets text files, data visualization, and data carpentry to name just a few. If we mobilize the data, we can use the data! This data is vital to fields outside of entomology that are expected and emerging! Biological collections data is vital within the realms of evolutionary medicine, disease discovery while tracking treatments, food security, biodiversity studies, conservation, computational design, and local and foreign land use models. The metrics of this data are important to administrators, researchers, funders, policy makers, managers, and directors alike.

<u>Upcoming events</u>

1-SPNHC 2019 Making the Case for Natural History Collections

2-Digital DATA Biodiversity Research Conference III

Focus: Methods, protocols, analytical tools for specimen based research in the biological sciences

3-Biodiversity next October 2019 Leiden Netherlands GBIV

4-Biodiversity Next-- how to cross borders

<u>How to be ambassador</u>

Advancing digitization of biodiversity collections -ADBC

National Digitization Network

iDigBio and thematic collection networks-TCNS

**Now that we have covered the field of modern and global digitization, let us take a step back in history with Isa Betancourt, an ANSP curator who has been "Carrying an entomological collection through the ages".** Historical collections are unique and delicate repositories of information. Data preservation for archival housing, such as the case for the Historic ANSP Entomology Collection, requires extra care when handling. The ANSP entomology collection is a massive and old collection, with 7 digitization projects underway. With 4 million specimens, 13,000 types, and some of the oldest insect specimens in North America, this collection is a major undertaking. It is well worth the effort, it is home to the world's best orthoptera (grasshoppers, crickets) collection, and has additional strengths in its diptera, odonate, hymenoptera, aquatic insects groups and the entomofauna of Mongolia collections. With so many insects to digitize, the staff is small. They only have 1 curator, 1 collection manager, 2 curatorial assistants, and 1 curator emeritus.

Perhaps the oldest collection listed in our symposium today is the historic 200 year old Titial Peale Butterfly and Moth collection. From 1799-1885, Peale collected thousands of insects from America and other regions of the world. During this time, he developed unique and ornate Peale boxes to protect his precious specimens from light, humidity, and dermestid damage. This is considered to be the museum's first digitization project from a conservation angle and it is funded by NSF as well as Save America's Treasures (National Park Service). The museum is also undergoing several other major digitization projects. They are in the process of digitizing the Gelhaus Crane Flies of Pennsylvania (8,000 specimens), Stream Survey collections (Puerto Rico watershed surveys and data), and working to create a collection wide Species index (Spindex) of their museum allowing the public to browse any specimen from anywhere in the world. Two other massive digitization projects currently underway include

LepNet, a system for using label transcription to digitize label data of 52,000 North American Lepidoptera specimens and OrthopNet, an NSF funded project also seeking to connect field notes to digitized specimens. These projects are valuable as repositories of information, and intriguing on a historical level as well. In the early twentieth century in Arizona, James Rehn and Morgan Hebard surveyed orthoptera of the western United States. At the ANSP, they found that the best way to obtain specimen level data was by reading Rehn's extensive field note entries hosted by Biodiversity Heritage Library as opposed to traditional specimen labels. His field notes included more than just crickets and grasshoppers...they included mammals and reptiles in their notes as well! At the museum, Isa and others work to transcribe field Notes from page photographs in these journals, locate genera and species in notes, and send this data to resources using iDigBio.

Not surprisingly, the massive collection size, paired with the small available manpower at the ANSP is a major challenge. Funding has been a major breakthrough at the museum, but somewhat limits the focus of digitization to these projects. The bottom line is that in order to carry an entomological collection through the ages. The digital images need a home beyond the museum, with major database support and image collection management.

**Perhaps the most impressive "Digital home" that exists for entomological collections is the Global Ant Database, AntWeb. Myrmecologist Christine Sosiak (NJIT), discusses how AntWeb and its affiliated databases have been a vital resource in her graduate research, mentorship, and outreach**. This massive database began with a very frustrated myrmecological community;

*Dear Dr. Fisher,*

*"I've collected 25,000 ant specimens and now I have to identify them and finish my crummy thesis in 6 months. It all seemed like such a good idea at the time What can I do?"*

Fed up with a surge of these types of letters, Brian Fisher aimed to make Myrmecology into the "Ornithology" of the entomology world. He achieved this goal by putting all global ant knowledge in one place, standardizing high definition images for all key features, including all collection and biogeographic information. Dorsal, ventral, lateral, and 3-D images are included for all castes within this diverse and interesting social insect group. Fossil amber data is also included for some specimens as well. All images were launched in 2002, with the help from the site host, California National Academy of Sciences, 20 major museums and many smaller ones. This massive digitization project, which incorporates AntWeb, AntCat, AntMaps, and AntWiki, has received millions of dollars in NSF grant funding to date.

Within the AntWeb framework exists another useful database, AntCat. Developed by Barry Boltson, this "catalogue" of ants includes all valid taxonomic ant names from around the world. This is not limited to current names, it includes all synonyms, genera, species, and subfamily data as well. Another resource, AntMaps, is a virtual user-friendly interface of GABBY biological information displaying global ant species richness data as a heat map. With this resource, you can select distinct areas to see overlap in assemblages, native species, invasive species, and thriving invasives all with the click of a mouse. Lastly, AntWiki, as the name suggests, is a repository of ant species information, digitized labels, and a taxonomic key repository (800+ worldwide keys).

Because AntWeb images are standardized, Christine is able to use ImageJ image processing software to analyze and measure morphological data from a massive range of specimens without ever leaving her computer. The real world applications of this database are massive, and can be used in combination with global biogeographic data and phylogenies to test diversification rate hypotheses and big environmental/metadata questions. In her own work, Christine has combined fossil morphology measurements with extant morphology collated from AntWeb. This database has also been an invaluable resource for developing undergraduate research questions with her students. For example, student Amina Siraj has been plotting morphological data from AntWeb as her research project.

In 2018, Antweb data was used with an ensemble of convolutional neural networks and it was discovered that the algorithm could identify genus level specimens at an 80% success rate. This being the case, Christine believes that even taxonomists are not safe from robots coming to steal our jobs. With AntWeb as a shining example, if you are digitizing a collection, it is vital to create a one stop portal for an ideal "digital home" with the most applicable future.

In a place where the far past (millions of years) meets the technological future, we turn our attention to our next topic, how **"Digitization improves dissemination discovery and long term preservation in fossil amber collections". Dr. Phillip Barden, an ant paleontologist from NJIT,** discusses the potential for a "holographic type" for specimens so old they have gone extinct. He uses microCT data to digitally reconstruct the morphological form of specimens trapped in the natural polymer, amber.

The demand for work of this type began in 2003, when the high resolution x-ray conpretrology meteorics of a scorpion were published. Four years later, scans revealed large amounts of information about 40 million year old spiders trapped in amber.

Ant paleontologists have discovered that many of the 730 described extinct ants found in amber are morphologically strange compared to the ants we know today. Phil has worked to "resurrect" these ancient ants, using microCT scan imagery and

reconstruction software. One of his most passionate projects focuses on a 99 mya species from Myanmar amber that he refers to as "The Hell Ant" (*Haidomyrmex*). Using an NSF funded AMNH CT scanner, he has postulated that the "Hell Ant" may have used vertically articulated mouthparts that resemble tusks to capture their prey. Another ant he has analyzed in his lab is *Linguamyrmex vladi*, named after "Vlad the Impaler". Also 99 mya, this ant is believed to have used a giant horn to impale its prey. They even have found that it sequesters metals in its exoskeleton so it will not impale its own face with its horn!

This digitization process involves placing the amber specimen inside of the micro-CT machine, where it is rotated and bombarded with x-rays. A specimen detector picks up the x-rays, and two dimensional snapshots are taken from a z-stack top down view to reconstruct the image. Brighter image areas result from sample absorption with less photons, and darker areas result from sample transmittance of more photons. Although it is often expensive to gain access to machines of this type, it is becoming more affordable. For example, the Argon Particle Accelerator in Illinois, is free but requires collaboration with a physicist. The Desktop model CT scanner is becoming more affordable, with a $200,000 price tag that will undoubtedly drop in upcoming years .The major advantage of CT scanner desktop modes is that they do not affect the specimen, whereas syncatrons can darken amber with increased x-ray excitement.

By using micro-CT reconstruction, we can learn more than just superficial morphology. It can be used to reconstruct behavior and muscle articulation of long extinct animals, produce histology quality images, soft tissue head capsule reconstruction, genital characterization of specimens used in divergence dating estimates, provide us with evidence of early social structures in organismal lineages and so much more. Additionally, it makes digitization more cross-disciplinary. At NJIT, Phil has worked with industrial design students to create detailed 3D printed resin castes of these extinct animals to use in outreach projects. He foresees a day where even micro-CT reconstructions will be a day of the past, and an initiative for digital holotypes will be a commonplace method for all collections.

Advancements of technology have allowed us incredible new opportunities in the dissemination of collections information and in communication. **Skyping in from the Cleveland Museum of Natural History, we will now discuss "Digitization perspectives from a mid-sized entomology collection" with Nicole L. Gunther.** The Cleveland Museum has been privately funded since 1920 and is very regional collection with many specimens being found in northeast Ohio. Several notable exhibits at this museum include "Lucy" (Don Johanson), Happy campsoaurs, Balto, a very large and clever beetle display, the Malacology Seashell Collection, the Pallister's Ohio insects collection (1920s-1922), Holden Odonata, and the South Pacific Lepidoptera Collection. The invertebrate zoology department has a fluctuating relationship with the entomology collection managements due to an absence of dedicated staff.

Tools and Collaborations used at the museum for digitization efforts include GBIF, InvertEbase, and resources across the following museums; Field Museum of Natural history, Cleveland museum, AUMNH, MI, DMNH, and the Frost Museum. Their digitization team is small and includes a digitization assistant, 5 work study students, 8 volunteers, and annual Kirtlandia research interns. To date, they have digitized 113,329 total specimens, and 46 % of the collection is completely digitized!

**The Workflow for students and volunteers is as follows:**

1-imaging, assign barcodes, remove specimens labels, image, replace labels, location in collection

2-transcription-transcribe verbatim label data in google sheets from flikr albums where in collection or off site

3-Set Data-upload spreadsheet set data in XbioD transfer data where in collection or off site

4-Check data-missing data localities taxon in not in database

Nicole believes that digitization has transformed their collection. They now know what numbers to report in their collection (250,000 specimens), the health of their collection, improve loan and data access, and increase visibility within their museum.

The Cleveland Museum is now more relevant to the community, and have seen an increase in GBIF citations, publications, and download events. They still struggle to keep from losing historical institutional knowledge due to a lack of staff, expertise, time, and funding.

We now turn our attention to the **"Rapid Development of a deep learning auto ID system for bee species using wing images" with Dr. Kimberly Russell of Rutgers University.**

Kim began her research with a focus on community ecology and conservation within super-diverse invertebrate groups such as spiders and bees. Gathering data for community level analysis is time consuming, with a 1 year time -lag to simply identify the specimens. In 1999, automated Identification of specimens seemed to be a Star-trek like fantasy. Kim developed her own artificial algorithms from scratch and created auto-ID software she named SPIDA to address this

impediment. Based on six species across three genera, this neural network system can be used to extract important information using wavelet transforms. Since its development, SPIDA has received an NSF grant- scale up, and has been published as a book chapter (Norman MacLeod) and a paper in 2007. SPIDA now includes an entire family of Australian spiders, 3000 images, and 121 species in 15 genera. These images have been transformed for input to ANN Species Identified Automatically with 96% accuracy per image.

Kim has also developed a deep learning auto id system for bee species using wing images. Large scale interest currently exists for monitoring wild bee populations across the US. A multitude of labs need bees identified by a specialist, but this is difficult to learn, and genus level does not give enough ecologically relevant information. Genus level characters do not say as much for bees as it does for spiders. Kim developed a system for species identification using wing scans because they are three dimensional items that can be flattened and imaged in a meaningful way. Using this information and computer algorithms, important information can be extracted in bulk, and processed for monitoring bee species. All with less time, less money, and less manpower! As for manpower, Kim has found that an undergraduate bee team works best and she has been able to develop a useable auto ID system for her lab in NJ. Proof of principle has been established for using bee wings in species identification, with 12 species being identified at 95% accuracy. Using SPYDA, wing venation can be used to identify species!

There are still many challenges to address when identifying species. We need more robust datasets, higher quality images image, less noise, and the recognition of unknowns in using these approaches.

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**We now move ahead to our Panel Discussion, moderated by Manpreet Kohli:**

**Topic 1**

**Moderator: If somebody just started digitizing a collection what are the first steps prior to digitization to prioritize specimen use? Where should they focus the most attention, equipment, and funding?**

*Andy Deans*-Depends on what you want to contribute. To start, catalogue these things via spreadsheet: what species, what type of data, when/where was it collected, was it for a small collection?

**Moderator: Hypothetically, if I had a 40,000 specimen collection, how would I start ID numbering each one? How would I set up a barcode system without being overwhelmed?**

*Isa Betancourt*-I would start by barcoding, and labeling a number at the bottom. Design should be heat printed on, durable, and indestructible if possible.

**Moderator: Do we put barcodes on all specimens? I know Orthopnet and Lepnet have sent out unique labels for their own database. How do we get the barcode?**

*Deb Paul*-iDigBio people have contributed these answers, surveys, GBIV, how to prioritize, sometimes opportunistically what are needs, how do we begin assigning. Workflow creation, tasks, time and people are needed. Barcodes, barcode needs, where to get how to get them, etc. Every person has unique needs and they help address these.

*Jessica Ware*-Some equipment you find to be more expensive than planned. Tiny color dots were expensive! Our grant was written primarily for the barcode scanners, which are so expensive. Color standards are expensive as well.

*Nicole Gunther*-Be sure to do strength and weakness assessment with all the systems people in your department have used. Do not reinvent the wheel!

*Crowd Response*-curator of insect curation /barcode program creation has published a paper open access, free open software program for making labels, matrix barcode at bottom. (Not sure paper name.)

**Crowd Question- Is there always a need for a barcode identifier?**

*Andy Deans*- we do not use barcodes, we use a data matrix code, used for generating the loan form

*Deb Paul*-Small collections have less need for barcoding. Currently; software reads barcodes. In the future; we foresee automated image processing without barcodes for hundreds of thousands of images. You will be able to track images and know where they are. For a small collection I suggest a globally unique identifier to find the collection specimen with in your lab, vs the one that will be a record on the web

**Moderator:-What are standard protocol for extraction characters on Darwin Core?**

*Andy Deans*-Darwin core are all data types that can be extracted. Terms with explicit description and data field, state, etc., are considered to be important characters.

*Deb Paul*-BSG is responsible for developing biodiversity standards we use for Darwin Core. They provide the standard "who what where" data.

*Andy Deans*-each student in my class must database and use spreadsheets with their own words, then we get in lab together and learn about DarwinCore to compare how they created the spreadsheet.

**Moderator: Should training undergraduates be part of the curriculum?**

*Deb Paul*-In Australia they use Smart backpacks for field collection to collect this data effortlessly. These packs record barometric, camera, and temperature data and are equipped with a hard drive so the site data is databased before its back in the lab. Training for undergraduates is vital in that currently, standards for digitization in labs are either absent or they are self-invented.

*Andy Deans*-People are very concerned with how to share their data with others to make sure it is actually shared correctly, so a training component is definitely important.

**Crowd-How do we ask for money from administrators for digitization efforts?**

*Isa Betancourt*-Getting grants from NSF helps, and often other institutions will match donations and funding.

*Jessica Ware*-I agree, the success rate is higher for digitizing work and broader impacts, and DBI is currently trying to find gems in everyone's grants

*Deb Paul*- Funded work often includes projects with Infrastructure to offer, digital outset images, etc., expertise with data standards. Everybody has an administrator, but the story each one wants to hear is different depending on goals of institution. Student engagement and cross-disciplinary digitization is something most administrators like to see. Otherwise, most collections themselves do not talk to each other. NSF is very interested to see an institution with multiple collection types.

*Nicole Gunther*- Points we need to sell: Development team linked to how our collections are unique. We need all funders to know what our assets at each museum are. All natural history collections are based on priorities.

**Moderator-How do we get more people involved? Do we use crowdsource, public, and interdisciplinary methods?**

*Phil Barden*-For MicroCT technology, most people were not investing until it got to a certain scale, now everybody uses it. At my institute (NJIT) we have opened up new funding opportunities once design students got involved. You need incentives for talented design students, volunteering inquiries are less successful than monetary incentives.

*Kim Russell*-mostly engineering students come in doing work-study projects, and they seem to appreciate form and function. Some have gone into other biomechanics fields, NASA, and the air force with a new unique viewpoint.

*Phil Barden*-We have a couple thousand specimen collection, it's modest and will develop modest collection-based questions. For example, my students ask "Does eye-size correlate with antenna size?" They get credit for taking a course and have to do the work to fuel their project. This, and the questions themselves fuel their passion for the project.

*Jessica Ware*-Several work-study students engaged with the dragonfly scanning because they found the work to be rhythmic and not stressful. They like that it is predictable even if they did not want to go into entomology, they enjoy the job

*Kim Russell*-all the students in my lab are doing it for credit, not payment, but 45 hrs a semester across majors creates a labor force. They can do projects or they can just put hours in. Either way the insects get pinned.

*Isa Betancourt*-For volunteers, sometimes the best work is done through public events. For example, we rehoused our spider collection in the past year using this method. A Geographical Society member applied to volunteer with her own collection and she didn't know any other place to go with it so it got done.

*Christine Sosiak*-When you show all these images to students who do not see these things otherwise, they become engaged. When you bring these organisms to the public, it is a gift and they really enjoy it!

*Deb Pau*l-Computer science departments can be useful to involve. Other involvement avenues include aid visualization, novel datasets, librarian and information science, human interface data, novelty etc. A SPNCH master student has started collection clubs for small collections models who seeded a club at Virginia Tech. Yale has a matching fund program with money for work study so they can hire half as many students. Include local sources with your collection!

**Crowd-How do we find assistance as curators in rural collections?**

**Example:** *Virginia museum of natural history, student power is limited with free labor only 2 days a week*

*They have 600,000 specimens, none are digitized, nobody knows about it. People find out about it by a chance drive past it.*

*Nicole Gunther*-CMNH was not on the radar until 15 years ago. Digitized collections have brought us the attention needed to get grants to get some samples identified in GBIF, otherwise we would not be seen either.

*Manpreet Kohli*-Public members and volunteers come into museum though right? It is a public institution, with volunteer coordinators, list projects available, retirees having interest in entomology, librarians, and teachers, they see unique collections and keep coming back. Some have been doing this for over 4 years which makes a museum a great place to bring public in to help digitize.

**Crowd-As a volunteer frustrated with lack of aid on my rural collection (12,000 people in town) what should I do?**

*Deb Paul*- NAU has a small collection in middle of nowhere. Things you can think about to help digitize collections with little manpower include using digitization software called Symbiota. You put specimen images in the cloud, not research grade just using iPhone, and virtually anybody can help you with your data, your metadata, or getting your name out as a curator and into the pipeline. There are many potential links that can be made between community and virtual community. Make sure US Collections lists your collection in there, its status (what isn't done yet, where it is at).

*Jessica Ware*-Zooniverse is useful in promoting your science

*Andy Deans*-You should consider engaging retirees with an interest in farm life , fly-fishing, and the "old days" You may end up with so many volunteers you don't know what to do with them.

*Crowd*-Zoo education programs from even a small zoo may have an existing volunteer department. If you can engage with natural history volunteers you can skim. Also, you can consider doing a bio-blitz to stir up interest.

*Deb Paul*-To get the images done, you can connect maybe with a photographer club. An additional twist that may help: Archbold is a research station in Florida that is very isolated. They got some money from iDigBio, held a 4 day imaging blitz, got a team together, and turned their research station into an imaging station. Four iDigBio people came and took 5,000 photos in 4 days. Now they have their collection photographed with label data, and they just need somebody to input the data. You can also have a partnership university come learn to do the blitz. Plus, in Northeastern US there are institutions that work to get many people engaged.

**Moderator-What if you have so many students and moving parts... is it a challenge of opposite proportions?**

*Kim Russell- on her army of undergrads*-Commitment and attention to detail are various between individuals in a group. I have had cases where the senior undergraduate becomes the leader of the team. The important part is to find peoples' distinct skills and hone them. Some much prefer imaging, some prefer organizing, some are slow, and some are very fast.

*Nicole Gunther*-Often in our museum samples such as those captured with a Malaise trap, we have people multitask. Some prep and ID, others ID and barcode. We split the work.

**Moderator-Final question, with your personal experiences in mind. Going forward, since we have this huge amount of data we are collecting, what is one big question you are excited to answer if not for digital data?**

*Jessica Ware*-dragonflies are mobile with expanding ranges and digital data will help us know about their geographic range expansion through time

*Andy Deans*-The most urgent and difficult problem we face today are insect declines …is it really happening? Once we have billions of data points, through many years, we will be better informed of the scale of insect loss. For example, when we examine specimens found in Frost's favorite haunts, do we still find what he found? We have tens of thousands of Archbold specimens to examine as well.

*Isa Betancourt*-every day we handle 100 year old specimens, this can inform us how this differs from what we find today.

*Deb Paul*-You can answer questions that go beyond the insect themselves. When we put together diverse digital collection datasets, we can predict ecological study ranges and shifting collection ranges. When we begin linking the data about plants, mammals, and insects we stand to gain the most knowledge.