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This thesis reports the results of a survey of entomologists assessing the utility of different ways to present entomological collections online. Respondents viewed real-world examples of three different digitization techniques—detailed images of individual specimens, a database of label information, and detailed images of entire drawers of specimens—and rated the usefulness of each for a variety of purposes. The survey also collected information on respondents' use of print and online resources, the online resources they use most frequently, and the features and resources most wanted in online resources. Respondents rated drawer images least useful for entomological research, but still useful, and nearly as useful, or more useful, than the other two methods for informing loan requests, education, and outreach. Drawer images also appeared useful for specimen identification. Although significant issues remain, relatively quick and inexpensive digitization methods such as drawer images can be useful for entomological collections.

Headings:

Surveys -- Internet resources.

Entomology -- Catalogs and collections -- Digitization.

North Carolina State University -- Insect Museum.

DIGITAL INSECTS: ASSESSING ONLINE PRESENTATIONS OF ENTOMOLOGICAL COLLECTIONS FOR RESEARCH, EDUCATION, AND OUTREACH

by
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Table of Contents

Introduction

The hundreds of millions of specimens in natural history collections around the world hold a wealth of information about the current state and history of life on earth. Digitizing these collections can vastly expand researcher access to these indispensable resources, and facilitate new insights through aggregation of data within and across collections. Important digitization efforts are underway, but progress is slow. The resources available for digitization are far outweighed by size of the collections to be digitized. Digitization at the specimen level is expensive and labor-intensive, but very few institutions have examined simpler means of digitizing their collections.

In 2011, the National Science Foundation launched a $10 million, 10-year program to fund the digitization of the nation's biological collections.[1] These collections—stuffed birds and mammals, snakes and fish preserved in jars of alcohol, leaves and lichens pressed between sheets of paper, and numerous other kinds of specimens—constitute an invaluable record of the world's biodiversity, and are essential resources for many natural sciences. The 2011 digitization effort is one of the latest to help bring the unique information about the natural world contained in hundreds, if not thousands, of museums into the digital age. Older

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[1] Advancing Digitization of Biological Collections (ADBC), NSF 11-567, http://www.nsf.gov/pubs/2011/nsf11567/nsf11567.htm

efforts, including the Global Biodiversity Informatics Foundation (GBIF) and the Taxonomic Databases Working Group (TDWG), focus on developing standards for databases of biological information, from gene sequences to species catalogs. The goal of these efforts is to make the world's biological data available online, in easily searchable and usable access systems.

One of the largest programs funded by the digitization effort is a regional consortium of Midwestern institutions to create Invernet, an online virtual museum of biological specimens.[2] The program will use an innovative imaging technology to help speed the delivery of online content. Rather than painstakingly photographing single specimens, entire drawers of specimens will be photographed at one time, with many high-resolution images stitched together in a Google Earth-like interface. Users will be able to pan and zoom into the image to reveal the details they are more interested in.

Will this system—and others like it—result in resources useful to the scientists who rely on collections for their research? Can less expensive and faster digitization methods, like drawer images, meet the needs of researchers as well as more traditional (and more expensive) methods of digitization, such as imaging single specimens and transcribing label data? If faster, cheaper digitization methods are not as useful as more elaborate systems, are they still useful enough to justify the time and money their development will consume? These are the principle questions this study addresses.

Although the Invertnet initiative will be the largest effort to date to use drawer imaging technology to digitize biological collections, it is not the only

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[2] Invertnet, http://invertnet.dyndns.org/.

such effort, nor the oldest. The NCSU Insect Museum adopted such an approach to digitizing their collection of some 1.5 million specimens by taking high-resolution photographs of entire drawers of specimens and posting the images online.[3] The GigaPan system allows users to virtually browse the collection and to add annotated "snapshots" of image details. These snapshots are visible to other users, thus not only can users gain information from the Museum, they can also add information and interact with other users. Museum staff hypothesize that the GigaPan images will result in better informed loan requests and increased interest in donations, curation advice from expert users, and increased public engagement with the collections.[4] Early results have been promising, but a comprehensive analysis of the value of the mass digitization effort, and ways to maximize its usefulness to researchers and the institution, remains to be done.

This thesis reports the results of an online survey of entomologists to examine the utility of relatively simple mass digitization techniques such as the GigaPan system for entomological research and other purposes. My hypothesis is that while such techniques might not be ideal for all kinds of research, their benefits can be substantial for many researchers and curators. The adoption of such techniques could make entomological collections available online much more rapidly, and at much lower cost, than is achievable through specimen-level digitization.

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[3] http://www.gigapan.org/profiles/23796/

[4] Matthew A. Bertone, and Andrew R. Deans. "Remote Curation and Outreach: Examples from the NCSU Insect Museum Gigapan Project." Paper presented at the Fine International Conference on Gigapixel Imaging for Science, Carnegie Mellon University, Pittsburgh, Pennsylvania, 11-13 November 2010; http://repository.cmu.edu/gigapixel/26/ (accessed December 2011).

This study was prompted by discussions with staff at the NCSU Insect Museum, where I served an internship in the summer of 2011. The museum staff would like to improve the GigaPan project, but do not know whether the benefits of those improvements will be worth the time and expense of implementing them. This study was designed to, first, help them prioritize their efforts, whether they be in revising the GigaPan system, or concentrating resources on other means of digitization. But the study also gathers wider information about the use of various online resources by entomologists, and examines how the needs for online resources differ among different entomological sub-disciplines, and specialists of different insect orders. The results of the study may thus have a wider relevancy for curators of entomological collections who are considering their own digitization efforts, regardless of their chosen presentation method. The study may have wider application to other types of natural history collections, as well.

To help develop the survey, I interviewed several entomologists connected to the NCSU Insect Museum about their work, and their use of online resoucres. The interviewees had a wide range of reactions to the GigaPan system. Some believed the system was highly useful, both for their own work and for entomological research in general. Others were more skeptical. One of the goals of the survey is to examine how various characteristics of respondents correlate with reactions to the GigaPan system, and with different needs for online resources and features. There may be a generational divide among entomologists in their use of online access systems, and different specialties may have very different requirements of digitization systems. Illuminating those

characteristics will be helpful to collection managers as they develop online resources. The survey also asked respondents to complete a simple identification task using the GigaPan system, and collected information about the chief difficulties involved in using the GigaPan system for identification, to learn how such a system might best be improved. At the very least, I hope that this study will inspire more innovation in mass digitization techniques, and help focus more attention on the needs of collection users.

Background & Objective

Entomologists—particularly taxonomists, though others as well—depend for much of their work on an international network of large and small collections of insects. The size of these collections varies from thousands to millions of specimens. There is no comprehensive catalog of the number of insect collections in the world and the specimens they contain. A recent estimate of all natural history specimens put the figure at 2-3 billion, of which 40% were entomological specimens.[5] There are likely, then, at least a billion insects in the world's entomological collections, only a fraction of which have any representation online.

Digitization of these collections is an enormous task, and is usually carried out by individual institutions on a largely ad-hoc basis. Digitization can refer to several different techniques. In general, these fall into three categories: transcription of specimen label information into an electronic database, digital imaging of individual specimens, and imaging of sets of specimens. The first is most common.[6] A 2008 survey of collections that had received support from the National Science Foundation found that of 49 entomological collections

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[5] Arturo H. Arino, "Approaches to Estimating the Universe of Natural History Collections," *Biodiversity Informatics*, 7 (2010): 81-92; Table 1, p. 88.

[6] Chris Dietrich, "Traditional Approaches to Collection Digitization," 2010, http://invertnet.org/resources/19 (PDF, accessed January 2012).

responding, 13 had at least half of their collection represented in an online database. Only one had more than half of their collection represented by online images, and 46 had imaged 5% or less of their collection.[7]

Imaging of sets of specimens was not identified in the survey, but at least two institutions—the NCSU Insect Museum and the London Natural History Museum—have experimented with the method,[8] and, as mentioned above, Invernet is planning to use a drawer imaging system to digitize its large collection of biological specimens.[9] To date, the NCSU Insect Museum has made the most extensive use of the method, and has posted online images of more than 1200 drawers of pinned specimens. This method of digitizing specimens is much faster and cheaper than specimen-level digitization. The equipment and software necessary cost a few thousand dollars, and with minimal training staff can image a drawer and post the image online in 15 minutes. In contrast, imaging of single specimens can take hours, and much more expensive equipment.[10] Most digitization efforts emphasize databases of label information

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[7] Pamela Ebert Flattau, et al. "Preliminary Findings from the NSF Survey of Object-Based Scientific Collections." Washington DC: Science and Technology Policy Institute (2008): 106-107.

[8] Matthew A. Bertone, and Andrew R. Deans. "Remote Curation and Outreach: Examples from the NCSU Insect Museum GigaPan Project." Paper presented at the Fine International Conference on Gigapixel Imaging for Science, Carnegie Mellon University, Pittsburgh, Pennsylvania, 11-13 November 2010. Vladimir Blagoderov, Ian Kitching, Thomas Simonsen, and Vincent Smith. "Report of Trial of SatScan Tray Scanner System by SmartDrive Ltd." *Nature Precedings*, 2010.

[9] A short announcement with links to media coverage of the digitization effort is here: http://illinois.edu/lb/iList/518#ADBC, and the still-developing Website of the digitized collection is here: http://invertnet.dyndns.org/.

[10] Jay Longson, et al. "Adapting Traditional Macro and Micro Photography for Scientific Gigapixel Imaging." Paper presented at the Fine International Conference on Gigapixel Imaging for Science, Carnegie Mellon University, Pittsburgh, Pennsylvania, 11-13 November 2010. AntWeb Documentation (2010) http://www.antweb.org/documentation.do. (accessed 16 May, 2011).

and "enriched metadata" of collections rather than imaging.[11] But even here, lack of funding and staff time is hampering digitization efforts. A 2009 survey of institutions with ongoing or recent digitization efforts found that the "overwhelming barrier to digitizing collections was a lack of funding or issues directly related to funding," including lack of staff and time.[12]

Entomological collections present unique challenges to digitization efforts. The storage technology for pinned specimens has evolved slowly since the 1700s, when pinned specimens with labels impaled on the pins beneath the specimen appear to have originated.[13] With good preparation and curation, pinned specimens can be preserved for research for decades, even hundreds of years. But the specimens can be very fragile, and often, important taxonomic information is contained in body parts not readily visible without dissection. Data about individual specimens is generally not kept in a central location, such as a ledger or card file. To image a specimen in more than one axis requires removing the specimen from its drawer. Reading label information can be impossible without removing the specimen, and older specimens often have

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[11] Roger Baird, "Leveraging the Fullest Potential of Scientific Collections through Digitization," *Biodiversity Informatics*, 7 (2010): 130-36. Walter G. Berendsohn, Vishwas Chavan, and James Macklin, "Summary of Recommendations of the GBIF Task Group on the Global Strategy and Action Plan for the Digitisation of Natural History Collections," *Biodiversity Informatics*, 7 (2010): 67-71.

[12] Ana Vollmar, James A. Macklin, and Linda S. Ford, "Natural History Specimen Digitization: Challenges and Concerns," *Biodiversity Informatics*, 7 (2010): 93-112.

[13] The history of the technology for storing insect collections is not well documented, but it appears that pinning insects arose about as early as the first insect collections. The use of standard-sized drawers and, later, unit trays, dates from the late 19th and mid-20th centuries, respectively. See Roger C. Smith, "The Tray System for Insect Collections," Transactions of the Kansas Academy of Science 31 (1928): 77-81a; paper delivered at 1926 meeting of the Academy; J. M. Aldrich, "The Division of Insects in the United States National Museum," *Annual Report of the Board of Regents of the Smithsonian Institution*, 1919: 367-379, p. 372; Henry Townes, "A Scientifically Designed Drawer for Scientific Insect Collections," *Entomological News* 84 (1973): 53-61, p. 53; and a brief mention of the use of drawers in W. Conner Sorensen, *Brethren of the Net: American Entomology, 1840-1880*, Tuscaloosa: University of Alabama Press, 1995, p. 40.

hand-written labels that can be difficult to decipher.[14] Even the collection of basic label information and the assignment of unique identifiers to specimens usually requires handling of each specimen. The technology for storing insect collections, while it was served well the needs of previous generations of entomologists, is not well suited for digitization with near-complete data capture. Digitization using traditional methods usually requires handling of thousands, sometimes millions, of individual specimens, many of which are extremely delicate.

Various methods have been proposed to help institutions prioritize digitization efforts, but this advice has been based only on discussions among collection managers. Surveys enquiring about the state of digitization efforts have been distributed to institutions and collection managers, but no research has been done on actual users of these collections. Consortia of collections have spearheaded digitization efforts, and there is a laudable impulse to make data from all collections interoperable among many domains, but little attention has been paid to the needs of domain-specific users, or to study how users interact with existing or planned resources. Researchers in information and library science have recently begun to reshape their understanding of how best to structure information systems through greater attention to user needs, and research in information behavior has shown that scientists increasingly rely on online resources, from electronic journals to Google, for their work.[15] It is highly

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[14] Ana Vollmar, James A. Macklin, and Linda S. Ford, "Natural History Specimen Digitization: Challenges and Concerns," *Biodiversity Informatics*, 7 (2010): 106-107.

[15] Xi Niu, Bradley M. Hemminger, Cory Lown, Stephanie Adams, Cecelia Brown, Allison Level, Marinda McLure, Audrey Powers, Michele R. Tennant, and Tara Cataldo, "National Study of Information Seeking Behavior of Academic Researchers in the United States," *Journal of the*

likely that entomologists do not stand apart from other types of researchers in this regard. But information needs and interaction with information resources can be highly domain-specific.[16] No study, so far as I know, has looked at specifically at entomologists and how they use online resources. Greater attention to the needs of domain-specific users may reveal better ways to digitize collections.

Even if digitization methods like the GigaPan system are not ideal, they may be adequate for enough users to justify their costs. Certainly, if more elaborate digitization efforts have not proved feasible for most or many institutions, simpler, perhaps less ideal, methods could still increase access to collection information, and expose collections to new users, even new user groups. Archivists have recently confronted similar issues. Faced with growing backlogs of unprocessed collections, archives began adopting a "more product, less process" approach, abandoning long-held standards of archival processing in favor of more flexible, much faster, processing techniques.[17] Entomological collections—and perhaps natural history collections more generally—may have reached a similar point. A better understanding of to what extent "more product, less process" techniques can meet the needs of users is the primary goal of this study.

American Society for Information Science and Technology, 61 (2010): 869-90.

[16] Jenny Fry, and Sanna Talja, "The Intellectual and Social Organization of Academic Fields and the Shaping of Digital Resources," *Journal of Information Science*, 33 (2007): 115-33. Rob Kling, Geoffrey McKim, and Adam King, "A Bit More to It: Scholarly Communication Forums as Socio-Technical Interaction Networks," *Journal of the American Society for Information Science and Technology*, 54 (2003): 47-67.

[17] Mark A. Greene, and Dennis Meissner, "More Product, Less Process: Revamping Traditional Archival Processing," *American Archivist*, 68 (2005): 208-63.

Methods

The study used an online survey to assess the utility of mass digitization techniques for entomological research, and to explore how online discovery of and access to entomological collections via simpler digitization methods might be improved. The survey asked respondents to assess the utility for their research of three different methods for presenting entomological collections online, to give general information about their use of and needs for online resources, and to attempt a simple identification task using a GigaPan image. This section discusses the development of the survey, its distribution, and possible limitations of the study.

Development and Distribution of the Survey

To develop the survey, I conducted interviews with entomologists at NCSU about their work with entomological collections, and their use of online resources. From this information, and in collaboration with staff at the NCSU Insect Museum, I drafted the survey questions and created the survey using Qualtrics online tools.[18] The full survey was then pilot tested by entomologists at NCSU, and revised in response to their suggestions.

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[18] http://www.qualtrics.com/. Access to Qualtrics is provided by the Odum Institute at UNC, and I am very grateful for their support in this regard, and for the advice provided by one of their consultants on the wording and scoring of some survey questions.

Insect Museum staff felt that other entomologists would more likely respond to a message from one of their colleagues, rather than from an Information Science student. So, to maximize the response, the messages soliciting participation were sent from one of them, Katja Seltmann, and the message text referenced the NCSU Insect Museum and Andrew Deans' research group at NCSU. The full text of the solicitation message is reprinted in Appendix 2. The link to the online survey was distributed to members of the Entomological Collections Network listserv, to members of the Entomo-L listserv (the most popular general entomology listserv), and directly to some colleagues of NCSU Insect Museum staff, who were believed to be interested in the project and capable of stimulating further responses.[19]

Main Comparison Questions

The full text of the survey can be read in Appendix 1, but let me here discuss in more depth how the survey attempts to fulfill the goals of the study. Evaluating the usefulness of relatively simple digitization systems is the primary goal of the survey. The survey presented respondents with three different ways entomological collections can be represented online: through detailed images of individual specimens; a database of label information, with few or no images; and finally the GigaPan system, representing a "more product, less process" digitization method. The survey gave respondents both a static screenshot of each system, and a link that opened the representative system in another

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[19] Unfortunately, the survey did not ask respondents how they had heard about the study. This information might have been helpful for judging possible bias among the groups from who received solicitation messages. But, as discussed in the Results section, the responses of Raleigh-based researchers did not significantly differ from responses of non-Raleigh researchers.

window. A screenshot of the question and accompanying images as they appeared on the survey is shown in Figure 1. The representative examples of the three digitization methods were chosen from my own exploration of available online resources, and a review of my choices by entomologists at NCSU Insect Museum. We chose AntWeb.org[20] as an example of detailed images of individual specimens, and the Smithsonian Entomology Collection as an example of an online database.[21] Both of these are well-known resources among entomologists. The GigaPan image linked to, and provided in a screenshot, was a drawer of butterfly specimens, the Nymphalidae.[22] The specimens are fairly large, but as respondents were not asked to make any identifications, or to extract any other information from the systems, other than to imagine how useful such a system might be for their own work, the choice of the GigaPan image to link was not, I feel, likely to affect the survey results. All three screenshots are reproduced below.

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[20] http://www.antweb.org/specimen.do?name=casent0177104

[21] http://collections.nmnh.si.edu/search/ento/

[22] http://www.gigapan.org/gigapans/75038/

Figure 1: Screenshot of Main Comparison Question

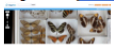
Below are examples of three different ways entomological collections might be presented online. There may not be online resources like these for the group of insects you usually work on, but for the purpose of this question, please imagine that there are, and base your answer on that.

The links and thumbnails below should open in a different window or tab. Look at the tab then click back here to answer this question. Do not close this tab, or your responses might be lost.

1. Detailed images of individual specimens. Example: AntWeb.org [link to website]

2. Database of label information from individual specimens, with no images. Example: Smithsonian Entomology Collections database [link to website]

3. Detailed images of drawers of specimens, where you can zoom-in to individual specimens. Example: NCSU Insect Museum GigaPans [link to website]



How useful do you think resources like these are or might be for your work?

	Useless	Somewhat useless	Neutral	Somewhat useful	Very useful
Detailed images of individual specimens	○	○	○	○	○
Database of label information	○	○	○	○	○
Detailed images of drawers of specimens	○	○	○	○	○

Figure 2: Example Screenshot from AntWeb.org

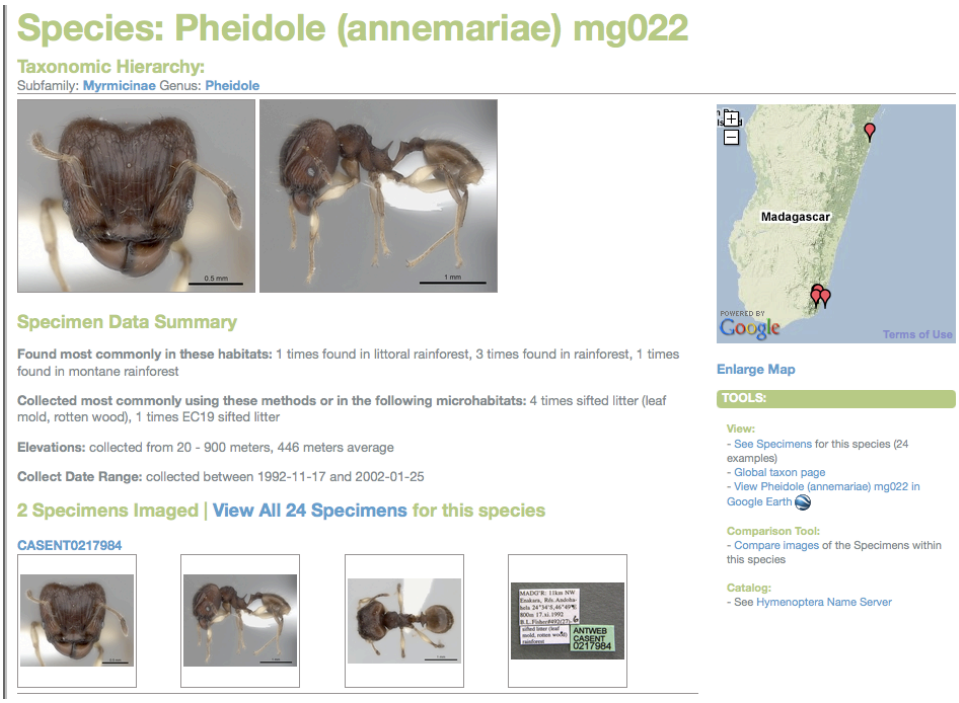


Figure 3: Example Screenshot from Smithsonian Entomology Database

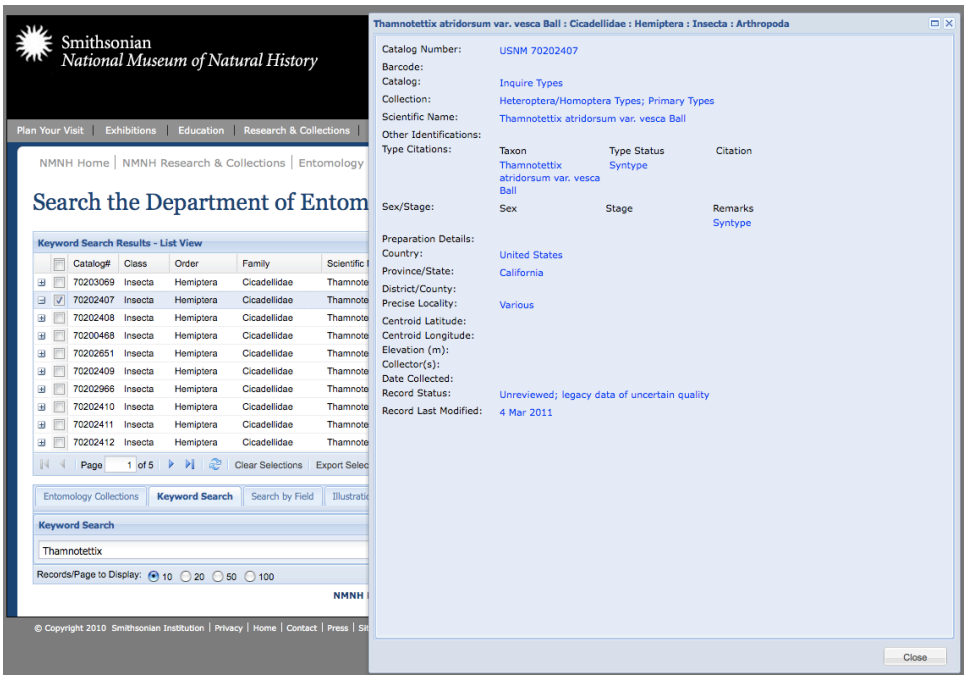
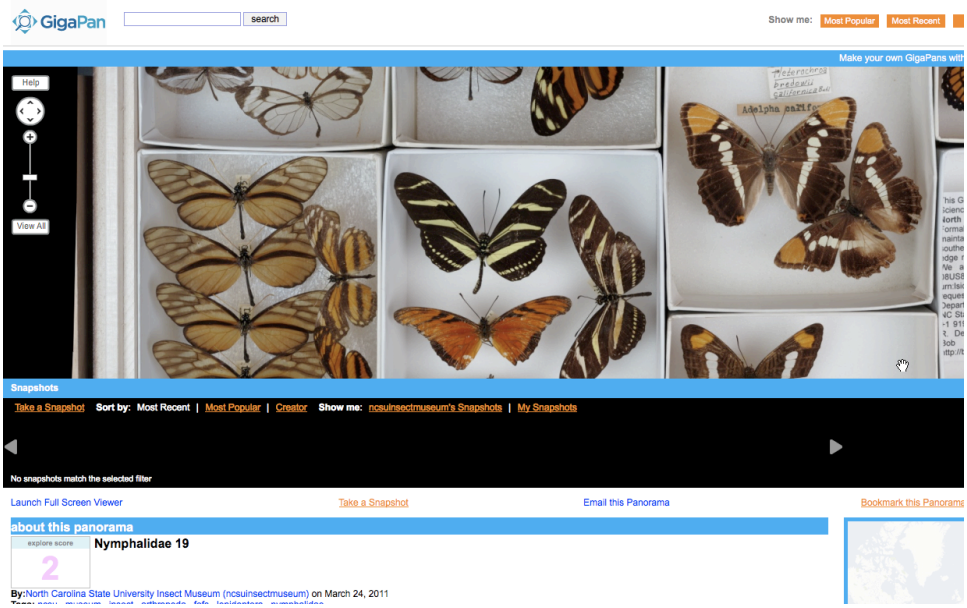


Figure 4: Example Screenshot from GigaPan System



Answering the comparative question required a bit of imagination from respondents, in that it was impossible to link to a representative system or screen pertinent to the research and order specialties of each respondent. If the representative system was not relevant to their particular sub-domains of knowledge, respondents had to imagine how useful a relevant system of a similar kind is or would be. Another complication was that for the database system, it was impossible to link directly to a page with data. Only the entry point to the database could be linked to. To explore that system, respondents would have to browse or do a simple query on their own in order to see how the system presented data. The static screenshot, however, showed a page with data, so respondents could get an idea of how the database presented information without having to browse the system themselves.

To have better parity in the way the online systems were presented, I contemplated using only static screenshots of each, but this, I felt, unfairly weakened the presentation of the GigaPan system, which relies on panning and zooming as one of its key functionalities. Moreover, I felt that respondents would likely be familiar enough with label databases and their functions that exploring the linked-to database would not be difficult for them. It is possible that this difference in how the systems were presented in the survey skewed the results, but I do not believe it did to any appreciable degree. The database system did not score badly in the comparison tests, as we shall see, and no respondents mentioned in their comments the lack of parity in the links.

Identification Task

To supplement the comparative questions, we included in the survey a simple identification task using GigaPan images. I wanted this task to help introduce respondents to the GigaPan system, and to help us gauge how easily respondents could extract identifying information from GigaPan images. The identification task was presented before the main comparative question, and Figure 5 shows a screenshot of the question as it appeared in the survey. It linked to a GigaPan image of a drawer of the four common orders of insects—Hymenoptera, Coleoptera, Lepidoptera, and Diptera[23]—and asked respondents to estimate the percent of the specimens they could identify to at least the family level, considering only the group in the image the respondent was most familiar with. The linked-to image is shown in Figure 6. A later question in the survey gave respondents the opportunity to volunteer for a follow-up study to investigate in more depth the use of GigaPan images for specimen identification. Thirty-nine respondents volunteered for the follow-up study, which asked them to identify specimens from the insect group they were most familiar with. This follow-up study is still on-going, and results are not yet available. Our hypothesis is that even if the GigaPan system is not rated highly *in comparison to more elaborate systems*, the identification tasks would help show whether or not the GigaPan images were useful, in an absolute sense, for online identification of specimens.

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[23] http://www.gigapan.org/gigapans/fullscreen/49310/

Figure 5: ID Task Using GigaPan Image

How good are you at identifying to the family level specimens from the following orders?

	Very Bad	Bad	Average	Good	Very Good
Hymenoptera	○	○	○	○	○
Coleoptera	○	○	○	○	○
Lepidoptera	○	○	○	○	○
Diptera	○	○	○	○	○

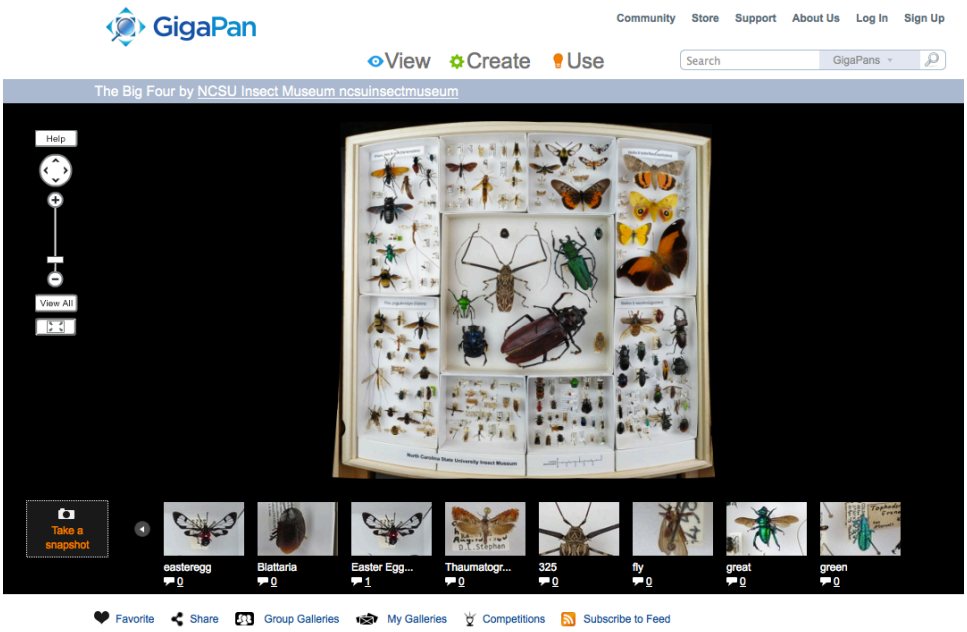
Take a look at this image of a drawer of pinned specimens (the link will open in new window). Considering only the order with which you are most familiar, and ignoring any label information, what number below is closest to the proportion of the specimens can you confidently identify at least down to the family level?

0%	25%	50%	75%	100%
○	○	○	○	○

For those specimens that were difficult or impossible to identify, what were the chief reasons why identification was difficult? (Check all that apply.)

- ☐ Lack of familiarity with the order or family
- ☐ Image was not detailed enough
- ☐ Specimen was too small
- ☐ Needed images from other angle(s)
- ☐ Other; please specify:

Figure 6: GigaPan Image for ID Task



Limitations of the Study

In designing the survey, I attempted to present representative examples of online presentation methods for comparison, and to test the usefulness of the GigaPan images both in comparison to other systems, and in isolation for a simple specimen identification task. Potential problems with these measures were, I feel, adequately addressed. But some other potential problems with the study I could not address, and the extent to which they affect the results and conclusions of this study are unknown.

The first of these is a lack of information about the representativeness of the study sample. The survey collected basic information about respondents' degrees, institutional affiliations, and research and insect order specialties. But I have not been able to find statistics about the distribution of such characteristics among the entomological community as a whole. Thus it is impossible to judge how accurately the sample reflects the population. The survey questions about institutional affiliation, work specialty, and insect order specialty, were based on similar questions on the Entomological Society of American (ESA) membership form,[24] and the entomologists whom I worked with in designing the survey found the categories sufficient to encompass the wide range of entomological work as they knew it. But I was able to obtain from the ESA only geographical information about their membership,[25] and, in any case, the ESA appears not to collect information about work and order specialties from all their members,

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[24] https://online.entsoc.org/esassa/censsacustmast.insert_page? The ESA is the world's largest entomological organization, with some 6,400 members (ESA, "About ESA" Webpage, http://www.entsoc.org/about_esa, accessed January 2012).

[25] Personal communication from Chris Stelzig, ESA Member Services, 14 June 2011.

only from those who complete the online form from the ESA Website.[26] Without such information from the ESA or a similarly large entomological organization, I have no way to test whether or not the study sample is representative of entomologists in general.

A second potential limitation is that the many sub-specialties of entomology may have very different preferences as users of digitized collections. Researchers looking primarily at biodiversity, for example, will likely be most interested in digitized label information and broader metadata about collections. Taxonomists of some families may require detailed images of certain body parts that a system like GigaPan cannot easily capture. A question asking a respondent to judge the utility of the GigaPan system will be judged differently according to how closely the specimens shown as examples are related to a respondent's specialty. A specialist on ants may judge the usefulness of the GigaPan system differently if shown an example of a drawer of moth specimens than if shown a drawer of ant specimens. Unfortunately, there was no way for a single survey to allow all respondents to view images of specimens pertinent to their research specialties. The follow-up study will address this in a limited way, but the diversity of needs within the entomological community will have to be the subject of further research. The survey results will also only apply to a certain type of entomological specimen—the dry, pinned specimen. Other kinds of specimens, such as those mounted on slides or preserved in vials of alcohol, are

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[26] The paper membership form, and the downloadable PDF of the form, do not ask for information about work or order specialties (http://www.entsoc.org/PDF/membership/Join2012.pdf, accessed January 2012).

not represented in the survey, and the drawer imaging system included in the evaluation does not have any obvious application to collections of those types.

Finally, there may be a significant group of entomologists who are not comfortable using online systems, and they are likely to be underrepresented in an online survey distributed via listserv. In interviews with six entomologists at NCSU in preparation for this study, there seemed to be a generational divide in terms of the use of online resources. Older entomologists I spoke to rarely used the Internet for their work, relying instead on printed publications and physical specimens. Younger entomologists were more likely to access information online, and were in general more enthusiastic about the GigaPan project. The online survey may thus overstate the usefulness to entomologists as a whole of any digitization technique, although comparisons among different techniques would still be useful.

The selection bias inherent in the use of an online survey may, however, have some ameliorating benefits in that those most likely to take the survey are also those most likely to be frequent users of online entomological resources. So, while the online survey will likely exclude entomologists who do not currently use Internet resources often, those who participate in the survey are more likely to be the user group for any new or current online system that might take advantage of the survey's findings.

Results and Discussion

This section reports findings from the principle components of the survey, discusses those results, and examines how responses differed among various groups. A simple tabulation of all complete survey responses is presented in Appendix 1. Below, I look first at what we know about who took the survey, including their research specialties, institutional affiliations, the insect orders they specialize in, and their use of online resources. The next section examines responses to the comparison of online presentation methods, the utility of each method for different purposes. I then examine the difficulties in determining whether insect order specialties might have impacted the survey results, and how responses differ by the geographic location of the respondent. Next, I look at what features in online presentations respondents desired most, and how respondents performed on the survey's simple identification task.

Characteristics of Those Who Completed the Survey

Three weeks after the survey link was distributed, over 150 respondents had completed at least part of the survey. From these responses, 104 respondents clicked through the entire survey, and were shown in the final Qualtrics report as having 'completed' the survey. Of these, however, only 94 recorded enough responses to be included in the data analysis. In this thesis, then, when I refer to those who completed the survey, I am referring only to these 94 respondents.

The analysis of the data was primarily done using JMP Pro 9 statistical software, with some additional use of Excel and Qualtrics' analysis tools.

Research Specialties

The survey asked respondents to report their primary and secondary fields of work or research, the year they completed the degree that qualified them to work in their field, their institutional affiliation, and the primary and secondary insect order they specialized in. To make comparisons among the groups easier, I divided the specialties into three larger categories based on whether the respondents identified taxonomy or systematics as either a primary or secondary specialty. The results are shown in Table 1. Non-taxonomists did not list either taxonomy or systematics as their primary or secondary specialty. Semi-taxonomists listed either taxonomy or systematics as their secondary, but not primary, specialty. Taxonomists listed taxonomy or systematics as their primary specialty. Since I could not definitively say whether the specialty "curatorial" involved taxonomy or

Table 1: Respondents' Primary Specialties

Non-taxonomists	**29**
Agricultural Entomology	5
Agronomy	1
Apiculture	2
Aquatic Entomology	1
Biodiversity	2
Biological Control	3
Botany	1
Ecology	6
Forest Entomology	1
IPM-Agricultural	1
Molecular Biology	1
Physiology	1
Plant-Insect Interactions	1
Regulatory Entomology	1
Urban and Structural Entomology	1
Zoology	1
Semi-taxonomist	**11**
Agricultural Entomology	1
Aquatic Entomology	2
Biodiversity	3
Biological Control	1
Ecology	1
Forest Entomology	1
Morphology	1
Zoology	1
Taxonomist	**44**
Systematics	31
Taxonomy	13
Unclassified	**10**
Biodiversity	2
Curatorial	8
Grand Total	**94**

not, any respondent who did not fall into the Taxonomist category or Semi-taxonomist category, but who gave curatorial as their primary or secondary specialty, I assigned to the Unclassified category.

Most of the respondents—44 of 94, or about 47%—identified themselves as working in either taxonomy or systematics. Another 11 respondents (12%) listed taxonomy or systematics as their secondary specialty. Non-taxonomists accounted for 29 (31%) of the respondents, and 10 (11%) fell into the Unclassified category. Respondents listed a diverse array of specialties aside from taxonomy and systematics. Ecology (6 respondents), agricultural entomology (5), and curatorial (8) were the most common primary specialties. No other specialty was reported more than 3 times. While I do not, as noted above, have any data about the mix of specialties among entomologists as a whole, it is probably safe to say that the survey sample is not representative in its plethora of entomologists concerned with taxonomy.

Institutional Affiliations

Most of the respondents are affiliated with a college or university, either as staff/faculty, or as students. Of the 94 complete surveys, 34 respondents (36%) were university or college staff or faculty, and three out of four of these hold PhDs. College students and museum workers were the next largest contingents among respondents, each accounting for 22% of the total number of completed surveys. Other affiliations were far less numerous, with only 10 respondents reporting affiliation with a federal or state agency, and four respondents identifying as amateur or hobbyist entomologists. Although the number of non-PhD, non-university-affiliated, respondents was rather low, the range of

Table 2: Respondents' Institutional Affiliations and Degrees Held

Affiliation	BA/BS	PhD	MA/MS	None	Total
University or College Staff or Faculty	1	26	7		34
Museum (private, government, or university)	2	9	7	3	21
University or College Student	7		12	2	21
Federal Government Agency	1	4			5
State or Local Government Agency	3	1	1		5
Amateur/Hobbyist	1	1		2	4
Private Business or Corporation			2		2
Other		1			1
Self-Employed			1		1
Grand Total	**15**	**42**	**30**	**7**	**94**

affiliations represented demonstrate the variety of work and research roles occupied by entomologists, and the corresponding difficulty of designing a single digitization system to suit the needs of all of them. See Table 2, below, for a complete breakdown of the responses.

Insect Order Specialties

Given the incredible morphological variation among insect species, it seemed logical to me that specialists in some orders would find particular digitization methods more useful than others. Representatives of some orders are generally much larger than representatives of other orders, or have (like Lepidoptera) features important for classification that are easier to capture in digital images. See Table 3 for a list of all primary order specialties. Two groups accounted for nearly half of the responses. Specialists in Coleoptera (Beetles) were 25 of the 94 respondents (27%), and specialists in Hymenoptera (Ants, bees, and wasps) were 20 of the respondents (21%). The only other large specialty group was the All, or General Entomology, group, with 17 respondents (18%). Expertise among the

remaining respondents is distributed among 14 other insect orders, with only 5 order specialties represented by more than a single respondent.

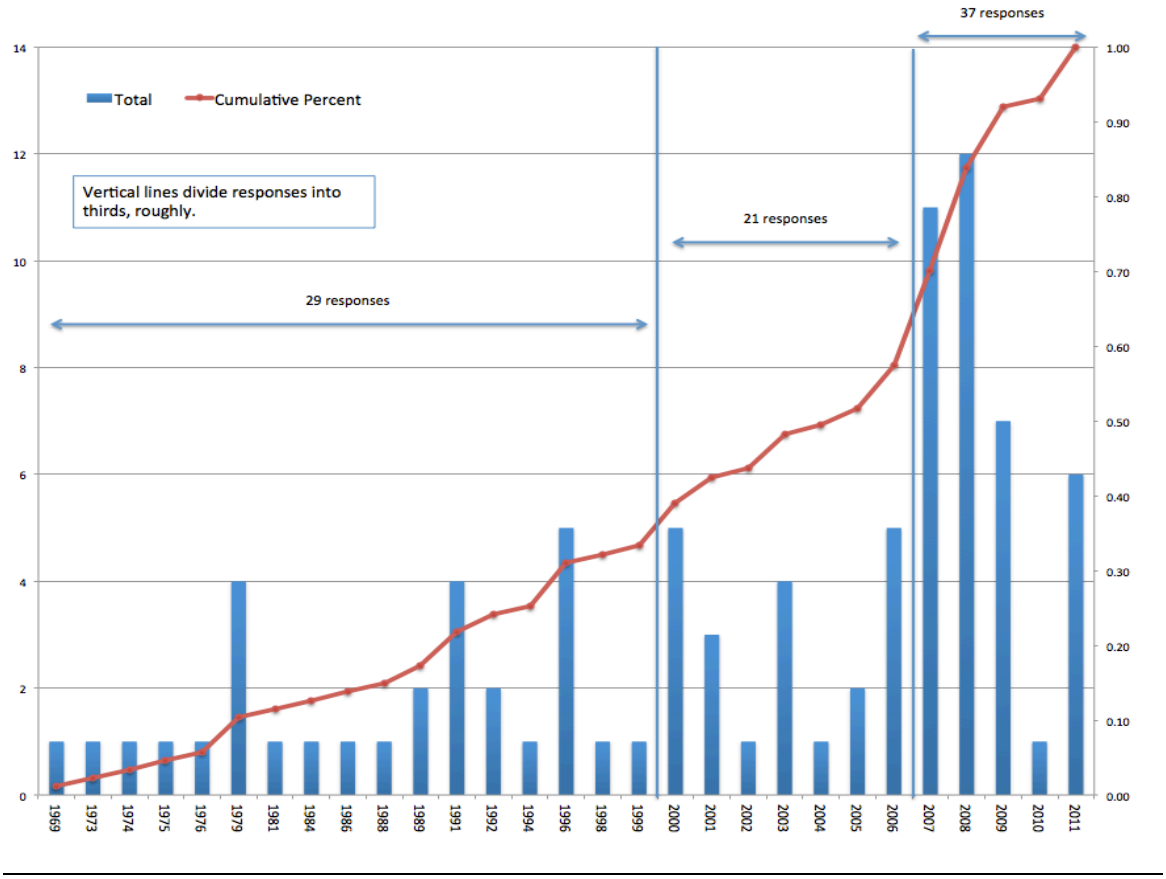
Table 3: Primary Order Specialties	N	%
Coleoptera (beetles)	25	27%
Hymenoptera (ants, bees, wasps)	20	20%
All, or General Entomology	17	18%
Homoptera (aphids, fleahoppers)	6	6%
Lepidoptera (butterflies, moths)	6	6%
Diptera (true flies)	5	5%
Hemiptera (true bugs)	4	4%
Thysanoptera (thrips)	2	2%
Neuroptera (lacewings)	1	1%
Blattodea (roaches)	1	1%
Isoptera (termites)	1	1%
Orthoptera (grasshoppers, crickets)	1	1%
Plecoptera (stonefiles)	1	1%
Trichoptera (caddis flies)	1	1%
Ephemeroptera (mayflies)	1	1%
Mecoptera (scorpionflies)	1	1%
no answer	1	1%
Grand Total	**94**	

Age of Respondents

Based on my initial interviews of entomologists for this project, I believed that older entomologists would find online tools less useful than younger entomologists. The survey asked respondents to report the year they had obtained the highest degree that qualified them for work in entomology as a proxy for age. See Figure 7: Chart of Respondents' By Degree Year, for a complete breakdown of the responses. Most of the respondents reported receiving their qualifying degrees quite recently. More than one third (37 respondents, or 43% of all respondents) received their degree in 2007 or after. Another 21 respondents (24%) received their degrees between 2000 and 2006. Finally, a long tail of respondents (29, or 33%) received their degrees between 1969 and 1999. Seven respondents did not have a qualifying degree, and so did not answer this question. As shown in more depth below (see page 34), year-of-degree did not have any apparent affect on how respondents rated the usefulness of online resources. Ratings for the usefulness of online

resources given by entomologists who received their professional degrees before 2000 were nearly identical to the ratings given by respondents who received their degrees more recently.

Figure 7: Chart of Respondents' By Degree Year



Geographical Distribution of Respondents

After the results of the survey began to come in, the entomologists I was working with to design the survey were curious about possible international differences in responses to the digitization methods the survey presented. They hypothesized that entomologists from outside the US, and in particular from less developed countries, might find even the simplest digitization methods more

more useful than their US-based colleagues. Although the survey did not ask respondents to supply information about their geographical location or nationality, the Qualtrics software captured the IP addresses of respondents, and using a simple online lookup tool I was able to resolve these to country and city from which the respondent was accessing the survey. This is, of course, not a direct measure of the nationality of respondents, and even the geographic location of a respondent's IP address may not match the location where he or she was actually taking the survey. But without repeating the survey with an additional question about nationality, using the IP address is the best we can do. It is not entirely unreasonable to assume that most respondents took the survey within the city and country where they commonly work.[27]

Table 4: Location of Respondents, Based on IP Address

Country	Total	%
United States	**65**	**69%**
Non-Raleigh	53	56%
Raleigh, NC	12	13%
Non-US	**29**	**31%**
Argentina	2	2%
Australia	6	6%
Canada	6	6%
Colombia	1	1%
Denmark	1	1%
France	2	2%
Germany	1	1%
Italy	1	1%
Mexico	1	1%
Netherlands	1	1%
Peru	1	1%
Romania	1	1%
Spain	1	1%
Turkey	1	1%
UK	3	3%
Grand Total	**94**	

With those caveats in mind, then, let us look at the geographic location of the respondents. The vast majority of respondents were completing the survey from the US: 65 of 94 respondents (69%) had a US-based IP address. This makes the respondents slightly more international than the general membership of the

[27] Note that in the survey results appended to this thesis, the IP addresses of respondents are not listed, as doing so would unduly compromise the anonymity of some respondents. Geographic location is instead given only according to the three broad categories used in the data analysis: US respondents from states other than North Carolina, US respondents from North Carolina, and Non-US respondents.

Entomological Society of America, which reports that 85% of its members are from the US.[28] US responses came from 28 different states, with the largest groups from North Carolina (16 responses, 25% of US responses, and 17% of all responses) and California (12 responses, 18% of US, 13% of total). To test possible differences between respondents in Raleigh and respondents elsewhere in the US and abroad, I separated responses from Raleigh into their own group. Raleigh respondents are highly likely to be affiliated with NCSU, and somewhat likely to be NCSU Insect Museum staff, or at least acquainted with the Museum and its activities. Because of this, they might be more favorably inclined toward the GigaPan digitization system, and if so, their responses would skew the overall results.

Use of Entomological Collections and Online Resources

A large majority of respondents reported finding online resources, print resources, and specimens very useful for their work. There were no significant differences in how respondents rated the usefulness of the five categories of resources included on the survey (Question 8). Online books and/or journals were rated most useful. On a scale of 1 (useless) to 5 (very useful), online books and journals had a mean score of 4.74. Online resources specifically for entomology, other than books and journals, were rated least useful, with a mean score of 4.49. This could reflect the fact that online resources for entomology tend to be designed for specialists in a particular type of work or order of insect.

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[28] Personal communication from Chris Stelzig, ESA Member Services, 14 June 2011. Op. cit., note 25.

Table 5: How Useful for Your Work are the Following Kinds of Resources?							
Resource	**Useless**	**Somewhat useless**	**Neutral**	**Somewhat useful**	**Very useful**	**N**	**Mean**
Online books and/or journals	0	1	2	17	74	94	4.74
Printed books and/or journals	0	2	2	20	70	94	4.68
Google or other all-purpose online resources	0	1	5	23	65	94	4.62
Specimens (borrowed or in your possession)	1	2	9	13	68	93	4.56
Online resources specifically for entomology (other than online books or journals)	0	4	6	24	60	94	4.49

The survey alone does not give us a good picture of how entomologists use online resources. A more in-depth study, involving more ethnological methods, would be helpful in that regard. But the survey did ask respondents to name the "online resources specifically for entomology" they use in their work. Eighty respondents answered that question, specifying up to 222 resources, ranging from general Google searches to sophisticated Websites devoted to particular insect orders and/or geographical regions. The original text of all the responses is reproduced in Appendix 1 (question 9). I say "up to 222 resources," because parsing some of the responses into individual resources, and grouping synonymous terms, involved some subjective interpretation of the respondents' intent. Grouping the responses into simple groups also proved difficult, because of the variety of possible uses many of the resources support. The list is also impressionistic because respondents were asked to recall resources in a very unstructured way. Several respondents noted in their response that there were

many other resources they were not listing, or that there were simple "too many to list." To accept the responses as meaningful, we have to assume that the resources the respondents listed were foremost in their minds because of the frequency of their use and/or their importance for the work of the respondents. This assumption is not unreasonable, I believe, but it is certainly open to question.

Table 6: Mean Ratings of Usefulness of Types of Resources by Proximity to Collection

8. How Useful for Your Work are the Following Kinds of Resources?
Group A = Respondents who work in a museum, and use its collection the most
Group B = Respondents who use more distant collections

	Mean	
(1 = Useless; 5 = Very Useful)	A (N=47)	B (N=47)
Printed books and/or journals	4.70	4.66
Online books and/or journals	4.66	4.83
Google or other all-purpose online resources	4.53	4.70
Online resources specifically for entomology (other than online books or journals)	4.34	4.64
Specimens (borrowed or in your possession)	4.77	4.35

Nonetheless, one of the striking things about the list of resources is the prevalence of Websites that feature simple images of insects. The unambiguous leader of the listed resources is BugGuide.net, which was listed by 25 of the 80 respondents. Similar, or even simpler, image resources, such as Google Images, Wikipedia, Wikimedia, and Flickr were also among the resources listed. From these results, it seems clear that simple imaging systems to help entomologists quick ID specimens can be highly useful.

The survey also tried to gauge the usefulness to respondents of physical entomological collections, and how proximity to collections might influence their use of online resources. As we have seen above, a large majority of respondents

reported that entomological specimens were very important to their work. Question 20 asked respondents "How important to your work are collections of entomological specimens." Again, a large majority—70 of 93 respondents, or 75%—reported that collections were "very important." Borrowing specimens, however, was not as widespread, as 31% of respondents reporting (Question 21) that they had not borrowed any specimens from an entomological collection in the past year. Those who had borrowed specimens tended to borrow from only a few collections, as 78% of respondents who had borrowed specimens reported borrowing from less than five collections in the last year (Question 22). More than half (51%) of those who use collections work at the institution that houses the collection they use the most, and a further 22% work within a short distance from the collection they use the most (Question 23). Even those respondents who work within the institution that houses the collection they use the most, however, used online resources extensively in their work. Respondents who work most with a collection were only slightly less likely to rate online resources as "very important" as were respondents who worked with more distant collections. The differences in rankings between the groups were not, however, statistically significant.

The age of respondents, as measured by the year they received their highest professional degree (Question 6), had no significant affect on how respondents rated the usefulness of online resources (Question 8). As shown above, in Figure 7, nearly two thirds of respondents reported receiving their highest professional degree after 1999. Respondents who received their highest degree in 1999 or before had virtually identical ratings for the usefulness of

online resources as did those who received their degrees in 2000 or after. There were no statistically significant differences in the ratings in Question 8 between those who had received their degrees before 2000 and more recent (and presumably younger) degree recipients.

Table 7: Mean Ratings of Usefulness of Types of Resources by Year of Highest Professional Degree

8. How Useful for Your Work are the Following Kinds of Resources?

Group A = Respondents who received their highest professional degree before 2000.

Group B = Respondents who received their highest professional degree in 2000 or after.

	Mean	
(1 = Useless; 5 = Very Useful)	A (N=29)	B (N=58)
Printed books and/or journals	4.86	4.55
Online books and/or journals	4.62	4.79
Google or other all-purpose online resources	4.55	4.62
Online resources specifically for entomology (other than online books or journals)	4.45	4.48
Specimens (borrowed or in your possession)	4.55	4.55

Comparison of Online Presentation Methods

The heart of the survey was a series of questions asking respondents to rate the usefulness of three different ways to present entomological collections online. (See page 13 and forward for a full discussion of how this part of the survey was structured.) Overall ratings for the usefulness of the GigaPan system were disappointingly low, although respondents reported high levels of success on the simple ID task using only a GigaPan image.

As I described in an earlier section, the main comparison question (Question 13) asked respondents to view three representative presentations of entomological collections, and then to rate how useful they thought each type of system would be for their own work. Detailed images of individual specimens (represented by AntWeb.org in the survey), was rated highest, with 77 of 94 respondents (82%) rating it as "very useful," the highest rating possible on the survey. The system's mean rating was 4.8 out of a possible 5. Databases of label

Table 8: How useful do you think resources like these are or might be for your work?

	Useless	Somewhat useles	Neutral	Somewhat useful	Very useful	N	mean
Detailed images of individual specimens	0	1	0	16	77	94	4.8
Database of label information	1	7	11	33	42	94	4.2
Detailed images of drawers of specimens	5	17	11	30	31	94	3.7

information were ranked second, with a mean rating of 4.2, while the Detailed images of drawers of specimens were rated lowest, with a mean rating of only 3.7. Only 33 of 94 respondents felt neutral toward drawer images or rated them useless or somewhat useless, indicating entomologist would find them useful, just not as useful as the other two methods shown.

Taxonomists and Non-taxonomists had nearly identical ratings for the usefulness of individual specimen images and label databases, but rated the usefulness of drawer images quite differently.[29] Non-taxonomists were likely to find the drawer images more useful than taxonomists. The difference is statistically significant at the .05 level using a Chi-square test, though only just (P=0.0489). Using the more conservative Pearson calculation of Chi-square the differences are not significant (P=0.0569).

Table 9: Usefulness of Presentation Types by Taxonomists (N=44) and Non-taxonomists (N=32)

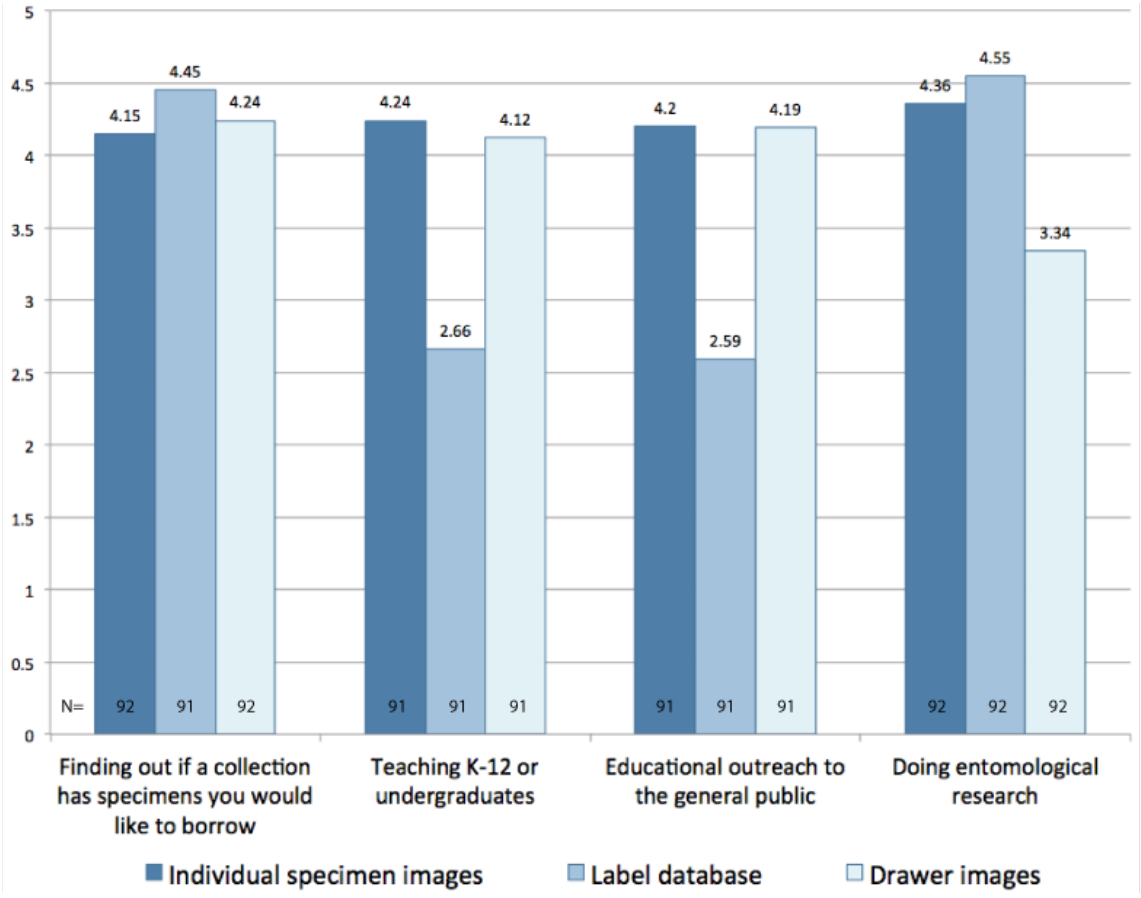
	Detailed images of individual specimens		Database of label information		Detailed images of drawers of specimens	
	Tax.	Non-Tax.	Tax.	Non-Tax.	Tax.	Non-Tax.
Useless	0	0	0	1	3	1
Somewhat useless	1	0	4	3	11	3
Neutral	0	0	3	3	8	2
Somewhat useful	6	4	18	9	13	11
Very useful	37	28	19	16	9	15
mean	4.80	4.88	4.18	4.13	3.32	4.13
difference	-0.08		0.05		-0.81	

[29] I describe how respondents were grouped into "taxonomist" and "non-taxonomist" groups above, under Research Specialties.

Comparison of Presentation Methods For Different Purposes

This raises the question of what purposes taxonomists and non-taxonomists felt the drawer imaging system was useful, or not useful, for. In Question 14, respondents rated the usefulness of the three different presentation types for four purposes: finding out if a collection has specimens you'd like to borrow; teaching K-12 or undergraduates; educational outreach to the general public; and doing entomological research. The ratings for all respondents are shown in Figure 8. Here, drawer images were rated more useful than individual specimen images for investigating possible loan requests, and nearly as useful as individual specimen images for education and outreach. But the only dramatic differences

Figure 8: Usefulness Ratings for Presentation Methods for Different Purposes

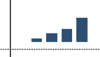


among the methods were that a database of label information was rated much less useful than the other two methods for teaching and outreach, while drawer images were (again) rated much less useful for entomological research.

Interestingly, ratings for doing entomological research were lower for all three methods in this second question than in Question 13, and rated most useful were databases of label information, rather than detailed images of individual specimens. This may reflect the different wording of the two questions—the first asked respondents to rate the usefulness for "your work," while the second asked them to rate the usefulness for "entomological research," which not all respondents would necessarily consider their work.

Differences between taxonomists and non-taxonomists can be clearly seen in the usefulness ratings for different purposes. As shown in Figure 9, non-taxonomists were more likely to rate both single-specimen images and drawer images as more useful than taxonomists. The largest differences were in ratings

Figure 9: Taxonomists' and Non-taxonomists' Ratings of Usefulness of Presentation Methods for Different Purposes

		Purpose											
		Finding out if a collection has specimens to borrow			Teaching K-12 or undergraduates			Educational outreach to the general public			Doing entomological research			Mean rating across all purposes	
Method		ratings	mean	dif.	ratings	mean	dif.	ratings	mean	dif.	ratings	mean	dif.		
Specimen images	non		4.20	0.08		4.43	0.31*		4.50	0.5*		4.50	0.24	4.41	0.29*
	tax		4.12			4.12			4.00			4.26		4.12	
Label database	non		4.20	-0.35		2.97	0.40*		2.93	0.36		4.53	-0.02	3.66	0.10
	tax		4.55			2.57			2.57			4.56		3.56	
Drawer images	non		4.30	0.02		4.33	0.33*		4.37	0.34*		3.90	0.95*	4.23	0.41*
	tax		4.28			4.00			4.02			2.95		3.81	

* Significant at .05 level, although calculation of Chi Square for ordinal ratings suspect due to low cell numbers

N = 30 Non-taxonomists, 42 taxonomists

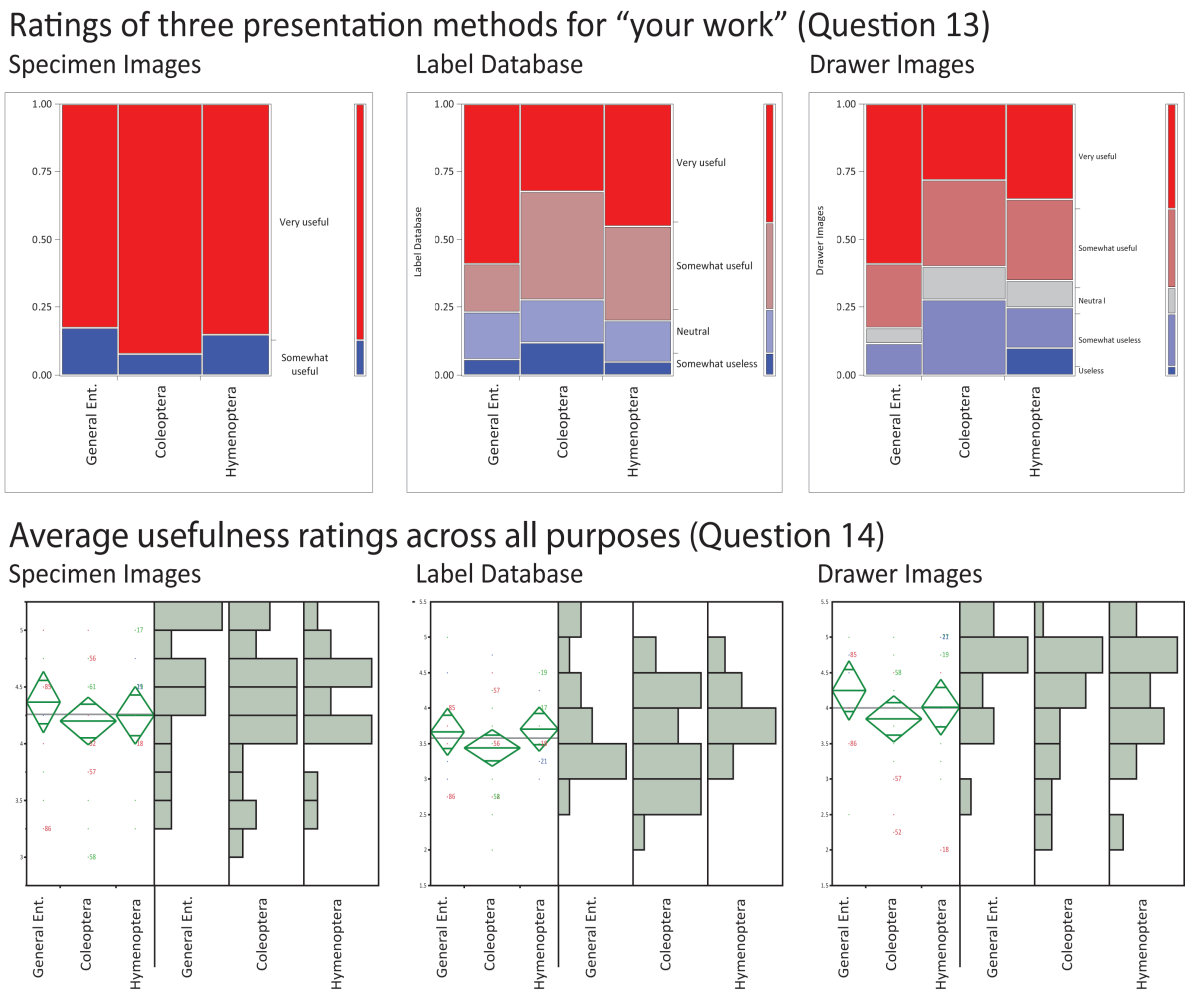
for drawer images. Both taxonomists and non-taxonomists rated drawer images as least useful for entomological research, but non-taxonomists thought the method would be significantly more useful than taxonomists. Non-taxonomists also had a more positive reaction to drawer images for teaching and outreach, though the differences between the two groups were not as large as for research. The ratings of the other two presentation methods given by taxonomists and non-taxonomists for doing entomological research do not differ significantly.

Comparison of Responses by Order Specialties

It is more difficult to say whether differences in primary order specialties had a significant relationship to how various presentation methods were rated. There are too few responses, too many different order specialties represented among the respondents (many with only one representative; see Table 3: Primary Order Specialties, above), and no meaningful way to consolidate the order specialties into larger groups. To simplify the data, I looked again at usefulness ratings for the three different presentation methods (Questions 13-1 through 13-3) and at average usefulness ratings for each system for all purposes (Questions 14-16). But this time, I excluded all order specialties except the three most common—Coleopterists (N=25), Hymenopterists (20), and General entomologists (17). Together, these account for 66% of all respondents. As shown in Figure 10, the differences in the responses of these three specialties were slight, and in no case statistically significant. The only marked difference was that General entomologists tended to rate the drawer images as more useful than Coleopterists and Hymenopterists. Reducing the complexity further, by

consolidating usefulness ratings into either "neutral to useless" or "somewhat or very useful" did not reveal any significant differences among the three specialties, either. I tentatively conclude from these data that order specialty is not as strongly related to respondents' usefulness ratings as respondents' sub-disciplines (taxonomist/non-taxonomist).

Figure 10: Differences Among Three Order Specialties in Ratings for Presentation Methods, and Average Ratings for Methods Across all Purposes



Differences Among Responses By Geographic Location

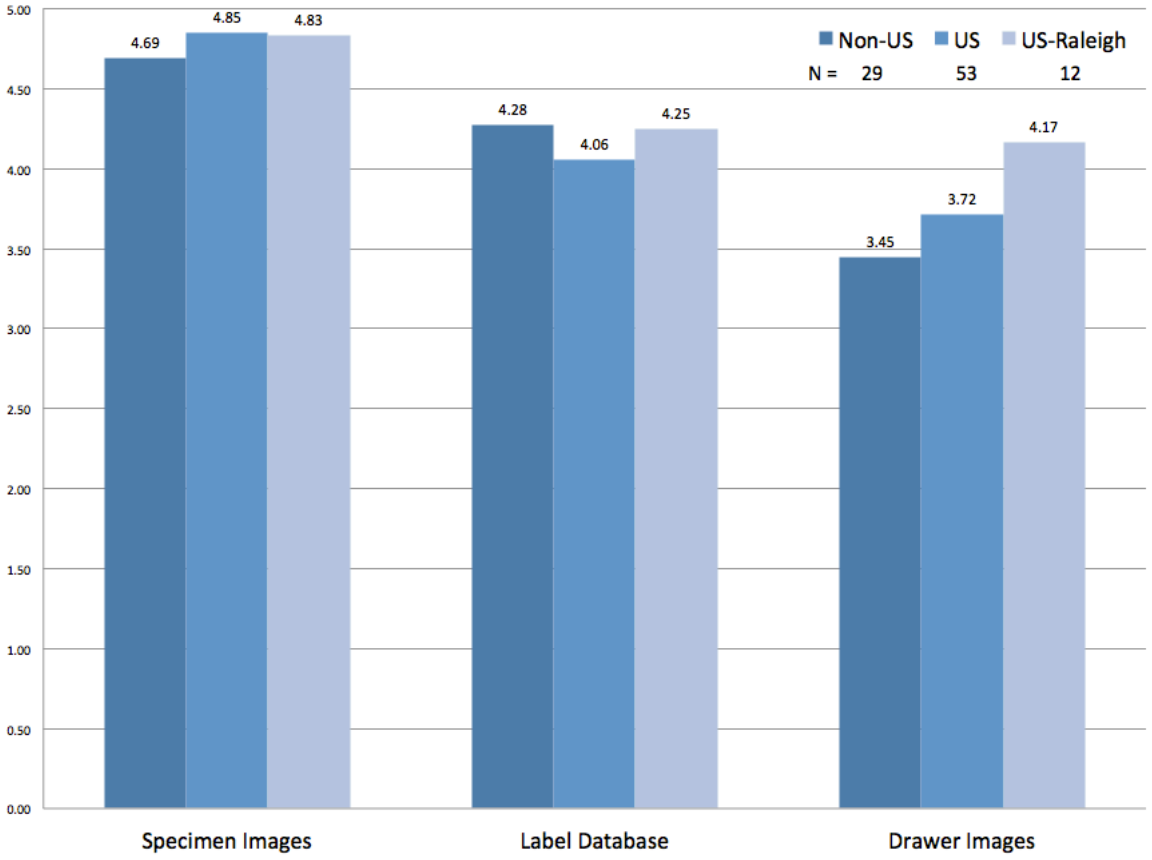
As mentioned above, the survey collected the IP addresses of respondents as a proxy for both nationality and likely connection to the NCSU Insect Museum. The entomologists at NCSU were interested to see if respondents from countries other than the US rated presentation methods as more or less useful than their US-based counterparts. I was also concerned that, because staff from the NCSU Insect Museum were among the survey respondents, their responses might be more positive toward the drawer imaging system their institution had developed, and thus would skew the overall results. Accordingly, I analyzed the data to look for significant differences among respondents taking the survey in Raleigh, in other locations in the US, and in other countries.

In the first set of comparison questions (Questions 13-1 through 13-3), the three groups had nearly identical responses, except for in ratings of the drawer imaging system (Figure 11, below). Here, Raleigh-based respondents rated the drawer image system higher than the other two groups, and non-US respondents rated drawer images lowest of the three groups. The differences among the groups are not, however, statistically significant. A similar pattern emerges in responses to Question 14, which asked respondents to rate the usefulness of the three presentation methods for different purposes. Raleigh-based respondents tended to rate the drawer image method higher than the other two groups. Looking at the average ratings for each method, across all purposes, the only significant difference was between the ratings of US-Raleigh and non-US respondents for the drawer images method. Excluding the responses of the 12 Raleigh-based respondents does not greatly alter the overall mean ratings of the

usefulness of the presentation methods, or the ratings for the methods for different purposes. The Raleigh-based respondents may have had a slight bias toward the drawer images, but it did not significantly affect the overall results.

Contrary to my and my collaborators' expectations, non-US respondents tended to rate both single-specimen images and drawer images lower than did US and US-Raleigh respondents. The differences for the specimen images ratings are only slight, but they are more pronounced in the ratings for the drawer images method, particularly between non-US and US-Raleigh respondents. Again, the differences are not statistically significant, but given the relatively low number of respondents, it is a difference that may bear further investigation.

Figure 11: Mean Usefulness Ratings for Presentation Methods by Geographic Location



Desired Features in Hypothetical Presentation Methods

Questions 17-19 asked respondents a variety of features that could be built into any hypothetical online presentation of a large entomological collection. Respondents rated and ranked the features according to usefulness without considering any specific presentation method in which the features might be available. As shown in Figure 12, below, "detailed images of individual specimens" was rated most useful, followed closely by "detailed images from several angles of individual specimens." The only feature that a majority of respondents rated as neutral, somewhat useless, or useless, was notes from the general public, which scored a mean usefulness rating of only 2.7 out of 5. Images of units or drawers of specimens was rated second from last, with a mean rating of 3.76.

Figure 12: Usefulness Ratings for Individual Features

17. In a hypothetical online presentation of a large entomological collection, how useful for your work would you find the following features?

Feature	Mean	Useless	Somewhat useless	Neutral	Somewhat useful	Very useful	N
Detailed images of individual specimens	4.78	0	2	0	14	74	90
Detailed images from several angles of individual specimens	4.7	0	1	1	22	67	91
Images of specimens that you can download	4.51	0	2	4	30	54	90
Readable text of specimen labels	4.45	0	1	6	35	49	91
Easily linking to or citing data from the resource	4.39	1	2	6	33	48	90
Reading the notes and comments of other entomologists	4.35	0	2	8	37	44	91
Text label information that you can download	4.31	0	1	13	33	43	90
Adding your own notes or comments to images or data	3.88	4	5	18	33	29	89
Detailed images of whole units or drawers of specimens	3.76	4	14	14	26	32	90
Reading the notes or comments of the general public	2.7	11	32	28	13	7	91

In designing the survey, I was concerned that respondents would rate more than one feature as "very useful," and so I added a ranking question to attempt to differentiate among the highest rated choices in Question 17. This question asked respondents to rank the features they had previously rated as "very useful." At the top, at least, the rankings are different from the order of the mean ratings shown in Figure 12 in several respects, though interpreting the results is not as straightforward. In the rankings, "detailed images from several angles" received the more votes as most useful—33—while "detailed images of individual specimens" finished in second place, with 21 ranks as "1." Whole-unit or drawer images did slightly better in the overall rankings, but received only 3 votes as most useful. The question is flawed, however, in that respondents were asked to rank only those features they had previously rated as "very useful," making comparing ranks across respondents difficult.

Figure 13: Rankings of "Very Useful" Features

18. Rank the following features according to which you would find most useful (1 = Most useful)

	Most useful								Least useful			Score per
Feature	1	2	3	4	5	6	7	8	9	10	N	**respondent***
Detailed images from several angles of individual specimens	33	18	6	2	0	3	1	1	1	0	65	8.892
Detailed images of individual specimens	21	28	14	2	4	0	2	0	2	0	73	8.548
Text label information that you can download	9	3	8	9	5	3	1	1	0	0	39	7.590
Readable text of specimen labels	3	8	12	12	4	4	1	0	0	0	44	7.500
Images of specimens that you can download	6	7	10	7	10	5	1	1	0	0	47	7.319
Detailed images of whole units or drawers of specimens	3	5	8	3	7	3	2	0	0	0	31	7.258
Easily linking to or citing data from the resource	3	8	4	8	6	4	5	4	1	1	44	6.386
Reading the notes and comments of other entomologists	3	2	4	11	8	3	5	4	2	0	42	6.095
Adding your own notes or comments to images or data	0	2	3	6	3	4	4	3	1	0	26	5.731
Reading the notes or comments of the general public	0	0	0	1	1	0	0	1	1	1	5	3.800
Total	81	81	69	61	48	29	22	15	8	2	416	7.457

* Ranks are scored as points, where a "1" rank = 10 points, "2" = 9, etc. The cumulative point total is then divided by the number of respondents ranking that feature (N).

Question 19 gave respondents wider scope for identifying useful features by asking them to write brief statements about "What online resources do you wish were available for your work, or what improvements to existing online resources would you like to see developed?" Sixty-two respondents offered their opinions, and their full responses can be found in Appendix 1. The interpretation of these responses is subjective, but about half of them mentioned the desire for high-quality images of individual specimens. A striking feature of the responses was that many of them revolved around the need to accurately identify insects. Toward this end, many respondents indicated they wished for a combination of high-quality images of single, authoritatively identified specimens, ideally with full label data, notes and images about taxonomically important characteristics, habitus images, and up-to-date maps or other georeferenced distribution information. This might well be described as the "gold standard" for the presentation of entomological collections online. Only a few respondents wished for resources that allowed more collaboration among entomologists, such as the ability to easily add one's own images to a central database, or the ability to view drawer images of unidentified specimens. A desire for information about entomological collections to be more centrally available was also a notable feature of the responses. Several respondents said they wished for merely a central database of what specimens collections had (or thought they had). This desire for more greater integration among online resources, and better federated search and browse capabilities, may indicate that adherence to data standards and interoperability should be concern for any online resource, regardless of its presentation method.

ID task performance

A secondary goal of the survey was to investigate the utility of the GigaPan system for quick identification of specimens. Toward this end, Question 11 asked respondents to look at a GigaPan image of a drawer containing specimens from "the big four" orders—Hymenoptera, Coleopteran, Lepidoptera, and Diptera.[30] Respondents were then asked to estimate the percent of specimens they could identify at least to the family level, considering only the order they were most familiar with. Not surprisingly, given their insect order specializations, most respondents reported being "good" or "very good" at identifying Hymenoptera and Coleoptera specimens. Very few respondents reported being "good" or "very good" at identifying Lepidoptera or Diptera specimens, but all the orders, majorities of respondents rated themselves at least "average" at identifying specimens to the family level. For the identification task itself, the respondents reported high degrees of success. Fifty-nine percent of respondents reported they could identify to the family level 75% or more of the specimens in the GigaPan image. The survey did not attempt to confirm respondents' estimated percent of identification, but the relatively high level of identification success inspired a follow-up study, in which participants will be asked to give more specific, and verifiable, identifications of specimens specifically chosen from insect groups in which the participants have indicated expertise. This follow-up study is still on-going, and results are not available for including in this thesis. Most respondents (56 of 93 responses, or 60%; see

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[30] The image's URL is http://www.gigapan.org/gigapans/fullscreen/49310/, and a screenshot of the full image is shown in Figure 6, on page 16.

Question 12 in Appendix 1) indicated that the lack of images from other angles was one of the chief reasons why identification of some specimens was difficult or impossible. Nearly as many (53, or 57%) said that the specimens pictured were too small. Lack of familiarity with the orders shown and a lack of detail in the image were other common responses.

Conclusions

The primary hypothesis that motivated this study was that entomologists would find the drawer image system significantly useful for their work. The results of the survey do not, alas, offer a clear confirmation or refutation of this hypothesis, though on balance the results support the contention that relatively simple digitization methods can be of value to the entomological community. Of the three presentation methods rated by survey respondents, the drawer image method was rated the least useful, but still a majority of respondents (61 of 94) rated the system as "Somewhat useful" or "Very useful." When looking only at responses from non-taxonomists, the drawer image method was rated as useful as a database of label information. In the comparison for different purposes, the drawer imaging system (Figure 8) was rated nearly as useful as detailed images of individual specimens for teaching K-12 or undergraduates, and educational outreach to the general public, and more useful than single-specimen images for finding out if a collection has specimens to borrow. Only for "doing entomological research" did respondents rate the usefulness of the drawer imaging method rate significantly below the other two methods. For this purpose, most taxonomists gave the drawer image method a rating of useless, somewhat useless, or neutral (Figure 9). Most non-taxonomists regarded the drawer images as either somewhat or very useful for entomological research. With the exception, then, of taxonomic research, the drawer image method

appears to be fairly useful, though not as useful as detailed images of individual specimens.

The results also show 1) that entomologists can generally identify specimens at least to the family level using drawer images, and 2) that relatively simple online resources to assist in the identification of specimens are among the most frequently used by entomologists. Respondents reported high levels of success on the survey's simple ID task, and resources for quick identification, such as BugGuide.net, were the most commonly mentioned online resources used by respondents in their work. More research is needed in this area to better clarify the online resources currently most valuable for different kinds of entomologists, and to more definitively describe how those resources are used in entomologists' daily work. But the simplicity of a presentation does not necessarily determine its usefulness, or lack thereof. Surely, as the experience of many "more product, less process" archival work has shown, having a relatively simple resource available quickly, at low cost, is in many contexts preferable to waiting until time and resources permit launching more useful, but more expensive, resources.

Of the features most desired in online presentations of entomological collections, survey respondents heavily favored detailed images of individual specimens, ideally from several angles, over other features (Figure 13). This result was not surprising. What was surprising, however, was the relative unpopularity of collaboration tools such as adding notes or comments to images or data, and reading the comments of other entomologists. Anecdotal evidence from my interviews with entomologists at NCSU had led me to believe that

online collaboration and crowd-sourcing simple tasks like the sorting of unidentified specimens would be of greater use to entomologists. Sites like BugGuide.net rely heavily on user contributions of images and IDs, but that user-generated content does not seem to have impaired BugGuide's usefulness to the working entomologists. This is another area that may warrant further study. This survey was not designed to probe the use of online collaboration by entomologists, and so definite conclusions are not possible. Despite the survey results, online collaboration to support the development and curation of entomological collections seems like a natural outgrowth of older, non-digital, patterns of entomological work.

A subsidiary area of investigation for the survey was how different entomological specialties would rate the usefulness of different presentation methods. The results show clear differences between the ratings given by taxonomists and non-taxonomists. Taxonomists were more likely to find the drawer image method less useful than were non-taxonomists, especially for doing entomological research (see Figure 9). The categorization of the respondents into "taxonomist," "non-taxonomist," "semi-taxonomist," and "unclassified" groups may be too great a simplification to support broad conclusions from this survey alone, and this area, too, may warrant further study. Still, from the data at hand, it does appear that the work of taxonomists may require different kinds of online resources than those useful to other entomological specialists. As I noted above, I have been unable to determine how accurately the survey sample represents the entomological community as a whole. Taxonomists comprised 47% of the survey's respondents. This likely

over-represents their numbers among all entomologists, but taxonomists may be more likely than other specialists to use online presentations of entomological collections, and so their constitute a larger, or more important, portion of any resource's user base than other specialists. But one possible conclusion from the survey data is that if the planners of an online resource do not anticipate taxonomists constituting an important segment of their users, a less expensive presentation method, such as drawer images, may suffice to make the resource quite useful to other specialists.

The survey does not offer enough data to determine whether differences in order specialties make a big difference in the usefulness of presentation methods. There are too many order specialties, and too few respondents, to allow significant comparisons. The survey found no significant differences in the usefulness ratings of different order specialists, even when analysis is restricted to the three most commonly-reported order specialties, and usefulness ratings collapsed into only two categories—"useless to neutral" and "somewhat or very useful" (see Figure 10). Although it is a narrow foundation, based on the survey's results it appears that discerning the sub-discipline of a resource's likely user base is more important for planning an online presentation than is determining the order specialties of likely users.

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Appendix 1: Full Text and Results of Online Survey

INTRODUCTION
This survey examines how entomologists use online presentations of entomological collections. It has 24 questions, and should take 10-15 minutes to complete. No identifying information will be collected unless you choose to be considered for a follow-up study.

To get started, click on the arrow below, right.

Your participation is completely voluntary. Your responses will be confidential and will be used only for the purpose of this research. You will not receive any commercial solicitations or other spam as a result of your participation.

*** The results of this survey could help entomological institutions better present their collections online, but taking the survey will not benefit you personally. The survey results may be published and used as part of the researcher's Master's thesis in Information Science at the University of North Carolina, Chapel Hill. By completing the survey, you are giving your consent to the use of your responses for this research.

This study has been reviewed by the UNC Office of Human Research Ethics (IRB Study No. 11-1319). If you have any questions, please contact the researcher:
Babi Hammond, hammondb@email.unc.edu.
Faculty advisor: Professor Jane Greenberg, janeg@email.unc.edu.

USING THE SURVEY
Click the forward and back arrows at the bottom right to go to the next screen or go back to review or change your answers. You do not have to complete the survey in one sitting. Unless your browser is set to block cookies, you can close the survey window and return to the survey URL up to a week later without having to repeat any of the questions.

1. What is your PRIMARY area of specialty? (Choose one.)

List #	Answer	Responses	%
46	Systematics	31	33%
47	Taxonomy	13	14%
14	Curatorial	8	9%
8	Biodiversity	7	7%
15	Ecology	7	7%
2	Agricultural Entomology	6	6%
9	Biological Control	4	4%
5	Aquatic Entomology	3	3%
4	Apiculture	2	2%
20	Forest Entomology	2	2%
52	Zoology	2	2%
3	Agronomy	1	1%
10	Botany	1	1%

26	IPM-Agricultural	1	1%
30	Molecular Biology	1	1%
31	Morphology	1	1%
39	Physiology	1	1%
41	Plant-Insect Interactions	1	1%
43	Regulatory Entomology	1	1%
49	Urban and Structural Entomology	1	1%
1	Acarology	0	0%
6	Behavior	0	0%
7	Biochemistry	0	0%
11	Chemical Control	0	0%
12	Crop Protection	0	0%
13	Cultural Control	0	0%
16	Education (undergraduate)	0	0%
17	Education (K-12)	0	0%
18	Env. Impacts	0	0%
19	Forensic Entomology	0	0%
21	Horticulture	0	0%
22	Host Plant Resistance	0	0%
23	Immature Insects	0	0%
24	Insect Photography	0	0%
25	Insect Rearing	0	0%
27	IPM-Urban	0	0%
28	Medical Entomology	0	0%
29	Microbiology	0	0%
32	Mosquito Control	0	0%
33	Paleontology	0	0%
34	Pedology	0	0%
35	Pest Control	0	0%
36	Pest Management	0	0%
37	Pheromones	0	0%
38	Physical Control	0	0%
40	Pathology	0	0%
42	Pollination	0	0%
44	Social Insects	0	0%
45	Stored Products	0	0%
48	Toxicology	0	0%
50	Vector-borne Pathogens	0	0%
51	Veterinary Entomology	0	0%
	Total	94	100%

2. What is your SECONDARY area of specialty? (Choose one.)

List #	Answer	Responses	%
48	Taxonomy	16	17%
9	Biodiversity	12	13%
47	Systematics	9	10%
15	Curatorial	8	9%
3	Agricultural Entomology	6	6%
16	Ecology	6	6%
1	None / Does not apply	5	5%
10	Biological Control	4	4%
25	Insect Photography	3	3%
32	Morphology	3	3%
53	Zoology	3	3%
7	Behavior	1	1%
21	Forest Entomology	1	1%
23	Host Plant Resistance	1	1%
24	Immature Insects	1	1%
26	Insect Rearing	1	1%
28	IPM-Urban	1	1%
29	Medical Entomology	1	1%
31	Molecular Biology	1	1%
34	Paleontology	1	1%
36	Pest Control	1	1%
37	Pest Management	1	1%
38	Pheromones	1	1%
42	Plant-Insect Interactions	1	1%
43	Pollination	1	1%
44	Regulatory Entomology	1	1%
45	Social Insects	1	1%
46	Stored Products	1	1%
49	Toxicology	1	1%
50	Urban and Structural Entomology	1	1%
2	Acarology	0	0%
4	Agronomy	0	0%
5	Apiculture	0	0%
6	Aquatic Entomology	0	0%
8	Biochemistry	0	0%
11	Botany	0	0%
12	Chemical Control	0	0%
13	Crop Protection	0	0%
14	Cultural Control	0	0%
17	Education (undergraduate)	0	0%

18	Education (K-12)	0	0%
19	Env. Impacts	0	0%
20	Forensic Entomology	0	0%
22	Horticulture	0	0%
27	IPM-Agricultural	0	0%
30	Microbiology	0	0%
33	Mosquito Control	0	0%
35	Pedology	0	0%
39	Physical Control	0	0%
40	Physiology	0	0%
41	Pathology	0	0%
51	Vector-borne Pathogens	0	0%
52	Veterinary Entomology	0	0%
	Total	94	100%

3. What order is your PRIMARY specialty? (Choose one.)

List #	Answer	Responses	%
6	Coleoptera (Beetles)	25	27%
16	Hymenoptera (Ants, Bees, and Wasps)	20	22%
1	All, or General Entomology	17	18%
15	Homoptera (aphids, fleahoppers)	6	6%
18	Lepidoptera (Butterflies & Moths)	6	6%
10	Diptera (Diptera True Files)	5	5%
14	Hemiptera (True Bugs)	4	4%
30	Thysanoptera (thrips)	2	2%
5	Blattodea (roaches)	1	1%
12	Ephemeroptera (mayflies)	1	1%
17	Isoptera (Termites)	1	1%
21	Mecoptera (Scorpionflies)	1	1%
22	Neuroptera (Lacewings)	1	1%
24	Orthoptera (grasshoppers, crickets)	1	1%
26	Plecoptera (Stonefiles)	1	1%
32	Trichoptera (Caddis Flies)	1	1%
2	Acari (mites, ticks)	0	0%
3	Anoplura (sucking lice)	0	0%
4	Araneae (spiders)	0	0%
7	Collembola (Springtails)	0	0%
8	Dermaptera (Earwigs)	0	0%
9	Diplura (Diplura Two Pronged Bristle-tails)	0	0%
11	Embiidna (Embioptera Web Spinners)	0	0%
13	Grylloblattodea (rockcrawlers)	0	0%
19	Mallophaga (chewing lice)	0	0%

20	Mantodea (mantids)	0	0%
23	Odonata (Dragonflies, damselflies)	0	0%
25	Phasmatodea (Stick-insects)	0	0%
27	Protura (Protura)	0	0%
28	Psocoptera (booklice)	0	0%
29	Siphonaptera (Fleas)	0	0%
31	Thysanura (Silverfish)	0	0%
33	Zoraptera (Zorapterans)	0	0%
34	Arthropoda	0	0%
35	Microcorypia	0	0%
36	Phthiraptera	0	0%
37	Strepsiptera	0	0%
	Total	93	100%

4. What order is your SECONDARY specialty? (Choose one.)

List #	Answer	Response	%
2	All, or General Entomology	21	23%
1	No Secondary Specialty	20	22%
7	Coleoptera (Beetles)	9	10%
19	Lepidoptera (Butterflies & Moths)	9	10%
17	Hymenoptera (Ants, Bees, and Wasps)	7	8%
15	Hemiptera (True Bugs)	6	7%
11	Diptera (Diptera True Files)	5	5%
6	Blattodea (roaches)	3	3%
16	Homoptera (aphids, fleahoppers)	2	2%
33	Trichoptera (Caddis Flies)	2	2%
35	Arthropoda	2	2%
3	Acari (mites, ticks)	1	1%
5	Araneae (spiders)	1	1%
18	Isoptera (Termites)	1	1%
23	Neuroptera (Lacewings)	1	1%
25	Orthoptera (grasshoppers, crickets)	1	1%
31	Thysanoptera (thrips)	1	1%
4	Anoplura (sucking lice)	0	0%
8	Collembola (Springtails)	0	0%
9	Dermaptera (Earwigs)	0	0%
10	Diplura (Diplura Two Pronged Bristle-tails)	0	0%
12	Embiidna (Embioptera Web Spinners)	0	0%
13	Ephemeroptera (mayflies)	0	0%
14	Grylloblattodea (rockcrawlers)	0	0%
20	Mallophaga (chewing lice)	0	0%
21	Mantodea (mantids)	0	0%

22	Mecoptera (Scorpionflies)	0	0%
24	Odonata (Dragonflies, damselflies)	0	0%
26	Phasmatodea (Stick-insects)	0	0%
27	Plecoptera (Stonefiles)	0	0%
28	Protura (Protura)	0	0%
29	Psocoptera (booklice)	0	0%
30	Siphonaptera (Fleas)	0	0%
32	Thysanura (Silverfish)	0	0%
34	Zoraptera (Zorapterans)	0	0%
36	Microcorypia	0	0%
37	Phthiraptera	0	0%
38	Strepsiptera	0	0%
	Total	92	100%

5. What is the highest professional degree you hold (not including degrees unrelated to your work in entomology)? (Choose one.)

#	Answer		Response	%
1	None		7	7%
2	Bachelors		15	16%
3	Masters		30	32%
4	Doctorate		42	45%
	Total		94	100%

Statistic	Value
Min Value	1
Max Value	4
Mean	3.14
Variance	0.89
Standard Deviation	0.95
Total Responses	94

6. What year did you receive your highest professional degree? (Type the four-digit year, e.g. "1996".)

Text Response	Responses	%
1969	1	1.1%
1973	1	1.1%
1974	1	1.1%
1975	1	1.1%
1976	1	1.1%
1979	4	4.6%
1981	1	1.1%
1984	1	1.1%
1986	1	1.1%

1988	1	1.1%
1989	2	2.3%
1991	4	4.6%
1992	2	2.3%
1994	1	1.1%
1996	5	5.7%
1998	1	1.1%
1999	1	1.1%
2000	5	5.7%
2001	3	3.4%
2002	1	1.1%
2003	4	4.6%
2004	1	1.1%
2005	2	2.3%
2006	5	5.7%
2007	11	12.6%
2008	12	13.8%
2009	7	8.0%
2010	1	1.1%
2011	6	6.9%
Total	87	100%

Note: 7 respondents reported having no degree; percentages shown above reflect only the 87 respondents who filled hold degrees.

7. What is your primary professional affiliation or employment? (Choose one.)

#	Answer		Response	%
1	University or College Staff or Faculty		34	36%
2	University or College Student		21	22%
3	State or Local Government Agency		5	5%
4	Federal Government Agency		5	5%
5	Museum (private, government, or university)		21	22%
6	K-12 Education		0	0%
7	Private Business or Corporation		2	2%
8	Self-Employed		1	1%
9	Retired		0	0%

10	Amateur / Hobbyist		4	4%
11	Other (please specify):		1	1%
	Total		94	100%

Other (please specify):
maternity

Statistic	Value
Min Value	1
Max Value	11
Mean	3.07
Variance	6.05
Standard Deviation	2.46
Total Responses	94

8. How useful for your work are the following kinds of resources?

#	Question	Useless	Somewhat useless	Neutral	Somewhat useful	Very useful	Responses	Mean
1	Printed books and / or journals	0	2	2	20	70	94	4.68
2	Online books and / or journals	0	1	2	17	74	94	4.74
3	Google or other all-purpose online resources	0	1	5	23	65	94	4.62
4	Online resources specifically for entomology (other than online books or journals)	0	4	6	24	60	94	4.49
5	Specimens (borrowed or in your possession)	1	2	9	13	68	93	4.56

Statistic	Printed books and/or journals	Online books and/or journals	Google or other all-purpose online resources	Online resources specifically for entomology (other than online books or journals)	Specimens (borrowed or in your possession)
Min Value	2	2	2	2	1
Max Value	5	5	5	5	5
Mean	4.68	4.74	4.62	4.49	4.56
Variance	0.39	0.30	0.41	0.64	0.71
Standard Deviation	0.63	0.55	0.64	0.80	0.84
Total Responses	94	94	94	94	93

9. What online resources specifically for entomology do you use in your work, if any?

Text Response
online journals
Online catalogs and databases of collection holdings.
Museum specimen databases.
www.bugguide.net
many, some examples: Harvard Type specimens, Rockefella beetle collection, www.bugguide.net, www.neotropicalbutterflies.com, http://www.thewcg.org.uk/, http://www.biol.uni.wroc.pl/cassidae/European%20Chrysomelidae/list%20of%20subfamilies.htm, CERAMBYX.UOCHB.CZ, many others
Entomological site of Institution or private collector
USDA's website scalenet, other lucid keys, photos, etc.
Bugwood Anything with good pictures to educate those who are not familiar with insects
Online journals, online lucid keys, online photographic collections (BugGuide, Google search)
Scholar Google, online journals, pages from reliable sources such a university ones.
BugGuide, MCZ Type Database, USDA Plants Database, nearctica.com, Arthropods of Florida, Google Books, JSTOR, BAMONA, LepSoc Season Summary, TexasEnto.net, Cerambycidae Catalog, Journal of The LepSoc, ITIS, to name a few...
Lost Ladybug Project, BAMONA, Odonata Central, Bug Guide,
Web of Science, Zoological Record, ICZN Online code
Google scholar, ESA online journals, UF libraries
bugguide.net, tree of life
Identification of species.

bugguide.net, discoverlife.org
nomina nearctica bugguide
hymenoptera online
Universal database of Chalcidoidea, Taxapad Ichneumonoidea database, glossary.hymao.org, Morphbank, forestryimages.org, USDAPlants, Mendeley
old and current lit google images museum websites people finders
ITIS, BugNet, Discover Life, GBIF, Zoological Record, BioOne, JSTOR...
bugguide.net, diptera.org, nomina nearctica, crane flies of pennsylvania, catalogue of crane flies of the world, and others
BOLD database; Treebase; assorted institutional databases
Identification keys, databases (Scalenet),Google Scholar
Nomenclature databases Taxonomic databases Regional databases
Zoological Record; general Google search for digitized primary literature and "home grown" taxonomic catalogs (e.g. Carabids of the World); Bugguide.net for rapid, preliminary determinations, etc.
Discover Life Tree of Life Google scholar Journal databases
Google, Wikipedia, websites specialized in entomology
web of science, bugguide, invasiveimages.org
online keys
www.sciaroidea.info www.diptera.org
Hymenoptera On-Line Antbase GBIF Neave Nomenclator Zoologicus Biodiversity Heritage Library
bug guide, Hymenoptera online, wasp web
Species File Software
online collection material, listservs
BugGuide, AntWeb, ITIS, Tree of Life
BugGuide, Canadian Journal of Arthropod Identification
BDWD Nomenclator; Hymenoptera On-line; Orthoptera Species File; Universal Chalcidoidea Database; Bumblebees of the World; Taxapad; relevant portions of DiscoverLife, Wikipedia, Wikispecies, ITIS, etc.
www.butterfliesofamerica.com www.neotropicalbutterflies.com various nomenclature databases
Biodiversity Heritage Library, LepIndex, Tortricid.net
web of science

a variety of taxon specific online bibliographies, BHL, online keys, etc.
BugGuide, MorphBank
too many to list
Universal Chalcidoidea Database (NHM - London), ESA website
Biodiversity Heritage Library, Tree of Life, Butterflies and Moths of North America, Moth Photographers Group, Bugguide
fauna europaea
The Australian Plant Pest Database
Web of Science, BugWood (for images)
all as possible
Web of Science, Google Scholar, Google Books
BugGuide, Nomina Neartica
http://www.butterfliesofamerica.com/L/Neotropical.htm
Wikipedia, Wikispecies, Encyclopedia of Life, Web of Science
type catalogs/photographic databases
BUGWOOD, BUGGUIDE, BARKBEETLE.ORG
personal webpages (publication lists etc.)
DiscoverLife, Bugguide.net, ITIS, Bombus website through the Natural History Museum (London)
Blogs (several)
web of science
Bugwood, Web of Science
NBCI
BugGuide and Insect Images.net
not specific to entomology, I guess, but: EOL, Morphbank, GenBank, BHL
Entomological journals (ESA & others), Goodle searches, Flickr for photos, Wikimedia for photos, CDC site for vector info, US military sites for vector info, Bugwood, etc.
BugGuide.net
Bug guide catalogs on British Museum website ITIS and their ilk
bugguide, specialty sites such as Antweb, BMNA, anything else that I can find among the odds and ends out there
published refereed literature

AFD Checklist, CSIRO what bug is that, google maps,
Specialist web sites (www.antbase.org, www.antweb.org, faunal treatment web sites)
Atlas of Living Australia (www.ala.org) Australian Faunal Directory (http://www.environment.gov.au/biodiversity/abrs/online-resources/fauna/afd/home)
ZooRecords, Web of knowledge
Every website with taxonomical list, synonyms, nomenclature (only websites administrated by public institutions like museum, university or research team).
journal databases through ncsu library, google in general for quick references to keys or insect-plant interactions
agricola literature search engine
bugguide, featured creatures, online type images, online databases and bibliographies, wikipedia
http://www.faunaeur.org/ http://www.biolib.cz/
ITIS.gov (Integrated Taxonomic Information System) EOL.org (Encyclopedia of Life) http://www.butterfliesandmoths.org/ (Butterflies and Moths of North America http://nathistoc.bio.uci.edu/lepidopt/ (Buterflies of Orange County, CA)

9a. List of responses to Question 9, parsed into individual terms

Resource Term	# of mentions	% of all mentions (N=222)	% of all responses (N=80)
Bugguide.net	25	11.26%	31.25%
Butterflies and Moths of North America	6	2.70%	7.50%
journals	6	2.70%	7.50%
Biodiversity Heritage Library (BHL)	5	2.25%	6.25%
Bugwood.org	5	2.25%	6.25%
Discoverlife.org	5	2.25%	6.25%
Google Scholar	5	2.25%	6.25%
identification keys	5	2.25%	6.25%
Wikipedia	5	2.25%	6.25%
Google	4	1.80%	5.00%
Hymenoptera Online	4	1.80%	5.00%
institutional websites	4	1.80%	5.00%
Nearctica.com	4	1.80%	5.00%
Tree of Life (tolweb.org)	4	1.80%	5.00%
Zoological Record	4	1.80%	5.00%
AntWeb.org	3	1.35%	3.75%
Encyclopedia of Life (http://eol.org/)	3	1.35%	3.75%
Morphbank image database	3	1.35%	3.75%
Universal Chalcidoidea Database	3	1.35%	3.75%
Antbase.net	2	0.90%	2.50%

bibliographies	2	0.90%	2.50%
Bumblebees of the World	2	0.90%	2.50%
Diptera.org	2	0.90%	2.50%
Fauna europaea (faunaeur.org)	2	0.90%	2.50%
Global Biodiversity Information Facility (GBIF)	2	0.90%	2.50%
Google Books	2	0.90%	2.50%
Google Images	2	0.90%	2.50%
Harvard Type Specimens	2	0.90%	2.50%
journals--JSTOR	2	0.90%	2.50%
Neotropicalbutterflies.com	2	0.90%	2.50%
nomenclature databases	2	0.90%	2.50%
Scalenet database	2	0.90%	2.50%
Taxapad.com Ichneumonoidea database	2	0.90%	2.50%
USDA Plants Database (plants.usda.gov)	2	0.90%	2.50%
Wikispecies	2	0.90%	2.50%
Arthopods of Florida	1	0.45%	1.25%
Atlas of Living Australia	1	0.45%	1.25%
Australian Faunal Directory	1	0.45%	1.25%
Australian Faunal Directory checklist	1	0.45%	1.25%
Australian Plant Pest database	1	0.45%	1.25%
Barcode of Life Data Systems (BOLD)	1	0.45%	1.25%
Barkbeetles.org	1	0.45%	1.25%
bibliographies--personal webpages	1	0.45%	1.25%
Biolib.cz (Biological Library)	1	0.45%	1.25%
BioOne	1	0.45%	1.25%
BioSystematic Database of World Diptera	1	0.45%	1.25%
blogs	1	0.45%	1.25%
British Museum catalogs	1	0.45%	1.25%
Buterflies of Orange County, CA	1	0.45%	1.25%
Butterfliesofamerica.com	1	0.45%	1.25%
Canadian Journal of Arthropod Identification	1	0.45%	1.25%
catalogs, databases	1	0.45%	1.25%
Centers for Disease Control	1	0.45%	1.25%
Cerambycidae Catalog (cerambyx.uochb.cz)	1	0.45%	1.25%
Crane Flies of Pennsylvania (http://iz.carnegiemnh.org/cranefly/index.htm)	1	0.45%	1.25%
Crane flies of the World catalog	1	0.45%	1.25%
CSIRO What Bug Is That (http://anic.ento.csiro.au/insectfamilies/)	1	0.45%	1.25%
databases, regional	1	0.45%	1.25%
ESA Website	1	0.45%	1.25%
Faunal treatment websites	1	0.45%	1.25%

Flickr	1	0.45%	1.25%
Forestryimages.org	1	0.45%	1.25%
GenBank	1	0.45%	1.25%
Glossary.hymao.org	1	0.45%	1.25%
Google Maps	1	0.45%	1.25%
http://www.biol.uni.wroc.pl/cassidae/European%20Chrysomelidae/list%20of%20subfamilies.htm	1	0.45%	1.25%
ICZN code	1	0.45%	1.25%
identification of species	1	0.45%	1.25%
images--anything w/ good pictures	1	0.45%	1.25%
images--type images	1	0.45%	1.25%
Insectimages.org	1	0.45%	1.25%
institutional databases	1	0.45%	1.25%
institutional specimen databases	1	0.45%	1.25%
Invasive.org (?)	1	0.45%	1.25%
journals--Agricola literature search	1	0.45%	1.25%
journals--ESA journals	1	0.45%	1.25%
journals--ESA, et al	1	0.45%	1.25%
journals--LepSoc	1	0.45%	1.25%
journals--Mendeley	1	0.45%	1.25%
journals--old and current lit	1	0.45%	1.25%
LepIndex (Global Lepidoptera Names Index)	1	0.45%	1.25%
Lepsoc.org season summary	1	0.45%	1.25%
lists, databases, nomenclature	1	0.45%	1.25%
listservs	1	0.45%	1.25%
Lost Ladybug Project (lostladybug.org)	1	0.45%	1.25%
Moth Photographers Group	1	0.45%	1.25%
National Center for Biotechnology Information (NBCI)	1	0.45%	1.25%
Nomenclator Zoologicus	1	0.45%	1.25%
Odonata Central	1	0.45%	1.25%
Orthoptera Species File taxonomic database	1	0.45%	1.25%
people finders	1	0.45%	1.25%
Rockefeller Beetles	1	0.45%	1.25%
Sciaroidea.info	1	0.45%	1.25%
Species File Software for taxonomic database development	1	0.45%	1.25%
taxonomic catalogs	1	0.45%	1.25%
taxonomic databases	1	0.45%	1.25%
TexasEnto.net	1	0.45%	1.25%
Thefeaturedcreature.com	1	0.45%	1.25%
Tortricid.net	1	0.45%	1.25%

Treebase.org	1	0.45%	1.25%
type catalogs, photographic databases	1	0.45%	1.25%
UF Libraries	1	0.45%	1.25%
US military sites	1	0.45%	1.25%
Waspweb.org	1	0.45%	1.25%
Watford Coleoptera Group (thewcg.org.uk)	1	0.45%	1.25%
Wikimedia	1	0.45%	1.25%

10. How good are you at identifying to the family level specimens from the following orders?

#	Question	Very Bad	Bad	Average	Good	Very Good	Responses	Mean
1	Hymenoptera	3	10	36	22	22	93	3.54
2	Coleoptera	1	8	33	31	20	93	3.66
3	Lepidoptera	3	24	35	24	7	93	3.09
4	Diptera	8	22	42	15	6	93	2.88

Statistic	Hymenoptera	Coleoptera	Lepidoptera	Diptera
Min Value	1	1	1	1
Max Value	5	5	5	5
Mean	3.54	3.66	3.09	2.88
Variance	1.14	0.90	0.95	1.00
Standard Deviation	1.07	0.95	0.97	1.00
Total Responses	93	93	93	93

11. Take a look at this image of a drawer of pinned specimens (the link will open in new window). Considering only the order with which you are most familiar, and ignoring any label information, what number below is closest to the proportion of the specimens can you confidently identify at least down to the family level?

#	Answer		Response	%
1	0%		1	1%
2	25%		16	17%
3	50%		21	23%
4	75%		39	42%
5	100%		16	17%
	Total		93	100%

Statistic	Value
Min Value	1
Max Value	5
Mean	3.57
Variance	1.01
Standard Deviation	1.00
Total Responses	93

12. For those specimens that were difficult or impossible to identify, what were the chief reasons why identification was difficult? (Check all that apply.)

#	Answer		Response	%
1	Lack of familiarity with the order or family		43	46%
2	Image was not detailed enough		42	45%
3	Specimen was too small		53	57%
4	Needed images from other angle(s)		56	60%
5	Other; please specify:		3	3%

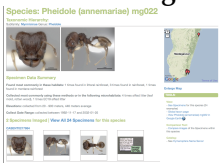
Other; please specify:
there are two heteropterans and a roach mixed in with the beetles
lighting
Image out of focus

Statistic	Value
Min Value	1
Max Value	5
Total Responses	93

13. Below are examples of three different ways entomological collections might be presented online. There may not be online resources like these for the group of insects you usually work on, but for the purpose of this question, please imagine that there are, and base your answer on that.

The links and thumbnails below should open in a different window or tab. Look at the tab then click back here to answer this question. Do not close this tab, or your responses might be lost.

- **Detailed images of individual specimens. Example: AntWeb.org [link to website]**



- **Database of label information from individual specimens, with no images. Example: Smithsonian Entomology Collections database [link to website]**

- **Detailed images of drawers of specimens, where you can zoom-in to individual specimens. Example: NCSU Insect Museum GigaPans [link to website]**

How useful do you think resources like these are or might be for your work?

#	Question	Useless	Somewhat useless	Neutral	Somewhat useful	Very useful	Responses	Mean
1	Detailed images of individual specimens	0	1	0	16	77	94	4.80
2	Database of label information	1	7	11	33	42	94	4.15
3	Detailed images of drawers of specimens	5	17	11	30	31	94	3.69

Statistic	Detailed images of individual specimens	Database of label information	Detailed images of drawers of specimens
Min Value	2	1	1
Max Value	5	5	5
Mean	4.80	4.15	3.69
Variance	0.23	0.95	1.57
Standard Deviation	0.48	0.97	1.25
Total Responses	94	94	94

14. How useful do you think Detailed Images of Individual Specimens are for the following purposes?

#	Question	Useless	Somewhat useless	Neutral	Somewhat useful	Very useful	Responses	Mean
1	Finding out if a collection has specimens you would like to borrow	3	7	9	27	46	92	4.15
2	Teaching K-12 or undergraduates	1	0	11	43	36	91	4.24
3	Educational outreach to the general public	1	2	13	37	38	91	4.20
4	Doing entomological research	3	3	6	26	54	92	4.36

Statistic	Finding out if a collection has specimens you would like to borrow	Teaching K-12 or undergraduates	Educational outreach to the general public	Doing entomological research
Min Value	1	1	1	1
Max Value	5	5	5	5
Mean	4.15	4.24	4.20	4.36
Variance	1.19	0.56	0.72	0.96
Standard Deviation	1.09	0.75	0.85	0.98
Total Responses	92	91	91	92

15. How useful do you think a Database of Label Information is for the following purposes?

#	Question	Useless	Somewhat useless	Neutral	Somewhat useful	Very useful	Responses	Mean
1	Finding out if a collection has specimens you would like to borrow	0	4	8	22	57	91	4.45
2	Teaching K-12 or undergraduates	11	37	20	18	5	91	2.66
3	Educational outreach to the general public	16	34	17	19	5	91	2.59
4	Doing entomological research	1	1	5	24	61	92	4.55

Statistic	Finding out if a collection has specimens you would like to borrow	Teaching K-12 or undergraduates	Educational outreach to the general public	Doing entomological research
Min Value	2	1	1	1
Max Value	5	5	5	5
Mean	4.45	2.66	2.59	4.55
Variance	0.69	1.20	1.36	0.56
Standard Deviation	0.83	1.10	1.16	0.75
Total Responses	91	91	91	92

16. How useful do you think Detailed Images of Drawers of Specimens are for the following purposes?

#	Question	Useless	Somewhat useless	Neutral	Somewhat useful	Very useful	Responses	Mean
1	Finding out if a collection has specimens you would like to borrow	2	5	7	33	45	92	4.24
2	Teaching K-12 or undergraduates	2	3	16	31	39	91	4.12
3	Educational outreach to the general public	2	5	8	35	41	91	4.19
4	Doing entomological research	9	16	21	27	19	92	3.34

Statistic	Finding out if a collection has specimens you would like to borrow	Teaching K-12 or undergraduates	Educational outreach to the general public	Doing entomological research
Min Value	1	1	1	1
Max Value	5	5	5	5
Mean	4.24	4.12	4.19	3.34
Variance	0.93	0.93	0.93	1.59
Standard Deviation	0.96	0.96	0.97	1.26
Total Responses	92	91	91	92

17. In a hypothetical online presentation of a large entomological collection, how useful for your work would you find the following features?

#	Question	Useless	Somewhat useless	Neutral	Somewhat useful	Very useful	Responses	Mean
1	Detailed images of individual specimens	0	2	0	14	74	90	4.78
2	Detailed images from several angles of individual specimens	0	1	1	22	67	91	4.70
3	Detailed images of whole units or drawers of specimens	4	14	14	26	32	90	3.76

4	Readable text of specimen labels	0	1	6	35	49	91	4.45
5	Text label information that you can download	0	1	13	33	43	90	4.31
6	Images of specimens that you can download	0	2	4	30	54	90	4.51
7	Adding your own notes or comments to images or data	4	5	18	33	29	89	3.88
8	Reading the notes and comments of other entomologists	0	2	8	37	44	91	4.35
9	Reading the notes or comments of the general public	11	32	28	13	7	91	2.70
10	Easily linking to or citing data from the resource	1	2	6	33	48	90	4.39

Statistic	Detailed images of individual specimens	Detailed images from several angles of individual specimens	Detailed images of whole units or drawers of specimens	Readable text of specimen labels	Text label information that you can download	Images of specimens that you can download	Adding your own notes or comments to images or data	Reading the notes and comments of other entomologists	Reading the notes or comments of the general public	Easily linking to or citing data from the resource
Min Value	2	2	1	2	2	2	1	2	1	1
Max Value	5	5	5	5	5	5	5	5	5	5
Mean	4.78	4.70	3.76	4.45	4.31	4.51	3.88	4.35	2.70	4.39
Variance	0.31	0.30	1.49	0.45	0.58	0.48	1.16	0.54	1.21	0.64
Standard Deviation	0.56	0.55	1.22	0.67	0.76	0.69	1.07	0.74	1.10	0.80
Total Responses	90	91	90	91	90	90	89	91	91	90

→ *Skip Rule: If Very useful Is Less Than 2, Then Skip To Q19*

18. Rank the following features according to which you would find most useful. (1 = Most useful.)

→ *Carry Forward Statements ranked Very Useful in Q17*

#	Answer	1	2	3	4	5	6	7	8	9	10	Responses
1	Detailed images of individual specimens	21	28	14	2	4	0	2	0	2	0	73
2	Detailed images from several angles of individual specimens	33	18	6	2	0	3	1	1	1	0	65
3	Detailed images of whole units or drawers of specimens	3	5	8	3	7	3	2	0	0	0	31
4	Readable text of specimen labels	3	8	12	12	4	4	1	0	0	0	44
5	Text label information that you can download	9	3	8	9	5	3	1	1	0	0	39
6	Images of specimens that you can download	6	7	10	7	10	5	1	1	0	0	47
7	Adding your own notes or comments to images or data	0	2	3	6	3	4	4	3	1	0	26
8	Reading the notes and comments of other entomologists	3	2	4	11	8	3	5	4	2	0	42
9	Reading the notes or comments of the general public	0	0	0	1	1	0	0	1	1	1	5
10	Easily linking to or citing data from the resource	3	8	4	8	6	4	5	4	1	1	44
	Total	81	81	69	61	48	29	22	15	8	2	-

Statistic	Detailed images of individual specimens	Detailed images from several angles of individual specimens	Detailed images of whole units or drawers of specimens	Readable text of specimen labels	Text label information that you can download	Images of specimens that you can download	Adding your own notes or comments to images or data	Reading the notes and comments of other entomologists	Reading the notes or comments of the general public	Easily linking to or citing data from the resource
Min Value	1	1	1	1	1	1	2	1	4	1
Max Value	9	9	7	7	8	8	9	9	10	10
Mean	2.45	2.11	3.74	3.50	3.41	3.68	5.27	4.90	7.20	4.61
Variance	2.95	3.19	3.00	2.07	3.41	3.09	3.88	4.48	6.70	5.54
Standard Deviation	1.72	1.79	1.73	1.44	1.85	1.76	1.97	2.12	2.59	2.35
Total Responses	73	65	31	44	39	47	26	42	5	44

19. What online resources do you wish were available for your work, or what improvements to existing online resources would you like to see developed?

Text Response
detailed images of individual specimens
More clarity as to what catalog\journal article any name changes are attributed to.
This grid isn't working properly. I can't choose 1 for more than one option. I would like to choose 1 for all of the options. ONline resources should offer more detailed specimen label data and images.
I would like to see more habitus pictures of species of neotropical Chrysomelidae. Now only the tribe Cassidini is very well presented here: http://culex.biol.uni.wroc.pl/cassidae/katalog%20internetowy/index.htm , neotropical species of the rest of this huge family are pretty much absent online and very scattered throughout the world musea.
Detailed images with lebel info
I wish there was a scalenet for more groups of insects. I also wish there were more in habitus photos on scalenet.
Not sure
detailed photographs of each species, notes of key characters that describe the species and photographs that illustrate these characters.

Lots of pictures with scientific names so as to approximate in ID...
More complete coverage of N. Amer. beetles and Hemipterans on BugGuide.
more cross talk between providers
Online type specimen image and label information database
Entering identifying characteristics of an unknown specimen with the result being a list possible species, with accompaning pictures.
Identification of Isoptera to species level.
I am amazed at what is out there already, and I support any further work. It is needed. I could use more views of insects with the particular characters that define them illustrated.
downloading entire georeferenced datasets
The ability to add images of my research to a collective resource for all hymenopterists. So when I take detail images they would appear with the specimen information in a flickr like interface. Nothing complex or intensive to upload, just sharing with links back to the specimen records (that are already online).
Specimen level database of BMNH
detailed images of types
I think it's important to integrate all the available on-line resources into an interface that is easy to search/navigate/download.
searchable specimen-level databases from major collections; searchable image banks of specimens in collections
database of specimens of important collections in my group
Accurate country data; specimens sortable by country
I don't like the above choice. For identification purposes, all I need are detailed images of one or several individuals (and by detailed, I mean images of relevant characters, not necessarily uniform habitus, lateral, etc. images). For revisionary purposes, I would need to see both detailed images of all individuals AND accurately interpretable labels (preferably images of the actual labels). For me, even having an electronic taxonomic inventory of what an institution *thinks* it has would be helpful, as would images of the drawers, but ONLY for instances in which I would like to borrow material. I would love to virtually "cruise through" collections spouting off determinations, but, conversely, if we had pictures of our drawers out there for everyone to comment on, we would *never* be able to keep up with public comments correcting even a 1-5% error rate in determinations, let alone unsolicited, new "arm chair" determinations. Sounds great, but we would never be able to keep up. And even if we were able to, do we take a new picture every time a bug in a particular drawer is moved?
I would like to find a detailed database with photos and distribution maps of the specimens. In addition of this, I would be great if you can access to the keys to identify specimens related to the photos and maps.
Specimen collections of worldwide museums
habitat information/associations, label data, high quality photographs

more databases for insect species with images
a central searchable and editable (by experts) repository including all species which would ideally include all of the following information fields: Family Subfamily Tribe Genus Genus author Genus date Genus type species Genus designation Key to genus available, regions covered Species name Species author Species date Species type locality Species holotype sex Holotype location Holotype location confirmed? : person and date Paratype locations Synonyms Egg known Egg reference Larva known Larva reference larval behaviour Pupa known Pupa reference pupal behaviour Male described Female described Adult behaviour Autapomorphic characters Parasites Fungal Associations Habit Natural History notes: Photos Habitus drawings SEM images Current workers other references to species General Distribution: NE NT PA OR AU AF Specific distribution: List of Lat and Long (decimal degrees, comma and semicolon separated) Collection methods that work well rearing techniques Genes sequenced life cycle developmental study predators diseases pest beneficial method of control mating behaviour pollination records detailed morphological studies fossil dispersal ability Phylogeny known? used as exemplar in phylogenetic study intraspecific variation noted oviposition behaviour
a database of images with annotated morphological concepts for all insects. Better availability of literature.
A no- or low-cost key construction software.
downloadable specimen images at high resolution (at various angles if important). collection and label information that can be downloaded as spreadsheet file.
hi resolution images of primary types from different angles.
Of the above list the only features not available for my work is the ability for *others* to add notes / comments to my museum's data - this would be a good feature to add to leverage crowdsourcing.
#1 - A master list of collecting localities that have been professionally georeferenced and annotated #2 - addition of images to online records that are presently data transcriptions alone
databases of locality data for the taxa I am interested in linked across multiple collections
species account data that includes georeferenced location data and synonymies
Whole drawer images of undetermined material to allow remote identification for loans. Specimen data databases for determined material to allow access to distribution and phenology data.
Would love to see images linked to distribution data, biology and detailed images from several angles.
An online repository of collection locality/event data. This would not be specific to any institution, and any registered user would be able to contribute data (registration process similar to morphbank). If, for example, I go to the trouble of puzzling out the contents of a brown, deteriorating, sloppily handwritten label from the early 1900s, it would be nice if I could post the results somewhere (along with hi-res images of the original label) so that others with specimens from the same series might benefit.
Searchable taxonomic hierarchies
more databases like antbase. annotated illustrated checklists of world fauna
Detailed specimen images with label data including host.

Gigapan drawer views for more collections, including UNIDENTIFIED drawers.
Digital images of specimens (particularly type specimens) from major entomological collections (e.g., Smithsonian, AMNH,...)
type photos and reliable locality data
As I think about creating cybertaxonomy publications, I think most about the stability and permanence of repositories for electronically linked data. Many platforms appear nice now, but I question the longevity of nearly all of them. GenBank (and it's international partners) are still in a class by themselves as far as I can tell.
I would like to see county-level maps available for all states that anyone could easily use and fill in for their organism.
Searchable database of collection locations to use for inferring range.
Comparison with similar or relate species
Something like morphbank but with MUCH more sophisticated annotation capability
There is an online key to Thysanoptera that I have used to try to ID specimens, however, I have only found it somewhat useful because the characters they have in the database (description and pictures) do not include a number of characters used by other well known and commonly used taxonomic keys. It would be nice for there to be consistency between keys, and I think more characters to choose from is better than less, because although using less is probably intended to simplify identification, in my case it only complicates it.
Better authoring software for non-programmers to "fill in the blanks". I am creating my own data resource and it's an uphill battle. A lot more things would be out there if entomologists could keep on being entomologists.
More old literature
Complete catalogues (taxa lists), Images of identified (verified ID) specimens, simple image management systems
Whole drawer images of entire families from multiple institutions nationally, to provide a snapshot of our national research capacity for particular orders or groups.
detailed images from several angles of type specimens (and authentically determined ones in some cases)
more valid taxonomic lists with synonyms in order to place acurate names on specimens
Types deposited in any museum. Lists of holdings of any museum, at least by (sub)species, if possible individual.
full database of specimens in a collection with detailed images of every specimen from several angles highlighting characters that set that species apart from others
Detailed habitus photographs and images of male genitalia of every beetle species in the world, or at least the one's I'm interested in. Failing that, authoritatively identified specimens depicting same....in one place, linked to a complete up to date annotated catalog.
Searchable databases by Locality, with data sets presented in a GIS context.

Statistic	Value
Total Responses	62

20. How important to your work are collections of entomological specimens?

#	Answer		Response	%
1	Unimportant		1	1%
2	Of little importance		7	8%
3	Moderately important		4	4%
4	Important		11	12%
5	Very Important		70	75%
	Total		93	100%

Statistic	Value
Min Value	1
Max Value	5
Mean	4.53
Variance	0.93
Standard Deviation	0.96
Total Responses	93

21. How many times in the past year have you borrowed specimens from an entomological collection?

#	Answer		Response	%
1	0 times		29	31%
2	Once or twice		15	16%
3	3-5 times		18	19%
4	5-10 times		19	20%
5	More than 10 times		12	13%
	Total		93	100%

Statistic	Value
Min Value	1
Max Value	5
Mean	2.68
Variance	2.05
Standard Deviation	1.43
Total Responses	93

22. How many different collections have you borrowed specimens from in the past year?

→ *This question not displayed if answer to Q21 = 0 times*

#	Answer		Response	%
1	1		10	16%
2	2-4		33	52%
3	5-7		14	22%
4	8-10		4	6%
5	More than 10		3	5%
	Total		64	100%

Statistic	Value
Min Value	1
Max Value	5
Mean	2.33
Variance	0.95
Standard Deviation	0.98
Total Responses	64

23. How far away from your work location is the collection that you use the most?

#	Answer		Response	%
1	I do not use collections		11	12%
2	I work in a museum, and use its collection the most		47	51%
3	Local, within a short travel distance		20	22%
4	Within a few hours travel distance		5	5%
5	Must devote a day or more to travel		9	10%
	Total		92	100%

Statistic	Value
Min Value	1
Max Value	5
Mean	2.50
Variance	1.20
Standard Deviation	1.09
Total Responses	92

24. Would you be willing to participate in a more detailed follow-up survey, designed to look specifically at online resources in your area(s) of specialty? If so, please type below the e-mail address at which you would prefer to be contacted.

[To protect confidentiality of respondents, individual responses are not printed.]

Statistic	Value
Total Responses	54

25. Do you have any additional comments? If so, please add them below.

Text Response
I used a lot of specimens from several collections for my PhD thesis; now that I work in a collection I'm interested in seeing how best we can implement these tools ourselves as we put our collection "out there" for the entomological community after 60 years of being inaccessible to workers.
I love this site on new world Cerambycidae: http://plant.cdfa.ca.gov/byciddb/default.asp It has helped me enormously in my ability to identify Cerambycidae I find here in Peru. I think this format of habitus pictures of the type specimens is the way forward and would love to see something similar for other families especially for neotropical Chrysomelidae.
no
I do not use collections at the moment but my goal is to begin putting one together.
BugGuide.net probably gets more usage than all other entomological databases combined....
Some of this work is labor-intensive and can be error-prone. I had graduate student make 3.7 errors/specimen retrieving label data on the specimens he could find in the unit trays. In one unit tray with five specimens he only found three. Definitely an opportunity to teach the concept that incorrect data is unacceptable.
Nice survey. Liked the integrated link outs to gigapan and other databases. Will this work be presented at regional/national meetings?
I'd be glad to make additional comments. For now, I'd ask: what fundamental questions does the entomological museum community have to answer in today's research environment- is it raw specimen collection data? is it taxonomic holdings (especially types!)? is it exemplars for external determinations? is it a pretty face to show the public? I am not against specimen level databasing or gigapan pictures of drawers, but the elephant in the room is that we (and virtually everyone else) barely have the staff to take care of the physical specimens, let alone the associated data. Adding an additional layer of meta-data (images of drawers) only adds to the underfunded mandate.
You do a very interesting project that would enhance efficiency of biodiversity inventory in the world
greetings
for my research only images of primary types are important. I do use species representative images for other purposes
I'm impressed with the gigapan approach but very concerned that it seems only useful for a static collection (like a historical collection eg Darwin's Beagle collection). As soon as a drawer is modified post-photography the photographs start becoming out of synch with the drawers. Eventually the photos will so out of synch with the collection they'll be considered unreliable. Images of individual specimens (one per species) combined with label data for all specimens seems a more logical long-term approach for a non-static collection.

I am particularly concerned about quality control of online data. Experience indicates that many, many specimens being databased and placed online are not accurately identified, and/or not accurately georeferenced (the latter is most often due to erroneous original label data that has been transcribed uncritically, rather than transcription error). This runs serious risks for researchers using online data as a research tool.
I am sure you have thought of this, but it seems to me that pictures of drawers (or unit trays) assume that the collection is static. Any time a drawer gets curated, a new photo will need to be taken. In my experience with butterflies, drawers in an active collection may be reorganized every few months, and maintaining up-to-date photos would add a huge additional curatorial burden. Maybe for braconids or some group where there are a lot of undetermined specimens this would be useful, but not for butterflies.
I have been looking at GigaPan images of collections recently because we are imaging our collection as part of a database project. I find the GigaPan is useless for digitizing collection data (cannot see labels), but it is a neat way to image drawers. The high res images are helpful in confirming IDs, but I would never use it as a substitute for looking at specimens first hand.
Thank you (I wonder if some respondents may not read your note and think that 7 is the highest response because it is on the right of the screen)
I love Gigapan! Unfortunately the current implementation lacks two features: some user-friendly browsing or searching capability, an the ability to zoom in on very small specimens. I am looking forward to being able to use the drawer shots once it's all done!
no
You should have expressly stated that you could 'zoom in' on the first image of the drawer of insects. I am a regular user of on-line material but I thought this was a screen shot and so it wasn't until much later in the survey that I realized that I could get a magnified view of the drawer. This changed my answers significantly.
many of my responses to the usefulness of various online resources should have been appended 'assuming the identifications are correct'.
This is a fantastic survey, and I'm glad that you're asking these questions. Please let me know if there's anything I can do to help. And please send out a link to your Master's degree on the ECN-listserv when you're ready!
no
I am impressed with the potential for some of these tools for use by me and many other specialists in entomology and for the general lay collector, as well as those who may just wish to get information or photos of specific types of insects.
With small insects, generalised images are useful for a first guess, not for authoritative identification. The web has too many incorrect identifications based on guesses from images of specimens
Hello, The main issue with whole drawer images is that by far the majority of coleoptera are too small to get enough resolution or have critical ventral characters, to be useful and curatorially whole drawer images present enormous workflow issues to the curatorial staff in that if any re-arrangement of a working collection takes place then drawers must be re-imaged. Photos of individual specimens would probably be most useful if multi angle ones of types & their labels were prioritised. In the borrowing section I have possibly given missleading information. As the primary technician in Coleoptera I have been the conduit for all our loans going out to other organisations and also for incoming loans for our research scientist so my answers include both and weren't about insects loans for my own scientific investigations.

I would be very interested in learning the outcomes from this survey. Please don't hesitate to contact me!
biggest problems with online specimen resources: (1) identifications of most specimens/data not authentic or verified (numerous misidentifications apparent in my group), (ii) specimen images generally not detailed enough (resolution and angles of view) to be useful for research and identification of other specimens (works for big flat specimens such as Lepidoptera but not for the average insect (5mm long) whose diagnostic characters are often on the underside)
Interesting survey. I liked the pictures.

Appendix 2: Full Text of Solicitation E-mail

From: Katja Seltmann <katja_seltmann@NCSU.EDU>
Subject: What is the best way to digitize entomological collections?
Date: August 19, 2011 9:44:22 AM EDT
To: <ENTOMO-L@LISTSERV.UOGUELPH.CA>
Reply-To: Entomology Discussion List <ENTOMO-L@LISTSERV.UOGUELPH.CA>

What is the best way to digitize entomological collections? As part of a CollectionsWeb internship, in collaboration with Andrew Deans and staff at the NCSU Insect Museum, we are looking for volunteers to complete a 10-15 minute online survey for a research study to help answer that question.

To learn more and volunteer to take the survey, visit this URL:
https://uncodum.qualtrics.com/SE/?SID=SV_cHHh7iSm1j7fCXG

Your participation is completely voluntary. Your responses will be confidential and will be used only for the purpose of this research. You will not receive any commercial solicitations or other spam as a result of your participation.

*** The results of this survey could help entomological institutions better present their collections online, but taking the survey will not benefit you personally. The survey results may be published and used as part of the researcher's Master's thesis in Information Science at the University of North Carolina, Chapel Hill. By completing the survey, you are giving your consent to the use of your responses for this research.

This study has been reviewed by the UNC Office of Human Research Ethics (IRB Study No. 11-1319).

If you have any questions, please contact the researcher:
Babi Hammond, hammondb@email.unc.edu.
Faculty advisor: Professor Jane Greenberg, janeg@email.unc.edu.

thanks for your help!
katja

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