- Evaluations
- Term paper: Saturday evening
- Labs
- Final: Wednesday, 11 December, 2013 at 8 AM

Importance of Biological Collections

The nation's natural science collections form an irreplaceable record of scientific discovery across time and space and are a resource that contributes vital information daily across the spectrum of scientific disciplines.

Mares (2009)

* public health
* forensics
* customs matters
* biological invasions
* ecology
* evolution

* climate change
* biogeography
* agriculture
* paleontology
* conservation biology
* etc.

Importance and Value of Roles of Taxonomic Collections

Natural science collections have

* aesthetic and cultural value
* scientific value
* outreach and educational value
* financial value

1. Biological collections provide record of Earth's biota

* many species exist only in natural history collections: passenger pigeons, Carolina parakeets, Tasmanian wolf
* collections especially critical for fragile biotas, e.g., many island taxa only exist as specimens in museums e.g., dodos and Hawaiian honeycreepers
  - Hawaiian, New Zealand, and Pacific faunas devastated by rats, Polynesians, and other invasive species

➢ With major climate changes looming many of you will be the last generation to see some species

2. Essential source of specimens for revisionary and monographic studies

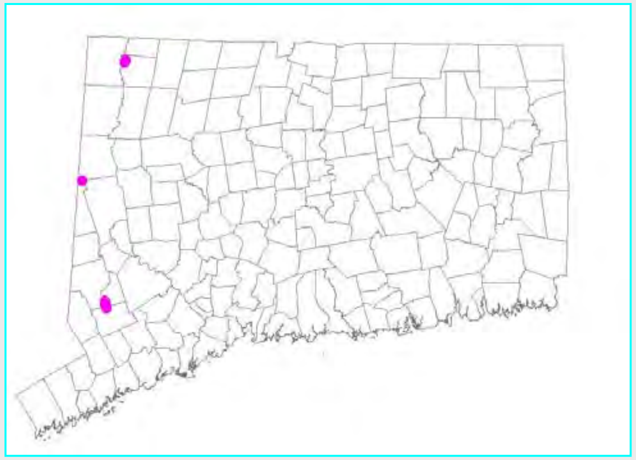
* population samples necessary for understanding the nature of variation: i.e., what is individual vs. geographic vs. species-level variation [a problem with barcode samples in Barcodes of Life Database, presently]
* essential for species-level revisions
  - especially important if variation is discontinuous or packaged in other non-obvious ways

2. Essential source of specimens for revisionary and monographic studies

* museum specimens quintessentially important for certain types of systematic studies:
  * fossils, e.g., dinosaurs
  * extinct taxa: e.g., some NZ wetas, many NA mussels
  * rare taxa: museums especially important if taxa are too rare or too difficult to sample/collect. Some examples:
    - subterranean taxa (certain army ants)
    - canopy taxa
    - behaviorally cryptic taxa
    - taxa that require highly specialized and/or expensive collecting efforts (e.g., shark tapeworms)

3. Sources of geographic data

* basic taxonomic distributions
* important yardstick by which we measure rarity
  - principle criterion for rarity: number of populations
  - global and state rarity rankings and endangered species legislation tied to occurrences

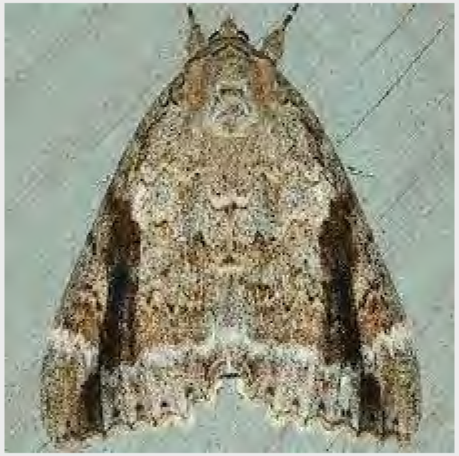


3. Source of geographic data

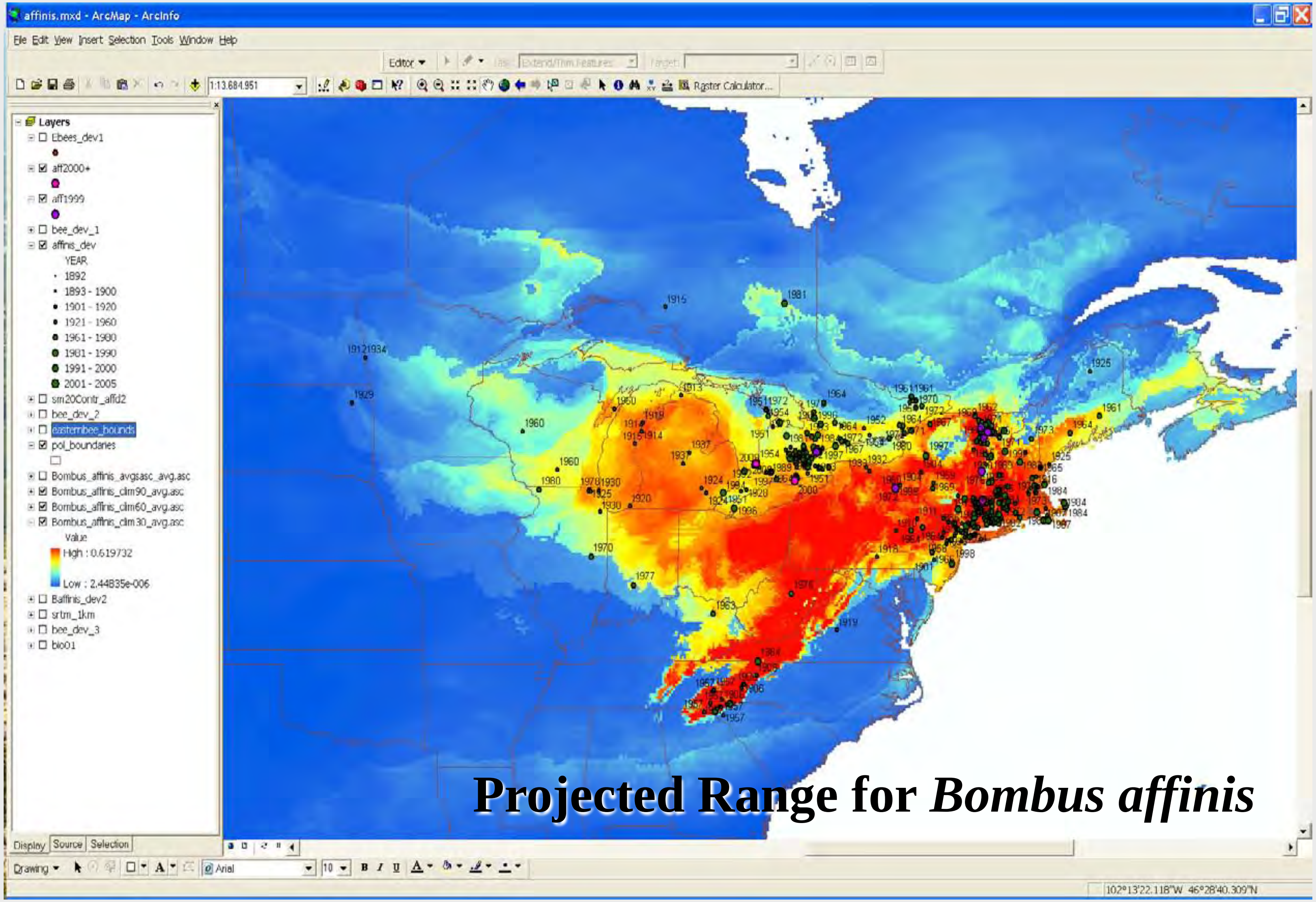
* distributional data can be used to make inferences, e.g., hostplant associations:

  - *Catocala marmorata* life history unknown, very rare in collections; combination of phylogeny and collection data allowed Larry Gall (Yale) to infer swamp cottonwood, *Populus heterophylla*, as one of the moth's primary hostplants (for larval development).

Populus heterophylla



3. Source of geographic data for climate/species/ niche modeling



4. Collections as sources of historic data

* geological scale:
  - fossils indicate camels and giant sloths were in North America
  - even tsetse flies were here
  - fossils frame our understanding of earth's great extinction events

* historic scale (from time of human influence)
  - yardstick for evaluating human influences on landscapes and documenting faunal changes

    e.g., biotic changes in New England
    - around 1850 CT was 70% agricultural
    - abundant early successional habitat: lupines, grasslands...no deer

4. Collections as sources of historic data

* tracking biological introductions
  - collections help identify the source and date of biological introductions
  - native parasite fauna of giant silk moths began disappearing after introduction of tachinid fly from Europe (*Compsilura*)
  - AIDS virus traced back to chimpanzees, e.g., vouchered tissue samples from chimp autopsies indicate four chimps died of an AIDS virus (called SIVcpz)
  - additionally a related virus SIVsm was found in Smithsonian samples of the sooty mangabey (that dated to collections made in 1896)

4. Collections as sources of historic data

(tracking biological introductions continued)

- Hantavirus: specimens at Texas Tech and University of New Mexico contained hantavirus that pre-dated 1993 viral outbreak in NM initially blamed on military biol. weapons lab

- Collections help identify the source of exotics and invasives and thus aid search for biological control agents

- Genetic analysis of museum specimens can be used to track spread of alien and invasives

5. Collections record of environmental contamination

* specimens can be used to track environmental degradation or improvement; *specimens hold environmental signatures*

  - feather (chemistry) of specimens can be used to track mercury pollution (over time and space)

  - egg shells of raptors were used to show effect of DDT (shell thicknesses diminished from 1940s forward)

6. Biological specimens can be sources of climatological/phenological data

Along the way, Lewis and Clark dug storage caches to preserve not only botanical and wildlife specimens, but also gear they didn't expect to need until their return trip.

* track global climate changes by determining isotope changes
  - measure oxygen in specimens (microfossils)
  - Lewis and Clark specimens are being used to measure atmospheric changes in 12C/14C ratios which is a reflection of atmospheric CO_2 concentrations

6. Biological specimens can be sources of climatological/phenological data

* collections will play a role in measuring and predicting the impacts of global warming
  - Parmesan (1996) looked at distributions of 35 European butterflies: 63% had ranges that had shifted northward and 3% had ranges that had shifted southward
* collections can help document phenological changes
  - Dunn and Winkler (1999) looked at 21,000 nesting card records in museums and universities for the tree swallows: pairs are nesting 9 days earlier over period from 1959 to 1991

Climate-associated phenological advances in bee pollinators and bee-pollinated plants

Ignasi Bartomeus[a,1], John S. Ascher[b], David Wagner[c], Bryan N. Danforth[d], Sheila Colla[e], Sarah Kornbluth[b], and Rachael Winfree[a]

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Edited by F. Stuart Chapin, University of Alaska, Fairbanks, AK, and approved November 7, 2011 (received for review September 21, 2011)

The phenology of many ecological processes is modulated by temperature, making them potentially sensitive to climate change. Mutualistic interactions may be especially vulnerable because of the potential for phenological mismatching if the species involved do not respond similarly to changes in temperature. Here we present an analysis of climate-associated shifts in the phenology of wild bees, the most important pollinators worldwide, and compare these shifts to published studies of bee-pollinated plants over the same time period. We report that over the past 130 y, the phenology of 10 bee species from northeastern North America has advanced by a mean of 10.4 ± 1.3 d. Most of this advance has taken place since 1970, paralleling global temperature increases. When the best available data are used to estimate analogous rates of advance for plants, these rates are not distinguishable from those of bees, suggesting that bee emergence is keeping pace with shifts in host-plant flowering, at least among the generalist species that we investigated.

Climate warming over the past 50 y is associated with phenological advances in a wide variety of organisms including plants, birds, and insects (1–3). Responses to climate warming are particularly important to understand for species that provide critical ecological functions such as pollinators. Furthermore, many ecological functions result from interactions among species, and because not all species respond to climate warming in the same manner, this could potentially lead to phenological mismatches that result in the loss of function (4–6). Alternapare with rates of phenological advance between plants and bee pollinators.

To evaluate long-term phenological trends in wild bees from northeastern North America (Fig. S1), we used museum data dating back to the 1880s. Ten bee species that emerge in early spring were selected for study, because spring-active taxa are known to be good indicators of response to climate change (2). Additionally, species were selected to encompass a range of natural history traits, including both cavity and soil nesters, and both solitary and eusocial species. All 10 species are generalists that visit a wide range of spring-blooming flowers. A primary challenge in investigating long-term phenological shifts is obtaining reliable historical data. In contrast to other animal taxa such as birds and butterflies, for bees there are no long-term standardized monitoring schemes that could provide historical data. We used data from the contemporary period (2000–2010) in conjunction with data we recorded from museum specimens dating back to the 1880s to examine a 130-y period for which no other form of data on bee phenology is available (the final analysis comprises 3,447 records). Museum specimen records indicate that a species was in flight on the collection date, thus representing the span of activity for a given species in a given year. Such complete distributions may be more robust to sampling bias compared with records of the earliest activity in each year, and have been used in studies of climate-induced phenological change for other taxa (e.g., 15, 16).

ECOLOGY

Results and Discussion

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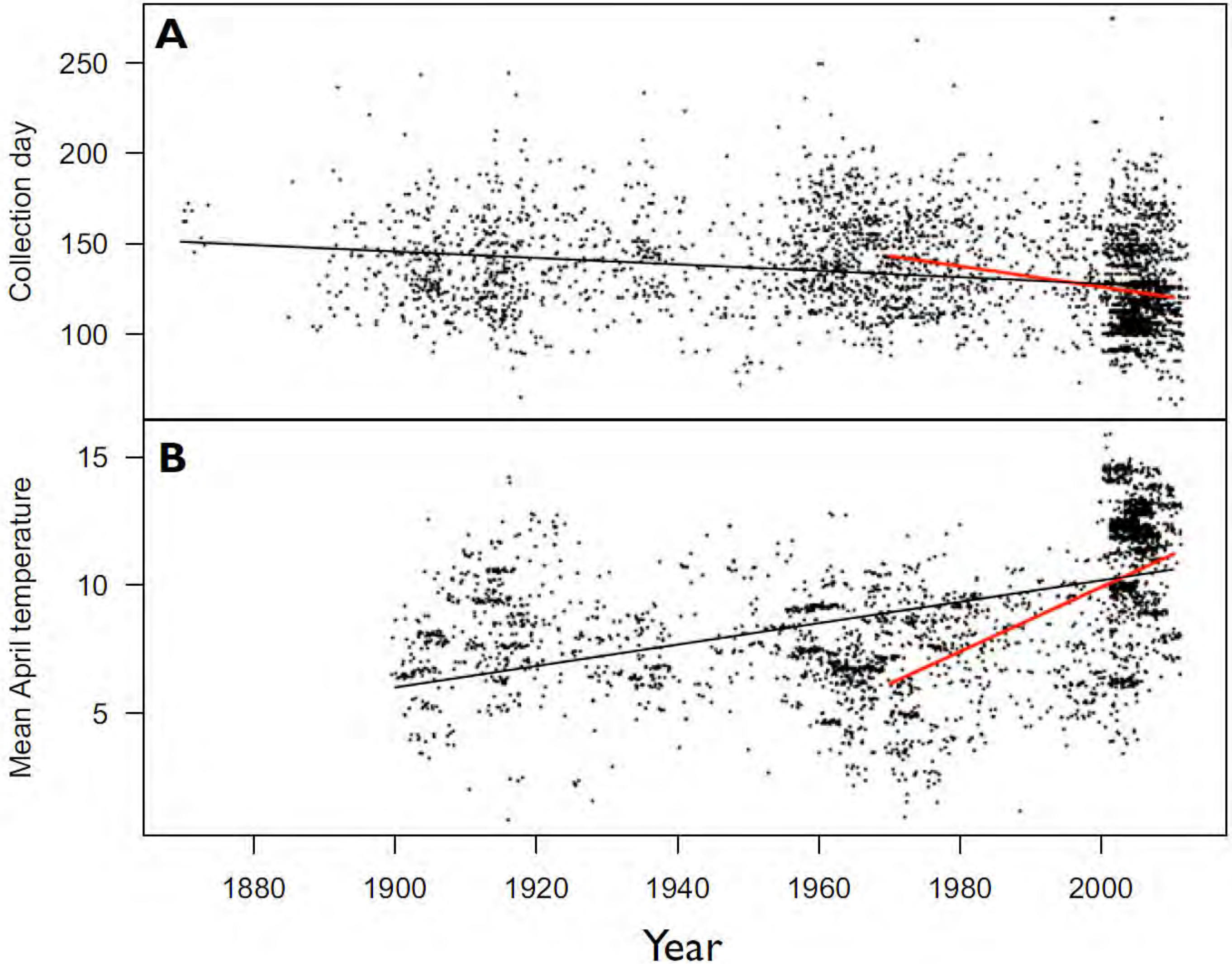

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Results and Discussion

ECOLOGY

7. Reference collections for identification

***** Many scientific disciplines are dependent on identifications: health sciences, agriculture, resource management, biotechnology, biomonitoring, conservation biology, and forensic science.

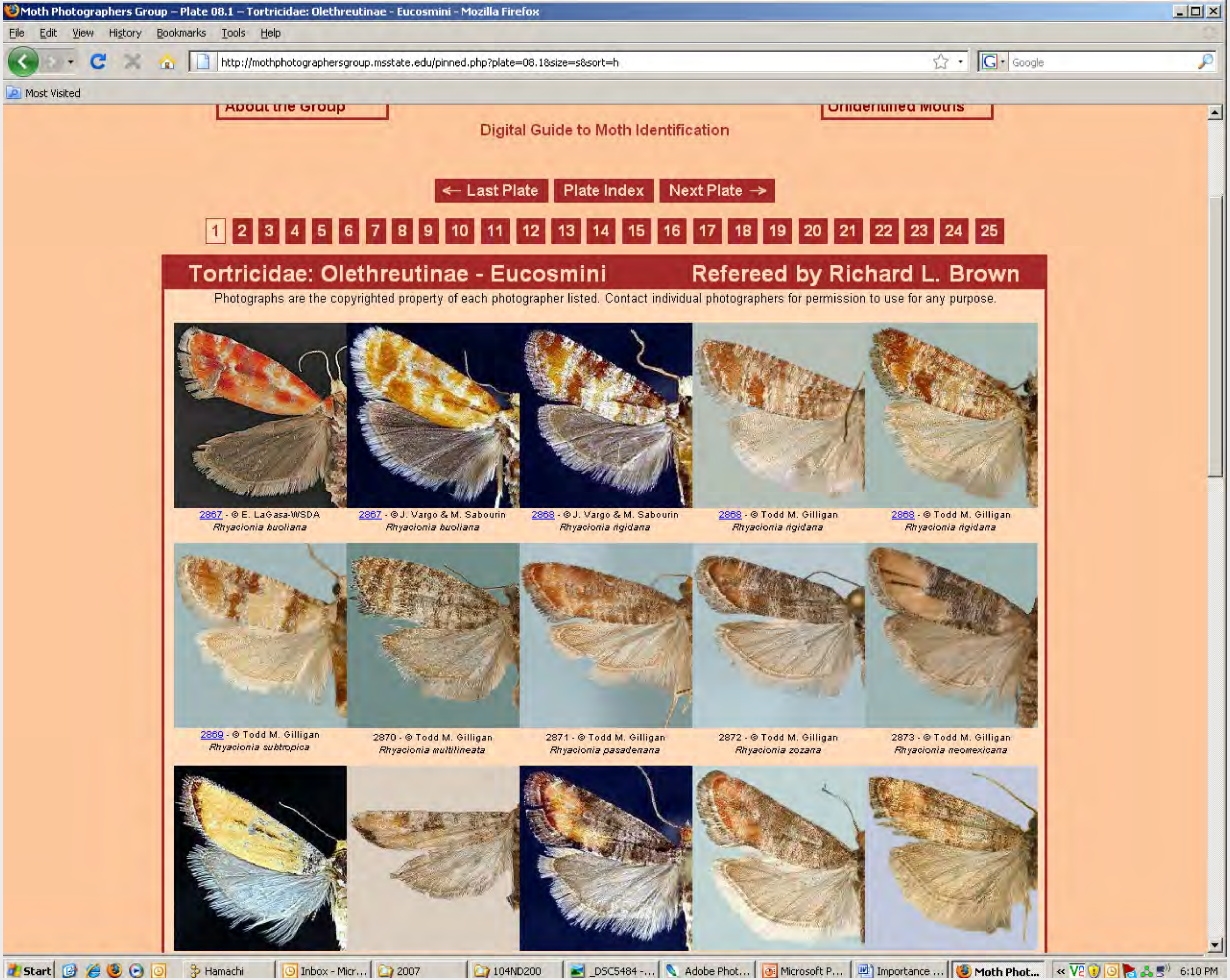
* special importance for identification of material intercepted at points of entry, customs, new pests, etc.

* Much environmental monitoring based on species-level identifications;

- *good ecology starts with good taxonomy and good statistics*

* conservation community relies heavily on reference collections and systematists for their identifications which are then used to make acquisition and management decisions

- future: most identifications will be done using on-line resources and/or by employing rapid DNA sequencing techniques (DNA barcoding technology)



http://mothphotographersgroup.msstate.edu/

VirtualHerbarium

bgbaseserver.eeb.uconn.edu/Teacher_website/index1.html

ECOLOGY & EVOLUTIONARY BIOLOGY

Examples of database uses | Lesson plans | Databases | Other resources

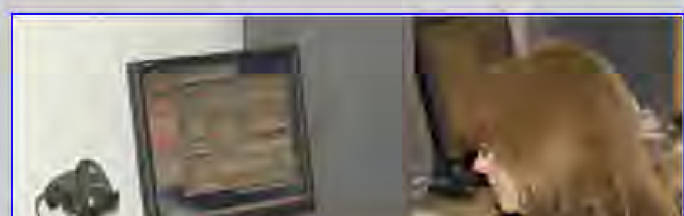
The Virtual Herbarium goes to school

Collections of biological specimens all over the world are being converted to digital format and made available online. Plants, animals, fungi -- it's all being entered into databases and, in some cases, made available as digital images.

Through this process, biological collections that have existed only in far-away corners of the globe are becoming almost instantly available to anyone with a computer and an Internet connection. Biologists have been using biological collections for centuries to investigate all kinds of important biological questions. They have travelled all over the world to examine specimens, spending years doing it. For them, the unprecedented access makes possible new kinds of research that can be done only with huge numbers of specimens, and simpler questions can be answered more quickly than was possible ever before.

But professional biologists are not the only ones who can benefit. Many analyses can be conducted by younger biologists-in-training as well. There is no reason why professionals should be the only ones with access to these global riches, this bonanza of biodiversity.

The George Safford Torrey Herbarium at the University of Connecticut began databasing its specimens years ago but now has taken the process to a new level. Thanks to a grant from the National Science Foundation, we will finish entering data on our vascular plant specimens in the next three years. Those data, plus images of every specimen, will be available online, as about 40% of the collection already is. This is a lot of work, but we believe it is worthwhile. We now want to make sure that lots of people are aware of this resource so they can put it to use. We think biology students in high school are an overlooked audience who could benefit from having a chance to work with online specimen data, participating in the process of discovery, which is what science is all about. We won't be surprised if high school biologists using online data make some real contributions to our understanding of how the world works.



Working with high school and middle school teachers, we are beginning to develop curricular material to help teachers use our database. We will post those materials here as they are developed, and we encourage other teachers to explore our data and to shape it to their own needs. We also will put links on this site to other web pages where information for high school students and their

The Dragonflies and Damselflies (Odonata) of Ecuador - Mozilla Firefox

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http://efg.cs.umb.edu/efg2/Redirect.jsp

Most Visited

The Dragonflies and Damselflies (Od...

The Dragonflies and Damselflies (Odonata) of Ecuador

William A. Haber, University of Massachusetts, Boston
David L. Wagner, University of Connecticut, Storrs

website

Scientific name	Family	Thumbnail
Hetaerina aurora	Calopterygidae	
Hetaerina caja	Calopterygidae	
Hetaerina capitalis	Calopterygidae	
Hetaerina fuscoguttata	Calopterygidae	

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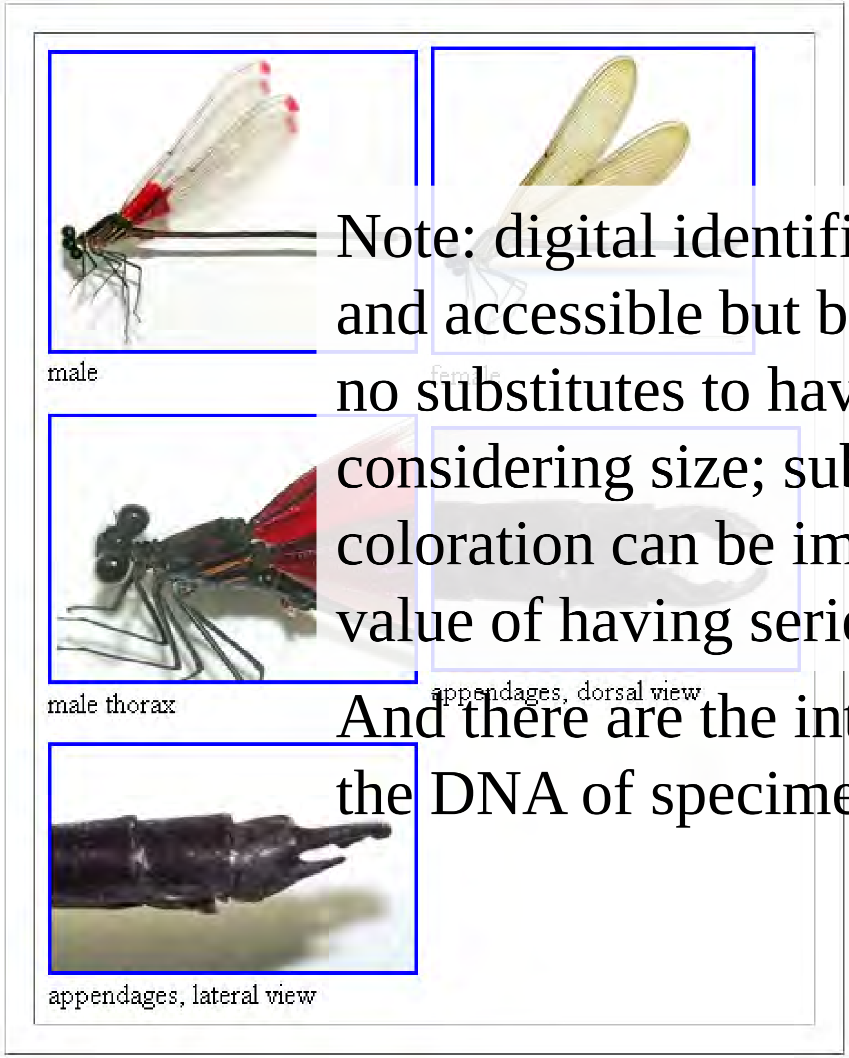
Species page

Hetaerina aurora Ris, 1918
Calopterygidae Ruby spotsDemoiselles



Male identification
Stigma absent.
All wing tips with a red spot.
Lower appendage half as long as upper.

Female identification
Stigma absent.
Labrum and postclypeus shiny black.
Dark areas of thorax metallic purple-red.
Three nearly complete dark stripes on side of thorax.
S10 with a dorsal tooth at apex, no dorso-lateral teeth, 3-4 ventro-lateral teeth.

Similar species
Hetaerina capitalis

Body length - male: 49.0

Abdomen length - male: 39.0

Body length - female: 39.0-43.0

Abdomen length - female: 30.0-34.0

Hindwing length - female: 27.0-30.0

Local distribution: Pacific slope at 1000 - 1700 m.

Habitat: Medium to large rivers in forested or open areas.

Abundance: Common.

Species range: Colombia and Ecuador

Updated: 24 May 2009

Note: digital identification sources are fabulous and accessible but be forewarned that there are no substitutes to having actual specimens when considering size; subtle differences in coloration can be important; and there is much value of having series for comparison..

And there are the internal structures…add, too, the DNA of specimens.

8. Collections play roles in teaching and public outreach about biodiversity

From ASC Newsletter October 1995. 23: 69.

"Natural science collections impart scientific understanding to society;

- they are integral to public education, interpretation, public enjoyment and inspiration about the natural world.

- they facilitate environmental protection and conservation efforts;

- they promote an understanding for and an appreciation for sustainable development;

- much of the raw materials for displays, field guides, etc., that engender an appreciation for biodiversity, come from natural history museums…”

9. Collections as repositories for voucher material

* Voucher specimens are important if species identity is essential
  - especially important where taxonomy is in a nascent state, e.g., in tropics (lianas, ferns, many poorly studied groups of insects)
  - or if taxon might later prove to be a complex, e.g., green lacewings morphs; periodical cicadas; common spring azure butterfly in Connecticut

Spring azure butterfly: appears to be a complex of six plus species

9. Collections as repositories for voucher material

* Still a large role as vouchers for all entries in DNA-sequencing efforts (esp. for poorly-known groups)

* Many journals require deposition of vouchers in major institutions

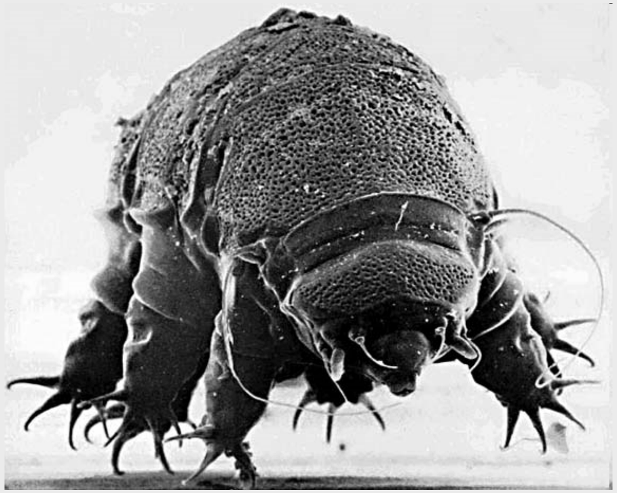
On voucher material

Anna K. Behrensmeyer, then acting associate director for science at the National Museum of Natural History (Smithsonian Institution), once pointed out that: “We must have the objects themselves to serve as the factual basis for knowledge, the final arbiter in matters of contested identity or meaning, the ‘ground truth’ that underlies our understanding of the world we inhabit.”

10. Biological prospecting

* pharmacological exploration for medicinals, pharmaceuticals, etc.
  - alkaloids in plants
  - steroids
  - promising extract from a Cameroon vine may block transmission of HIV/AIDS from mother to child across umbilicus.
* Horticultural varieties
  - seeds of wild tomato in collection led to new tomato cultivar with higher soluble solid content that is returning $8 million per year

11. Biological specimens themselves communities/ecosystems



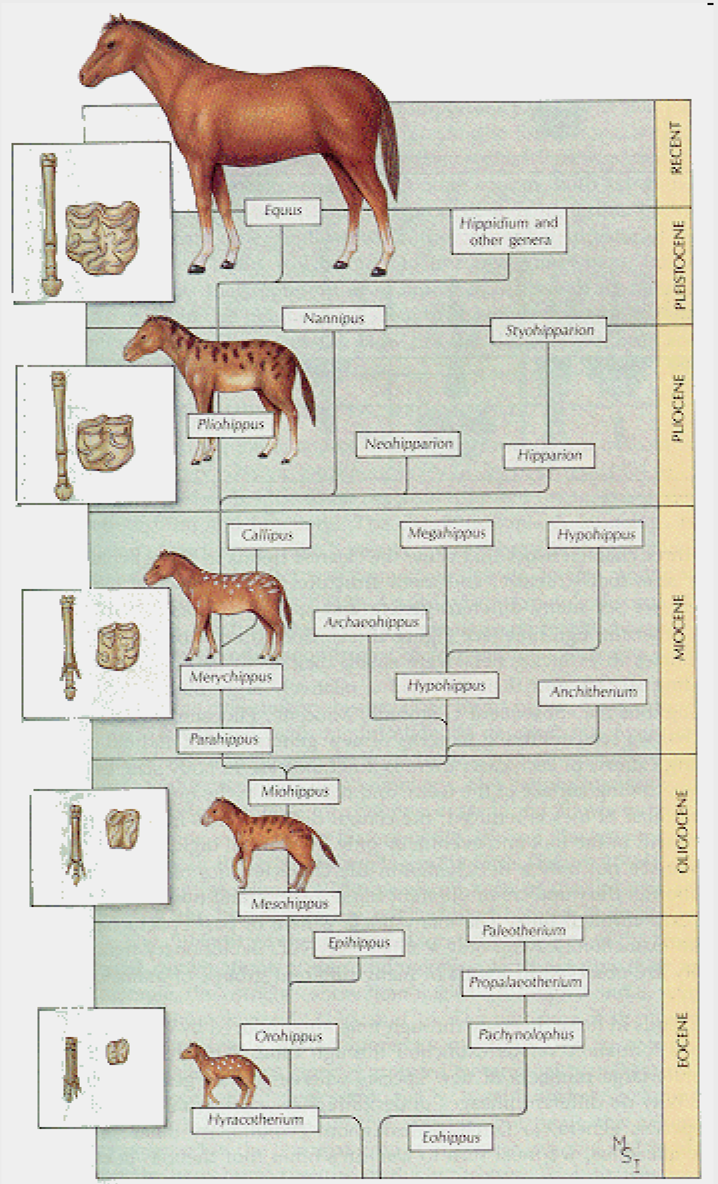
* Almost every bird species has 1-20 associated feather and quill mites
* Moss samples are rich in microcrobes and microinvertebrates, e.g., many water bears (tardigrades) await discovery in moss samples
* Leafminers, galls, and other insects can be found in herbarium specimens
* Some fish are "parasite hotels"

12. Source of ecological data

* Plant-pollinator associations
- explicit association given with specimen data
- identify pollinator, by examining attached pollen or pollinia (esp. orchid bees and sphingids)
- pollen on Costa Rican sphingids (hawk-moths) helped document massive (long-distance) movement from dry to wet forests (work of Bill Haber)

* Locality data allows ecological inferences,
- e.g., label data often allows one to infer if a species is a serpentine or limestone obligate, grassland taxon, sandplain associate, etc.

13. Collections provide basis for evolutionary studies



Biological collections have been used thousands of times in ecological and evolutionary studies; a few illustrative examples…

a) theory of evolution borne out of Darwin's natural history collections on the Beagle

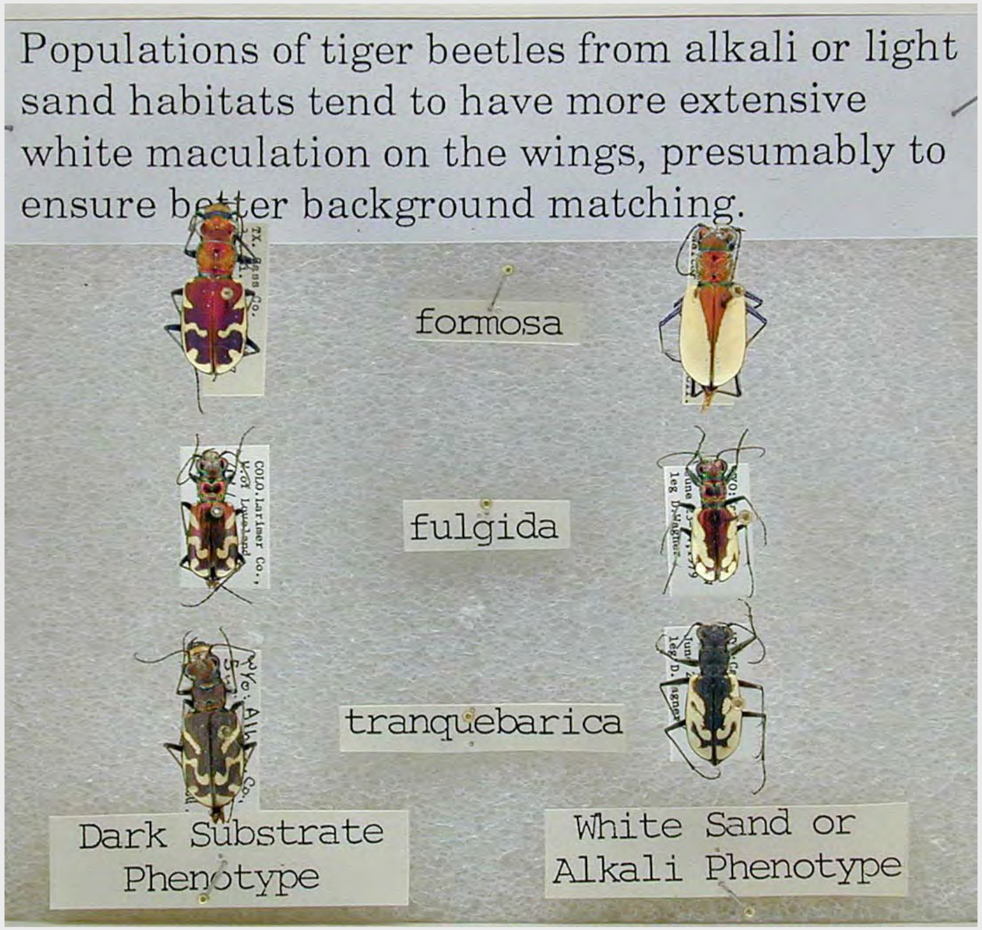
b) industrial melanism

c) mimicry: proposed by Sir Walter Henry Bates in 1862 based on his studies of butterfly wing patterns (with Alfred Russell Wallace)

d) evolutionary trends:

- horse evolution: fusion of toes

13. Collections provide basis for evolutionary studies



e) correlation studies:

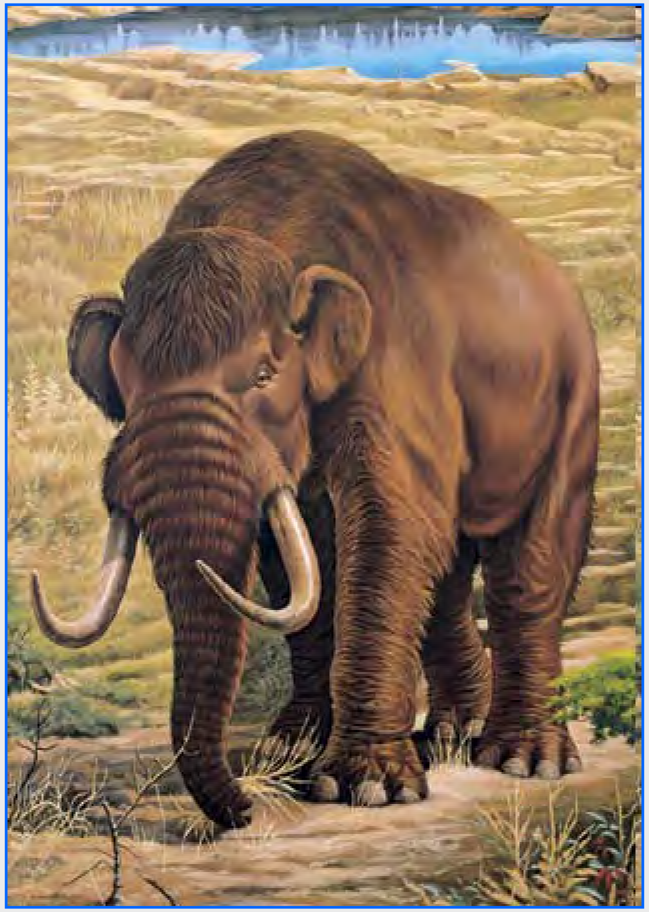
- darker coloration and thermoregulation in arctic butterflies (Kingsolver)

- tiger beetles that live on white sands and alkali have more white maculation on the elytra...better background-matchers.

f) functional morphology, e.g., beaks and Darwin's finches: bill thickness closely correlated to diet and community attributes on each of the islands.

14. Biological collections as sources of DNA

* Many museum specimens are appropriate for extracting mitochondrial or high copy number DNA
* Specimens sometimes a source for ancient DNA
  - sound DNA recovered from 13,000-year-old mastodon
* Repair enzymes may allow DNA repair prior to amplification
* Soon be able to meaningfully sequence type specimens (with highly degraded DNA)



15. Collections have monetary value

* Pinned insects with full data that are well spread and identified to species are worth about $5/specimen (as a tax deduction)
  - insect paratypes - $25-$50
  - insect holotypes - $100-$500

* *Triceratops* skeleton - 500,000 euros at 2008 Christie’s auction in Paris

Five Types of Systematic Collections

a. Exhibit and Outreach
b. Teaching
c. Identification
d. Faunal and specialty
e. Research

Challenges for Natural History Museums

1. Specimen backlogs
2. Decreases in funding and staffing
3. Collection maintenance costs increasing
4. Collections take up a lot of space

   - administrators want overhead recovery….universities getting more business like each year

With biodiversity crisis looming on horizon institutions apt to see continued growth of collections in the face of dwindling human and monetary resources.

Many Roles of the Museum Systematist

a. research output
b. curation
c. overseeing collection growth, engaging in collecting expeditions, faunal and floral surveys
d. overseeing digitization of biological specimens, literature, etc.
e. education and outreach
f. identification(s)
g. etc.

The Future of Natural History Collections

* fewer larger collections
* support coming from NSF and private endowments
* digitization and online access
* seamless querying off worldwide biodiversity resources

Readings and Websites

Mares, M. A. 2009. Natural Science Collections: America's Irreplaceable Resource. BioScience 59: 544-545.

Natural Science Collections Alliance (http://nscalliance.org/)

Thomson K. S. 2005. Natural History Museum Collections in the 21st Century. http://www.actionbioscience.org/evolution/thomson.html

Winston, J. E. 2007. Archives of a small planet: The significance of museum collections and museum-based research in invertebrate taxonomy. Zootaxa 1668: 47-54. (http://www.mapress.com/zootaxa/2007f/zt01668p054.pdf).