

Why ontologies are important for understanding morphological images

Greg Riccardi and Austin Mast
Florida State University



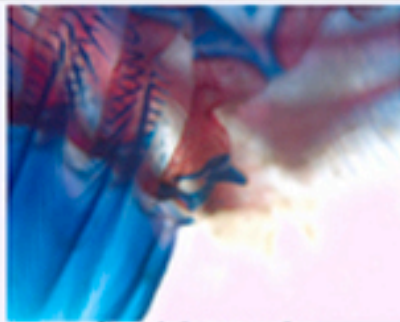
Acanthopis choromynchos



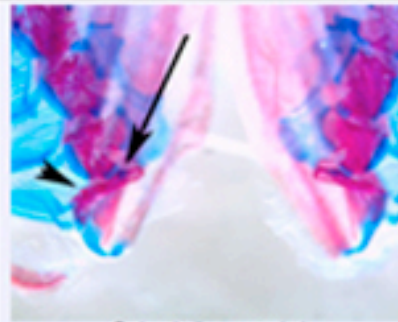
Barbus barbus



Barbus barbus



Chromobola macroacanthus



Gyrinocheilus aymonieri

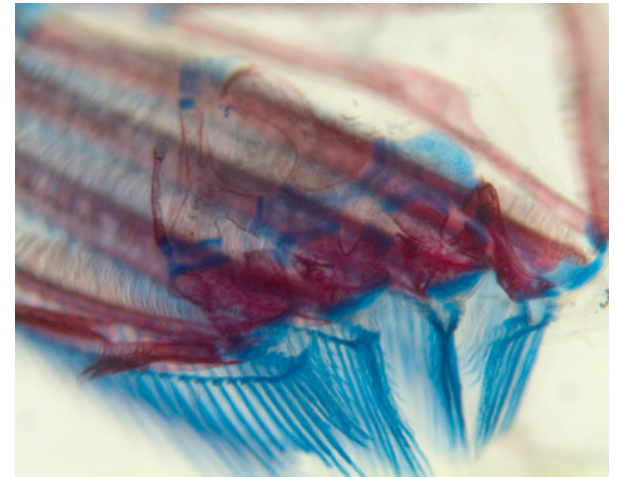


Balantiocheilus melanopte



Topics

- Morphbank overview
- Images and Research Work Processes
- Ontology Integration



riccardi@ci.fsu.edu



Early Exposure to Biodiversity Informatics

- The Friendly Book
by Margaret Wise Brown
ill. Garth Williams
©1954
- Includes
 - Morphology
 - Behavior
 - Ecology
 - Taxonomy
- Current version is missing 4 pages
 - I like bugs
 - I like seeds
 - I like fish



Bugs

I like bugs.
Black bugs.
Green bugs.
Bad bugs,
Mean bugs,
Any kind of bug.

A bug on a rug,
A bug in the grass,
A bug on the sidewalk,
A bug in a glass,
I like bugs.

Round bugs,
Shiny bugs,
Fat bugs,
Buggy bugs,
Big bugs,
Ladybugs,
I like bugs!

by Margaret Wise Brown



riccardi@ci.fsu.edu




Early exposure to biodiversity info



From *Friendly Stories* by Margaret Wise Brown



“I like seeds” has disappeared

 [Advanced Search](#)
[Preferences](#)

Web [+ Show options...](#)

Your search - **margaret wise brown "i like seeds"** - did not match any documents.

Suggestions:

- Make sure all words are spelled correctly.
- Try different keywords.
- Try more general keywords.
- Try fewer keywords.

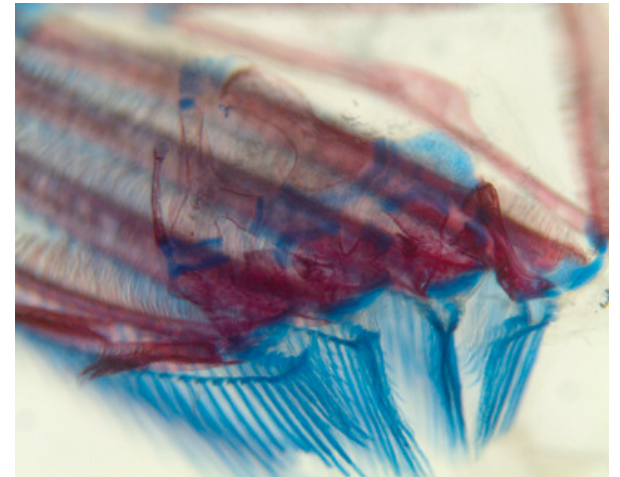


riccardi@ci.fsu.edu



Topics

- **Morphbank overview**
- Images and Research Work Processes
- Ontology Integration

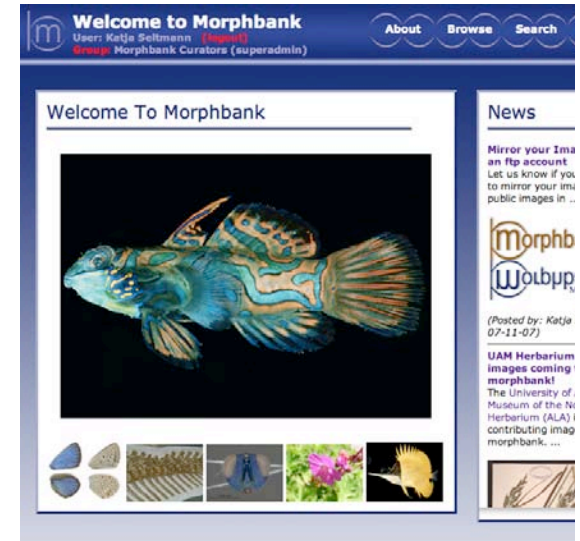


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Morphbank Project

- Repository of images of organisms
 - 220,000 images so far
 - Each image has a context:
 - Specimen, taxon, locality, specimen part, view angle, etc.
- Repository of information related to the images
 - Specimens, localities, users, groups, taxa, annotations, collections
 - Owner, group, date, permissions
 - Unique identity for each object
- All objects are connected through collections and associations (*aka* annotations)

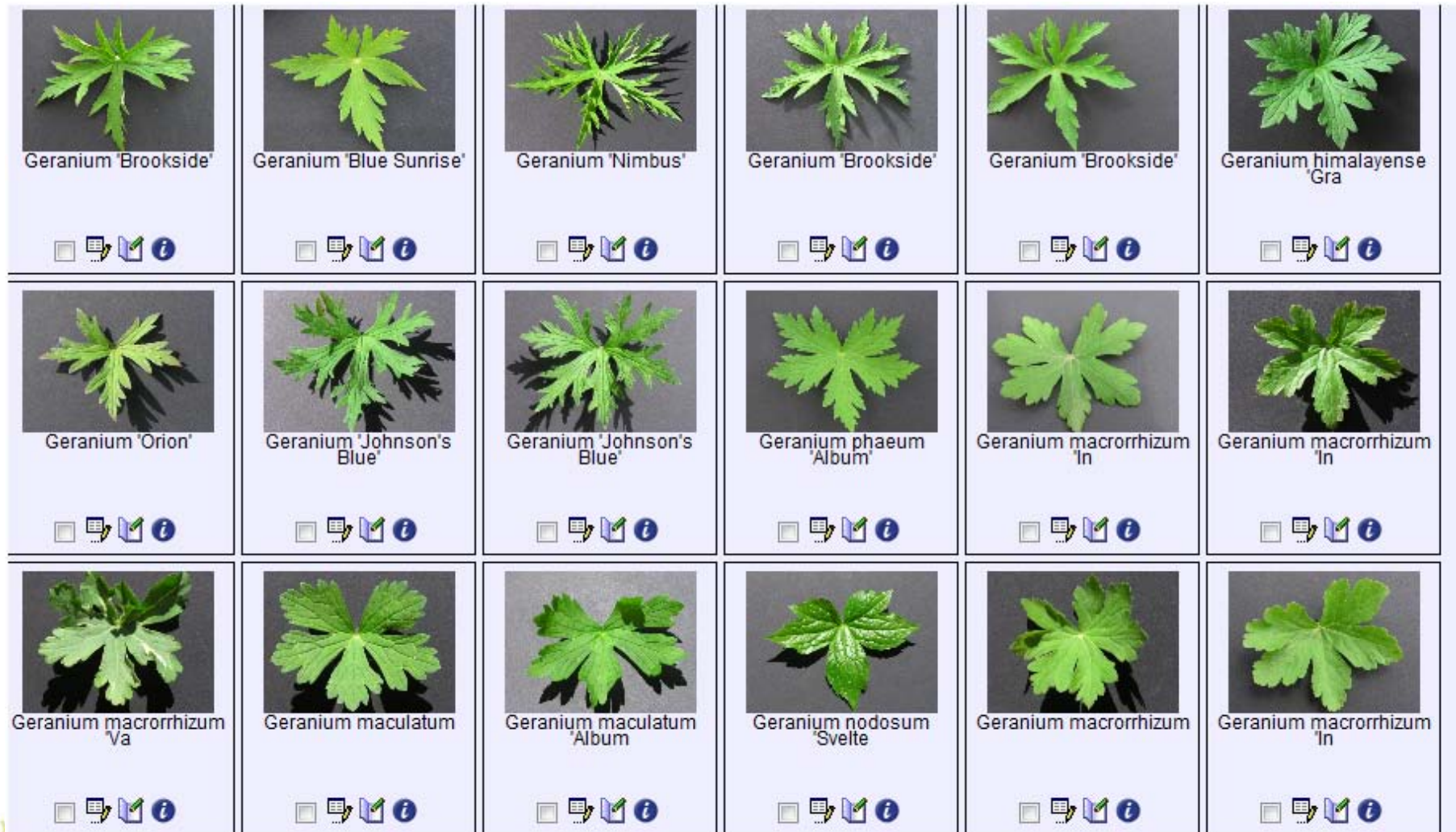




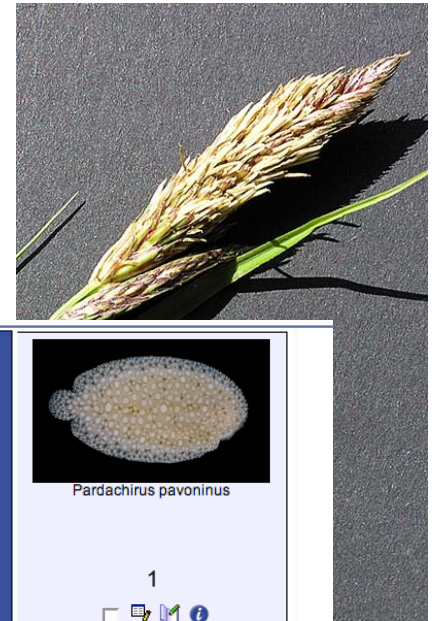
- Create value for users
 - Actively adapt system to needs of users
 - Give users credit for contribution
- Support for contributors
 - Hire people who like people
 - Make sure that anyone who wants to give us content is made welcome
 - Help contributors to understand metadata standards and the value of data







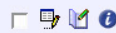


























Sorting Images by Observed Features



Defining a Character and its States



State: 0 Elongate 	 <i>Gymnothorax undulatus</i> 0 	 <i>Callechelys marmorata</i> 0 	 <i>Sphyraena</i> 0,3 	State: 1 Broad and flat 	 <i>Pardachirus pavoninus</i> 1 
 <i>Asterorhombus intermedius</i> 1 	State: 2 Laterally compressed subrectangular 	 <i>Forcipiger longirostris</i> 2 	 <i>Chaetodon fasciatus</i> 2 	 <i>Chaetodon mertensii</i> 2 	 <i>Pomacanthus semicirculatus</i> 2 
State: 3 Laterally compressed ovoid 	 <i>Carangoides hedlandensis</i> 3 	 <i>Chromis atripectoralis</i> 3 	 <i>Sphyraena</i> 0,3 	Undefined ? 	 <i>Amphiprion tricinctus</i> ? 



Linking to Morphbank Images

Handbook of Nearctic Chalcidoidea


start key browse couplets glossary about

start key > couplet 1 > couplet 2 > couplet 3

ovipositor horizontal or curved

Couplet 3a
Ovipositor directed horizontally (in most species not extended beyond apex of metasoma (gaster)); tegula a nearly oval disc; forewing not folded longitudinally.
Family Chalcididae

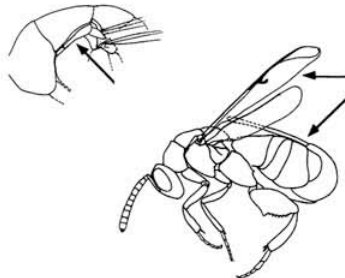
Added images:




Epitranus clavatus

Couplet 3b
Ovipositor curved dorsally over metasoma (gaster); tegula narrowly extended forward; forewing often folded longitudinally.
Family Leucospidae

Original drawing:




Added images:



Single show
User: Katja Seltmann (logged)
Group: Morphbank Administration (administrator)

About Browse Search Tools Help

Image Record: [111266] Epitranus clavatus

<p>Contributor: Michael Gates</p> <p>Submitter: Michael Gates</p> <p>Date Submitted: 12-05-2006</p> <p>Last Modified: 12-05-2006</p> <p>Publish Date: 12-04-2006</p> <p>Magnification: NULL</p> <p>Dimension (px): 1366x1024</p> <p>Resolution (PPi):</p> <p>Submitted as: TIFF</p> <p>Original File Name:</p> <p>View id: 111240</p> <p>Specimen part: Body</p> <p>Angle: Lateral from left</p> <p>Technique: EntoVision</p> <p>Preparation: No preparation</p> <p>Download: tif (2.2 MB)</p> <p>jpg (882.8 KB)</p> <p>Copyright: Michael Gates</p>	
<p>Specimen</p> <p>Specimen id: 111250</p> <p>Base of record: [5] - Specimen</p> <p>Sex: Female</p> <p>Form: Indeterminate</p> <p>Stage: Adult</p> <p>Catalog number: Info. not provided</p> <p>Collector: D. R. Smith</p> <p>Date collected: 06-30-2000</p>	<p>Locality</p> <p>Locality id: 111229</p> <p>Continent ocean: [NA] - NORTH AMERICA</p> <p>Country: [US] - UNITED STATES</p> <p>Locality: West Virginia: Hardy Co.: 3mi NE Mathias</p> <p>Latitude:</p> <p>Longitude:</p> <p>Elevation (m):</p>
<p>Determination</p> <p>Class: Insecta</p> <p>Order: Hymenoptera</p> <p>Family: Chalcididae</p> <p>Genus: Epitranus</p> <p>Species: Epitranus clavatus</p>	<p>Determination annotations (Add Annotation...)</p>

E. Grissell, M. E. Schauff & Mike Gates

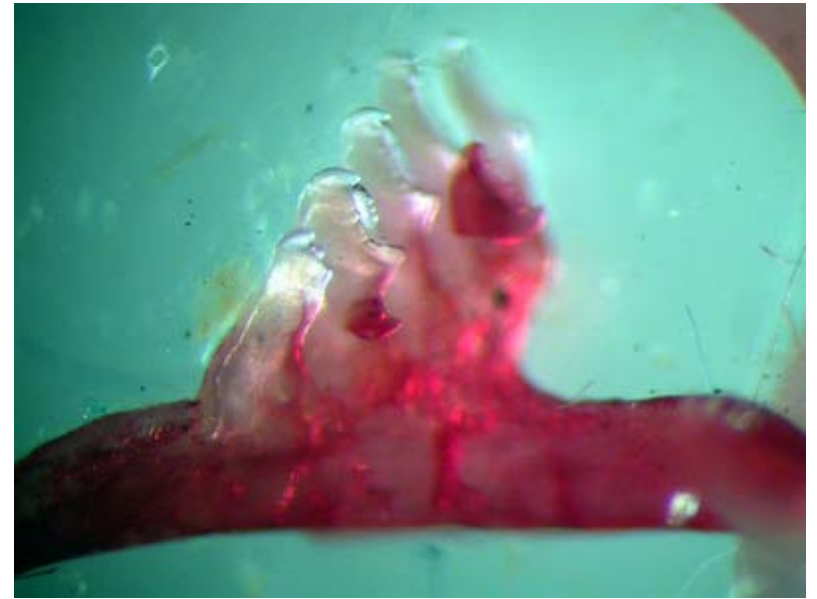


<http://www.morphbank.net/?id=111266&imgType=jpeg>



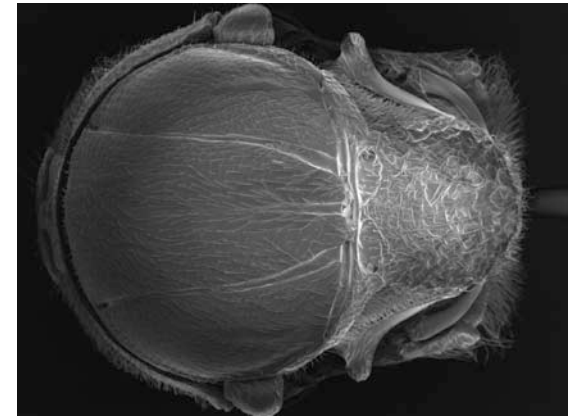
Upload of Images and Metadata

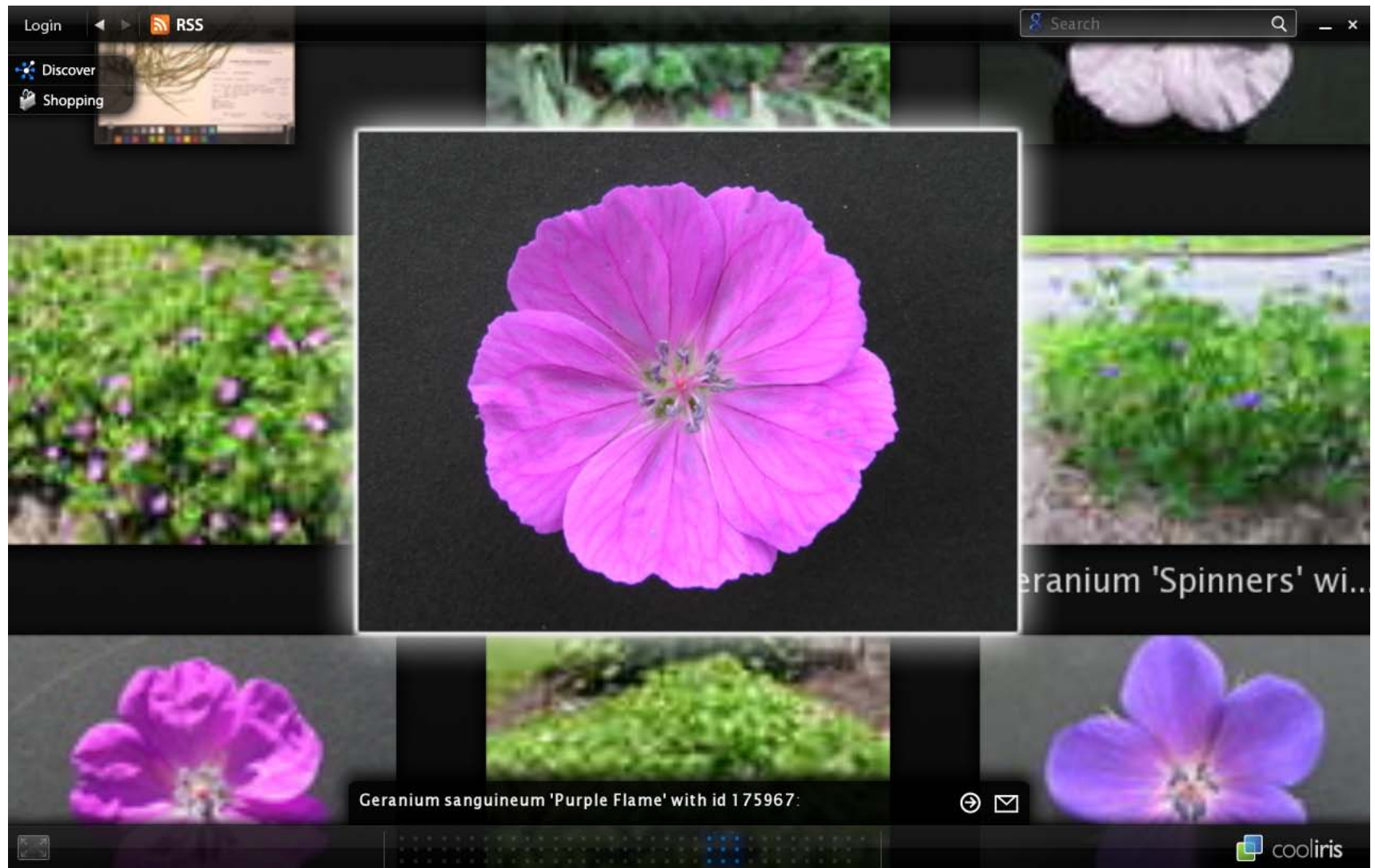
- Web site for small number of images
- Bulk insertion
 - Organize metadata
 - Present in excel or xml
 - Organize images
 - Attach to metadata
 - Send info to Morphbank
 - Via ftp and/or service interface



Other People's Software

- NIMBY (not in my backyard)
Software
 - I'd love to use your software as long as I don't have to maintain it.
 - Invest in standards that allow other people's software to enhance my infrastructure







<http://services.morphbank.net/mb2/request?method=search&objecttype=5>

Search Maps

[Show search options](#)

Find businesses, addresses and places of interest. [Learn more](#)

[Get Directions](#) [My Maps](#)

[Print](#) [Send](#) [Link](#)

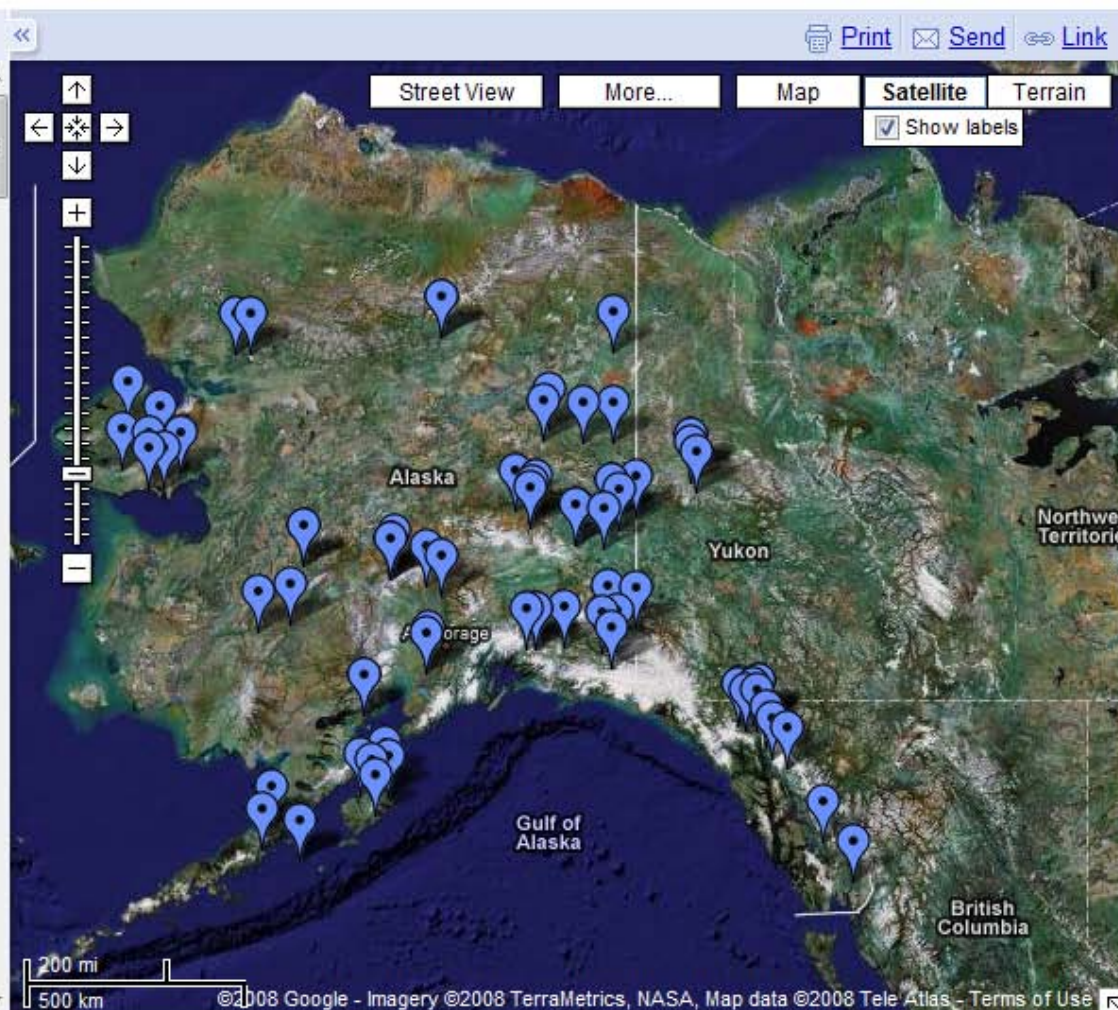
Some content has been hidden
Zoom to see more

[Save to My Maps](#)

Keyword query

Search Results for keywords 'alaska' object types
Specimen number of matches 55141 number returned 100
all objects are geolocated

- ☒  *Arctagrostis latifolia* ssp. *arundinacea* with id 140507
- ☒  *Arctagrostis latifolia* var. *arundinacea* with id 140445
- ☒  *Arctagrostis latifolia* var. *arundinacea* with id 140450
- ☒  *Arctagrostis latifolia* var. *arundinacea* with id 140456
- ☒  *Arctagrostis latifolia* var. *arundinacea* with id 140460
- ☒  *Arctagrostis latifolia* var. *arundinacea* with id 140464
- ☒  *Arctagrostis latifolia* var. *arundinacea* with id 140470

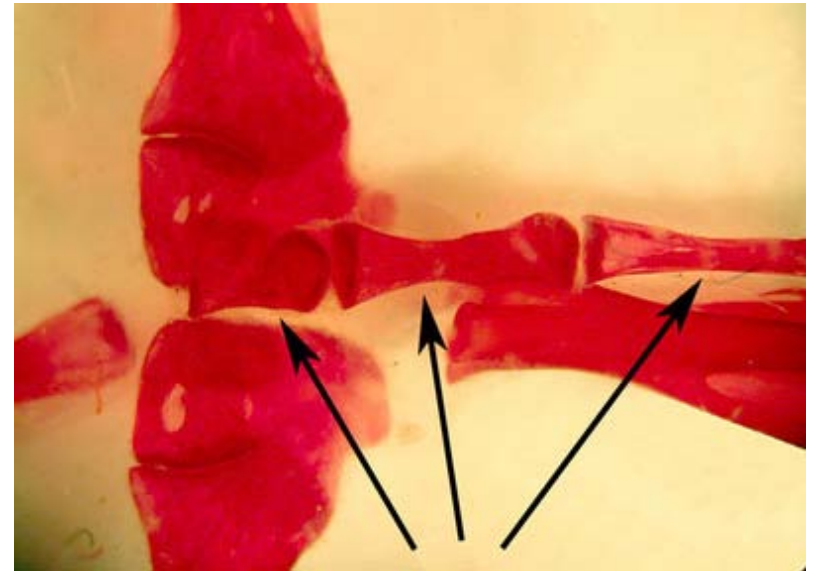


15ccardi@ci.fsu.edu



Live Examples From Service API

- Interface with image tools
 - mediarss
- Interface with RSS Readers
 - Find by keyword
 - Find recent changes
- Interface with Google maps
 - Georss
- Import and export with XML



Controlled Vocabulary in Morphbank



- Each image has a specimen and a view
 - Specimen has Darwin Core fields
 - Taxon, sex, form, preparation type, ...
 - View has fields that describe what you see
 - specimen part, view angle, sex, imaging technique, imaging preparation type
- Field values create a controlled vocabulary for describing image content
- Search for keywords within vocabulary
 - geranium (taxon)
 - leaf (specimen part)
 - adaxial (view angle)

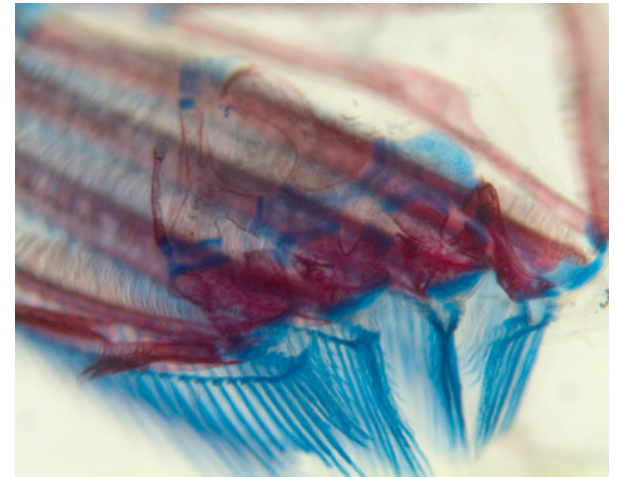


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Topics

- Morphbank overview
- **Images and Research Work Processes**
- Ontology Integration

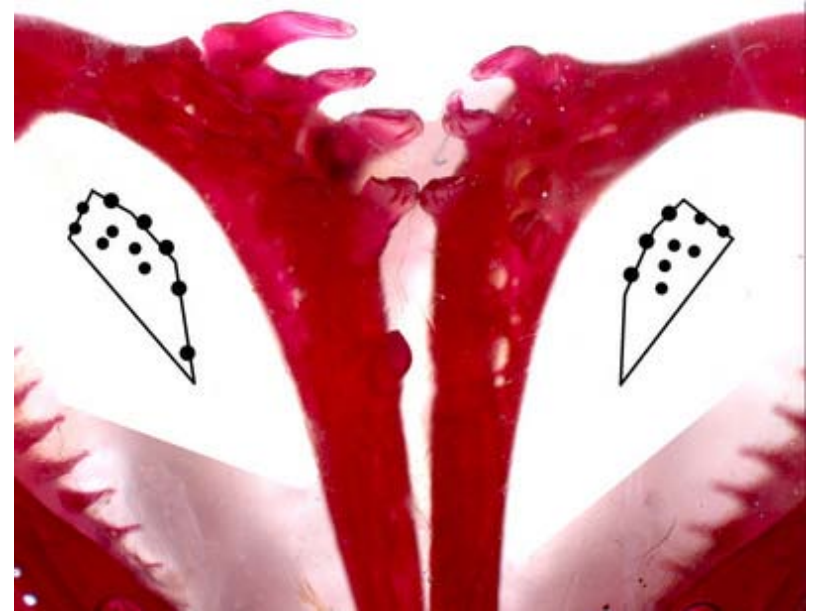


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Morphology Work Processes

- What did Linnaeus do?
 - Collected specimens
 - Examined and described features
 - Created illustrations with annotations
 - Catalogued features and separated specimens
- What has changed?
 - How has the process been improved?
 - What are new work processes?



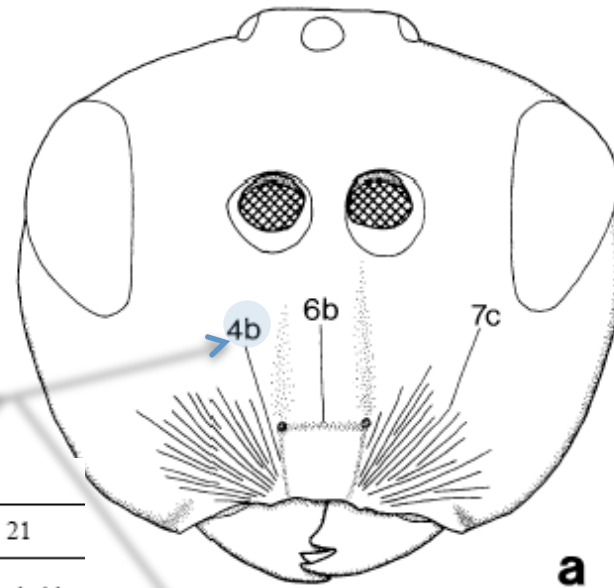
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Morphology Publication Example

Head, anterior view, female

1. [Modified from R1] *Shape of ventral part of clypeus*: (a) rounded, broadly projecting over mandibles (Fig. R8); (b) not projecting from cranial margin or slightly and narrowly projecting medially (Fig. R7). (CI = 0.20, RI = 0.67)
2. *Shape of projecting ventral clypeal margin*: (a) straight or rounded (not illustrated); (b) with a median incision (Fig. R8). (CI = 0.29, RI = 0.29)
3. [= R2] (CI = 1.00, RI = 1.00)
4. *Direction of clypeo-pleurostomal lines*: (a) ventrally diverging (Fig. R8); (b) ventrally converging (Fig. R7a). (CI = 0.33, RI = 0.67)
5. [= R3] (CI = 0.17, RI = 0.38)

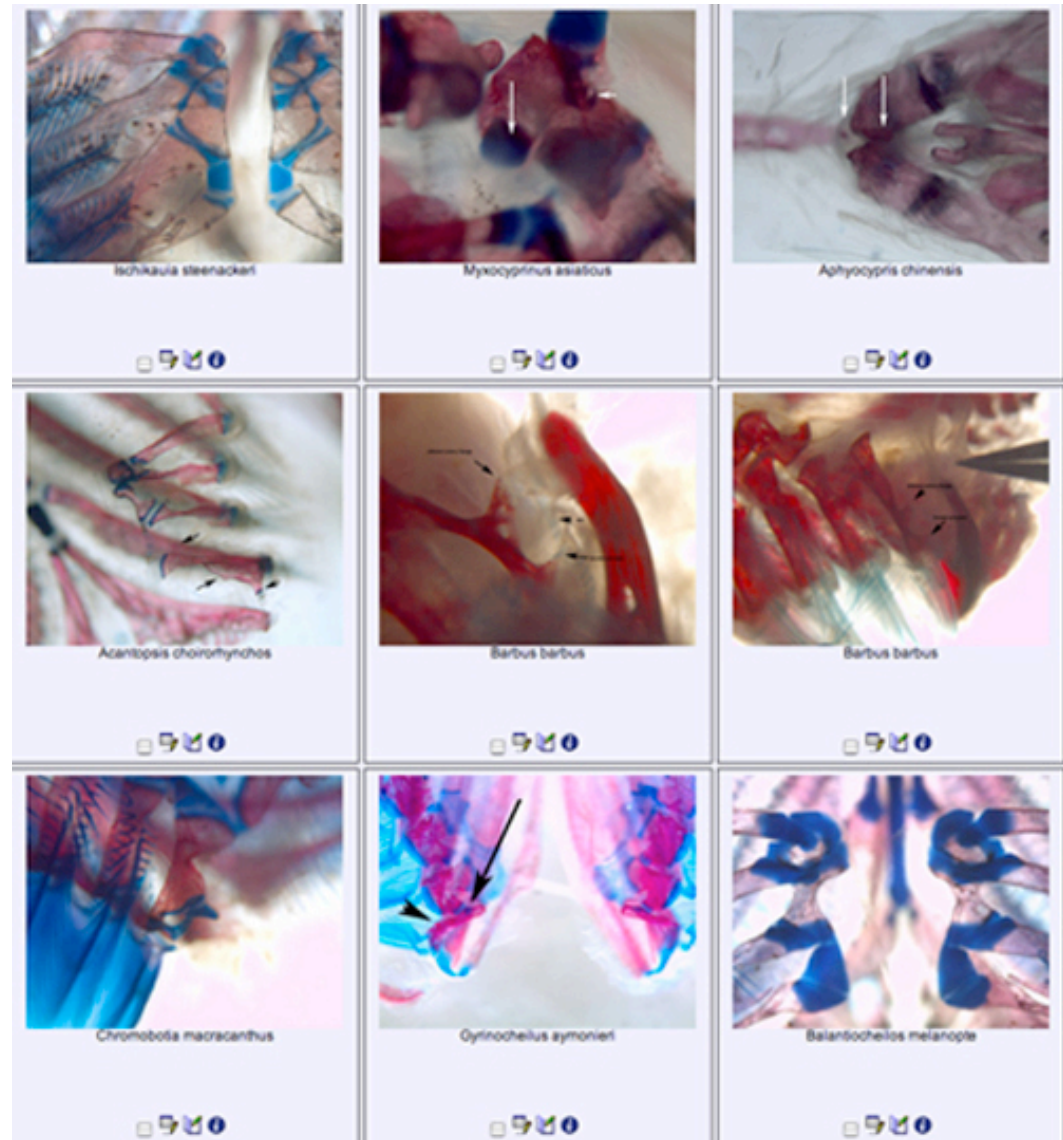


Taxon		Character				
		1	6	11	16	21
<i>Synergus</i>	1	b-b-b	aaaaa	aaaca	cbbac	ababb
<i>Periclistus</i>	2	b-b-b	aaaaa	aaaca	cbbac	ababb
<i>Ceroptres</i>	3	b-b-b	aaaba	aaaca	cbaac	ababb
<i>Synophromorpha</i>	4	b-b-a	aaaba	aaacb	-baab	abaab
<i>Xestophanes</i>	5	b-b-a	aaaba	aaabb	-ba-b	baaab
<i>Diastrophus</i>	6	abb-b	ababa	aaacb	-ba-c	baaab
<i>Gonaspis</i>	7	b-b-b	aaaba	aaabb	-ba-c	baaab
<i>Liposthenes</i>	8	abaaa	adaaa	ababa	ccaca	aaaab
<i>Au. keneri</i>	9	aaaab	acaaa	aaaba	b????	?????
<i>Cecconia</i>	10	b-aba	baaaa	aaaba	a????	?????
<i>Antistrophus</i>	11	b-aba	bcaaa	a?aba	ababa	aaabb
<i>Rhodus</i>	12	b-aba	aaaaa	aaaaa	a????	?????
<i>Hedickiana</i>	13	b-aba	baaaa	aaaaa	a????	?a??b



CTOL Images

- Apparent work process
 - Collect
 - Image
 - Annotate




CTOL in Morphbank

Image Record: [460879] *Gyrinocheilus aymonieri*



Contributor: Cypriniform Tree of Life
Submitter: Paula Mabee
Date Submitted: 2008-09-08
Last Modified: 2009-06-08



[BioPortal](#) [Browse](#) [Search](#) [Projects](#) [Annotate](#) [All Mappings](#) [All Resources Alpha](#) [Sign In](#)

Teleost anatomy and development

Teleost anatomy and development Version 1.78

ceratobranchial 5 tooth | [Link Here](#) | [Subscribe](#)

[View Ontology Details](#)

Jump To:

Go

- embryonic structure
- female organism
- male organism
- anatomical system
 - nervous system
 - musculature system
 - sensory system
 - skeletal system
 - cardiovascular system
 - liver and biliary system
 - immune system
 - hematopoietic system
 - endocrine system
 - respiratory system
 - renal system

ID:	TAO:0000694
Definition:	The tips of the ceratobranchial5 teeth form before the ceratobranchial itself (3.0 mm NL). As they grow ventrally, they meet the perichondrally ossified surface of ceratobranchial5 and become firmly ankylosed to the bone. Ceratobranchial teeth are the only teeth present in zebrafish and other cypriniforms.
Database References:	ZFIN
Develops From:	dental organ
Part Of:	pharynx ceratobranchial 5 bone
Exact Synonym:	"pharyngeal teeth"
Is A:	tooth



Spider ATOL Workflow

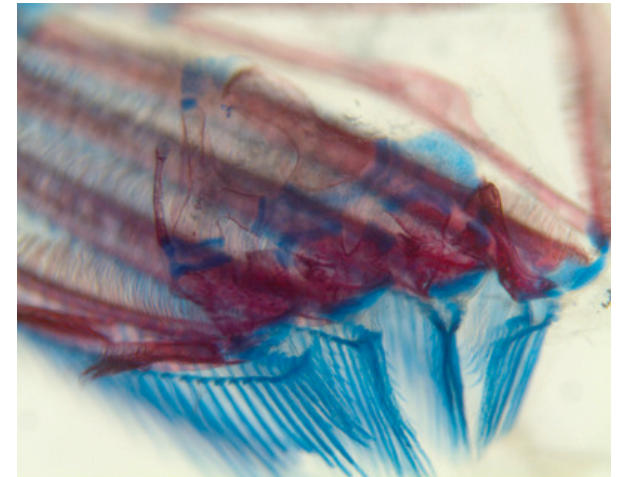


- Spider ATOL: 35000 images organized according to genus and anatomy
- Purpose of images
 - Illustrate the matrix
 - Or populate the matrix with values, according to information in images
- Workflow:
 - Define “standard views” based on presentation of features in the literature
 - Define characters and associate with standard views
 - Acquire an image for each view, for each genus
 - Add images to matrix of genus x character
 - Add values to matrix with assistance from images



Online Work Process

- Collect and digitize specimens
- Catalog metadata and images
 - Add to online digital repositories ASAP
 - Protect digital information from outsiders
- Annotate images
- Create phenome descriptions
 - Extend ontology
 - Annotate anatomy
- Share online among collaborators

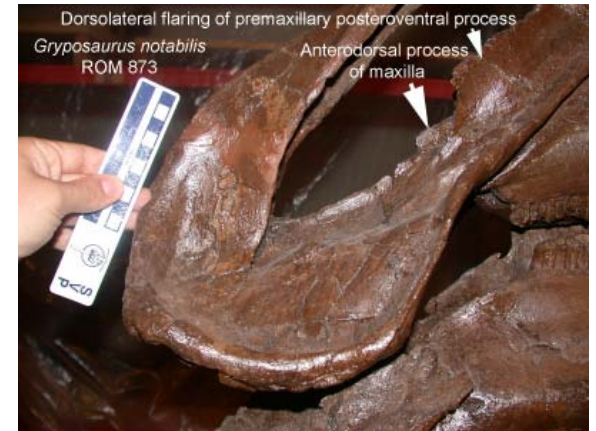


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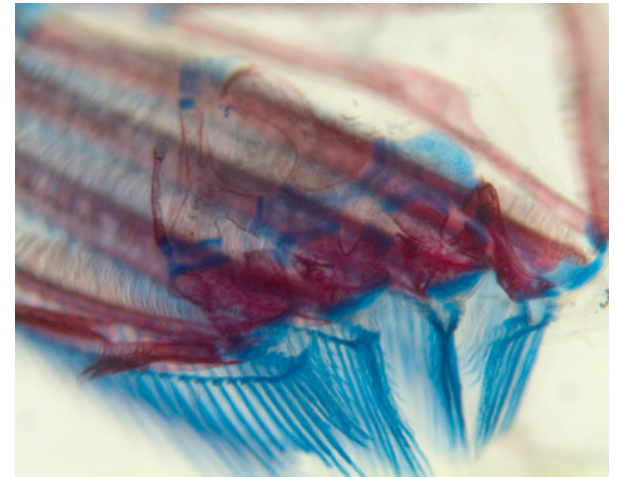
Advantages of Online Workflow

- Illustration of
 - matrix, phenomes, morphology
- Integrity of work process/provenance
- Active sharing among collaborators
- Smooth transition to publication and archiving
- Fitness for use: Bob Morris quote:
 - We are coming to love the phrase "fitness for use". In a sense, it should be the only thing that matters for science. In the end, science is about falsification of hypotheses. You have a model and you have some data. Your question is always of the form "Does data D falsify hypothesis H and was it actually data fit for that purpose?"



Topics

- Morphbank overview
- Images and Research Work Processes
- **Ontology Integration**
 - The next project for Morphbank



riccardi@ci.fsu.edu



Morphontify

- Specify (Beach, U. Kansas)
 - Specimen management
 - Desktop tool for specimen metadata management
- Morphster and Ontobrowser (Miranker, U. Texas)
 - Ontology Management for Phylogenetics
 - Extension of ontology to incorporate annotations
- Integration of Specify, Morphster and Morphbank
 - Searching for images using ontology terms
 - Linking images and other digital objects to ontology terms
 - Access to information from any user interface





*We're going to transform the nature
of natural history collections.*

[Home](#)[Documentation](#)[Download](#)[Forum](#)[Search](#)

What's New

- ▶ 07/17/2009 - 6.0.9 Update, Stretchy or Stiff, and WorkBench
- ▶ 07/01/2009 - Next Release and News
- ▶ 06/11/2009 - Specify Converter, WorkBench and GBIF's IPT
- ▶ 05/29/2009 - New Release 6.0.07
- ▶ 05/19/2009 - Settling Down
- ▶ 05/07/2009 - Specify update and other news
- ▶ 05/05/2009 - Another Specify 6 Update this week

Specify 6 Database Schema

- ▶ [Graphical Version](#)

Welcome to Specify 6

The Specify Software Project is delighted to announce the availability of Specify 6, a museum and herbarium collections data management system for Windows, Mac OS X, and Linux. Specify 6 processes specimen information for computerizing holdings, for tracking collection management transactions, and for mobilizing species occurrence data to the internet. Specify 6 was released on April 10, 2009, it is free and open source licensed.

Specify 6 has an intuitive user interface and highly-customizable data forms aimed at streamlining routine collections data tasks while preparing and validating collection information for research analysis. Specify has numerous features including robust support for paleontological data, field notebooks, file attachments, GUIDs, hierarchical storage locations, data uploads through the Specify Workbench and Excel, repository agreements, accession logging, conservation treatments, collection object containers, along with numerous additional functions. Specify 6 supports the use of record sets for various types of processing, such as georeferencing with GEOLocate, label and report printing, and importing and exporting, and Specify's data model now handles all institutional collections within a single database for simplified administration.



Morphster Project



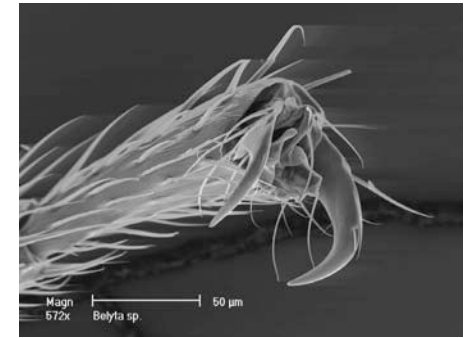
- Dan Miranker at U. Texas at Austin
 - Ferner Cilloniz and other students
 - NSF funding
- Morphster is an ontology management system
 - Desktop application
 - Import and transform various ontology representations
 - Image annotation
- Ontobrowser is a Web site
 - Browse ontology terms
 - Illustrate ontology terms with images



riccardi@ci.fsu.edu



Illustration of Ontology



- Associate feature that can be seen in an image with ontology terms that describe the image
 - Area of interest in the image
 - Terms that describe anatomy, shape, etc.
- Replace
 - The (un) controlled vocabulary of Morphbank
 - With the controlled vocabulary of Morphster
- Resulting system is
 - Better for users because it is illustrated
 - Better for harvesters because it is precise



Ontobrowser with Morphbank

Herrerasaurus

▼ Anatomy Ontology

☐ Skeleton

teeth

maxilla

⊕ Jaw

Naris

prefrontal

PosteriorProcessOfDentary

⊕ Openings

opisthotic

postorbital

lacrimal

Mandibular_fenestra

Infratemporal_fenestra

surangular

squamosal

⊕ Axial_Skeleton

quadratojugal

Antorbital_fenestra

hide advanced

☒ Show Anatomy
Ontology

☒ Enable Morphbank

☒ Show Anatomy
Details

☐ Show SV Details

▼ Anatomy Illustration

► Name: maxilla

Definition: No definition

Comments: No comments

Relationships:

[\[maxilla\]](#) [\[Subclass of\]](#) [\[Skeleton\]](#)

[\[maxilla\]](#) [\[Subclass of\]](#) [\[Axial_Skeleton\]](#)

[\[maxilla\]](#) [\[Subclass of\]](#) [\[Cranial\]](#)

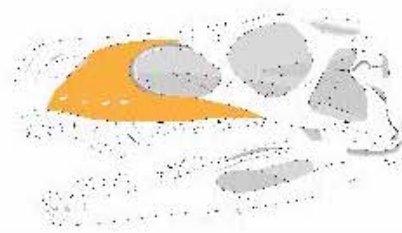
[\[maxilla\]](#) [\[Subclass of\]](#) [\[Skull\]](#)

Found Morphbank images.

EXEMPLAR IMAGES



ANATOMY SELECTED IMAGE



SIMILAR IMAGES



▼ Anatomy Ontology

[Instances]

- [-] Homologues [131 image(s)]
 - + whole organism [12 image(s)]
- [-] cephalothorax [72 image(s)]
 - + carapace [6 image(s)]
 - foregut
 - coxal glands
 - + labrum [1 image(s)]
 - + labium [1 image(s)]
 - + sternum
 - + pleural area
 - + midgut
 - + appendages cephalothorax [62 image(s)]
 - color
 - cuticle
- + abdomen [47 image(s)]
- + silk and behavior

hide advanced

☒ Show Anatomy
Ontology

☒ Enable Morphbank

☐ Show Standard View

☐ Show Characters

☐ Keep Trees
Synchronized

☒ Show Anatomy
Details

☐ Show SV Details

☐ Show Character
Details



▼ Anatomy Illustration

► Name: labium

Definition: No definition

Comments: Figs 72\13\, 72\35 in SPDrf:Ubick_et_al_2005_glossary

Relationships:

[\[labium\]](#) [\[part of\]](#) [\[cephalothorax\]](#)

Found Morphbank images.

EXEMPLAR IMAGES



ANATOMY SELECTED IMAGE



SIMILAR IMAGES



riccardi@ci.fsu.edu



Try Ontobrowser

- <http://www.morphster.org:8080/ontobrowserV3/>
- An example search:
 - Select ontology Herrerasaurus
 - Click the "Show Advance" button
 - Click "Enable-> Morphbank".
 - Go to the "Term Keyword Search" on the right and search for maxilla.

TERM KEYWORD SEARCH

Anatomy Ontology Results

TERM: [MAXILLA](#)
RELATIONSHIP: [SUBCLASS OF](#)
PARENT: [SKELETON](#)

TERM: [MAXILLA](#)
RELATIONSHIP: [SUBCLASS OF](#)
PARENT: [AXIAL_SKELETON](#)

TERM: [MAXILLA](#)
RELATIONSHIP: [SUBCLASS OF](#)
PARENT: [CRANIAL](#)

TERM: [MAXILLA](#)
RELATIONSHIP: [SUBCLASS OF](#)
PARENT: [SKULL](#)

TERM: [PREMAXILLA](#)
RELATIONSHIP: [SUBCLASS OF](#)
PARENT: [SKELETON](#)

