4-2023

Simple Darwin Core for Non-Biologists Primer

Megan N. O'Donnell
Iowa State University, mno@iastate.edu

Leslie M. Delserone
University of Nebraska-Lincoln, ldelserone2@unl.edu

DATA CURATION NETWORK

Simple Darwin Core for Non-Biologists Primer

Authors: Megan N. O'Donnell and Leslie M. Delserone

DCN Mentor: Jake Carlson

Overview

Topic	Description
File Extension	Most commonly seen as .txt or .csv
Structure	Most commonly tabular for digital data
Versions	Last GitHub Release: 2021-07-15 https://doi.org/10.5281/zenodo.5251698
Primary fields or areas of use	Data, images, or objects in the biological sciences, biodiversity informatics, ecology, evolutionary biology, natural history, etc.
Source and affiliation	Biodiversity Information Standards (TDWG)
Metadata standards	Darwin Core: https://www.tdwg.org/standards/dwc/

Key questions for curation review	• Will Darwin Core add value to the data?
	  ○ Will application of the metadata make the data easier to use and integrate with other data?
	• Are these data that can be described by Darwin Core?
	  ○ Do the data describe biological occurrences of wildlife or describe natural history specimens?

	• What fields need to be included to make the data:
	  ○ Understandable and complete enough to be of use to other researchers?
	  ○ Compatible with other data or databases (see Appendix B)?
	• If needed, is there a readme file, DublinCore record, or other form of documentation providing the provenance (i.e., history and context) of the data?
	• Is there additional digital or physical evidence (e.g., lab notebooks, labels, photographs, specimens, etc.) that validates the occurrence data?
	  ○ Can this evidence be linked to the Darwin Core occurrences with identifiers?

Tools for curation review	• Visual inspection, comparison with requirements of repository or datasets to be combined • Darwin Core Archive Assistant Add-on • GBIF Data Validation Tool • Simple DarwinCore Cheat sheet
Date Created	2022-09
Created by	M. N. O'Donnell and L. M. Delserone
Date updated and summary of changes made	2023-04. DCN reviewers' revisions incorporated

Suggested Citation: O'Donell, Megan N. and Delserone, Leslie M. (2023). Simple Darwin Core for Non-Biologists Primer. Data Curation Network GitHub Repository.

Introduction

Biodiversity researchers are interested in the associations between life forms and their environments. Their research data can be digital and/or physical in nature. Digital data

formats are numerous, but some of the most frequently used formats include tabular data (.txt, .csv) and images (.jpeg, .png, .tiff), while physical collections range from large to microscopic organisms. These data document a life form's unique relationship in space and time with its environment, and provide a record of and insights into climate change, other environmental challenges, and the loss of species (Wieczorek et al., 2012).

In the late 1990s, the community of biodiversity researchers initiated the development of the Darwin Core (DwC) metadata standard in order to better describe and share data and objects. It expands upon older methods and standards of recording and reporting organismal data captured in researchers' paper field notebooks, in the literature, on labels attached to specimens in museum collections, and by citizen scientists. After a decade of work by the Taxonomic Databases Working Group (TDWG), the standard was approved in 2009 (Wieczorek et al., 2012). Darwin Core has continued to mature and develop, and continues to add resources and new parts to the standard including:

- a core list of terms (http://rs.tdwg.org/dwc/doc/list/), and
- an XML implementation (http://rs.tdwg.org/dwc/terms/guides/xml/),
- incorporation into the Resource Description Format (RDF; http://rs.tdwg.org/dwc/terms/guides/rdf/), and
- several controlled vocabularies (see https://www.tdwg.org/standards/dwc/).

This primer focuses on Simple DwC (http://rs.tdwg.org/dwc/terms/simple/), a "mechanism used to share biodiversity information using the simplest methods and structure" (Darwin Core Task Group, 2014). With Simple DwC, the DwC schema is applied to a single flat file (i.e., table or spreadsheet). Because it is a self-contained data set that can be opened, edited, and analyzed using a wide variety of software, Simple DwC is easier to implement than other forms of DwC that use XML, RDF, or relational databases. The introduction to the Simple DwC documentation states, "Simple Darwin Core is a predefined subset of the terms that have common use across a wide variety of biodiversity applications. The terms used in Simple Darwin Core are those that are found at the cross-section of taxonomic names, places, and events that document biological occurrences on the planet. The two driving principles are simplicity and flexibility" (Darwin Core Maintenance Group, 2021). The primer's goal is to assist a curator presented with a data set structured in Simple DwC, or to assist a curator in a decision to apply the standard to a data set.

DwC Communities

As previously mentioned, DwC developed within the biodiversity research community. Researchers who might use Simple DwC, or generate relevant data to which the

standard may be applied, are biologists, bioinformatics scientists, ecologists, evolutionary biologists, natural historians, and citizen scientists. Darwin Core also is incorporated into software[1] used by natural history museums and herbaria to inventory and describe the specimens they house.

Description of Simple DwC

Simple DwC (http://rs.tdwg.org/dwc/terms/simple/2021-07-15) has a simple structure of *records* and *fields* (think *rows* and *columns*) arranged in a matrix and usually saved as a spreadsheet. It is important to understand that a single record (i.e., a row) documents a *single occurrence*[2]*,* and a collection of records (i.e., the spreadsheet file) documents *multiple occurrences*. An *occurrence* is "an existence of an Organism…at a particular place at a particular time" (see https://dwc.tdwg.org/terms/#occurrence).

Simple DwC is defined as such by its developers because there are no mandatory fields; a researcher (or a curator) determines which fields best describe an occurrence. What is "mandatory" (or best practice) is that the same fields appear in the collection of records describing multiple occurrences of that life form. Inconsistent usage and population of selected fields is a common flaw in DwC files eligible for submission to a larger database.

It is difficult to know how and where to start when everything is allowed. Simple DwC does not define which fields are "must have," "nice to have," or "does not apply" as the nature of the occurrence (i.e., data or resource being described) will determine which fields are appropriate to populate. However, most biodiversity databases and repositories have required, or highly recommended, fields that introduce standardization within their systems. The "required" fields used by these databases include the taxonomic classification of an organism (kingdom through specific/infraspecific epithet), scientific name and its authorship, accepted name, taxonomic status, bibliographic citation, and date and time of sighting or collection.

For these reasons, the type of data/resource as well as the final destination of the finished Simple DwC data set should be considered in determining which fields are populated. In addition, the curator should consider the likely value or use of the data by others in deciding which Simple DwC fields should be populated and to what extent; consultation with the data creator/collector may be desirable.

---

[1] For example, Symbiota (https://symbiota.org/) crosswalks to Darwin Core or has 1:1 field matches (see https://symbiota.org/symbiota-occurrence-data-fields-2/)

[2] An occurrence is the equivalent of an "observation" in the parlance of Tidy data.

Example use cases highlighting the differences among selected Simple DwC fields

- An herbarium is inventorying their flowering plant specimens. Important information for this use case includes when and where the organism was found, its taxonomy, who collected it, who identified it, and the specimen's inventory number.
- A research group is tracking the spread of a destructive introduced species (ex: spotted lanternfly). Important information for this use case includes detailed information on when and where the organism was found, including GPS coordinates, how it was collected, who identified it, its life stage, sex, reproductive potential, and links to associated image and DNA evidence.
- A library has historic records of local bird sightings it would like to share more widely. Important information for this use case includes when and where the organism was found, its taxonomy, who found it, and information on where to locate the source documents.

Examples of Simple DwC records

All of the examples in the following section are from the Global Biodiversity Information Facility (GBIF) which is likely the largest database in the world built on DwC. The GBIF stores two versions of each record: the original record and an interpreted (i.e., standardized) version that has been optimized for use in the GBIF (Global Biodiversity Information Facility, n.d.). The "remarks" column in the records details the changes between the two versions.

Single records: metadata describing a *single occurrence*.

- Museum specimen of a *Procyon lotor* (Northern raccoon) skull
- Herbarium specimen of an orchid
- iNaturalist digital photo of Dog Vomit Slime Mold

Many records (i.e., data set): a set of metadata describing *multiple occurrences*.

- iNaturalist Research-grade Observations
- *Procyon lotor* (Northern Raccoon)

Notes on DwC usage

The DwC standard documents individual life forms, not populations[3]. For populations, the ecological research community uses Ecological Metadata Language, which is beyond the scope of this document to describe (EML; see https://www.dcc.ac.uk/resources/metadata-standards/eml-ecological-metadata-language).

The GBIF is currently working to establish a new relational database model based on DwC that can support a wider variety of uses. How this effort will impact DwC and Simple DwC is not yet known but it may result in some standardization of "required fields" for different types of DwC use cases in the future.

Key Questions to Ask Yourself

- Will Darwin Core add value to the data?
    - Will application of the metadata make the data easier to use and integrate with other data?
- Are these data that can be described by Darwin Core?
    - Do the data describe biological occurrences of wildlife or describe natural history specimens?
- What fields need to be included to make the data:
    - Understandable and complete enough to be of use to other researchers?
    - Compatible with other data or databases (see Appendix B)?
- If needed, is there a readme file, DublinCore record, or other form of documentation providing the provenance (i.e., history and context) of the data?
- Is there additional digital or physical evidence (e.g., lab notebooks, labels, photographs, specimens, etc.) that validates the occurrence data?
    - Can this evidence be linked to the Darwin Core occurrences with identifiers?

Key Clarifications to Get from the Researcher

1. How were the data collected and recorded?
2. How might the data be used by others and for what purpose?
3. Do the data contain any sensitive information that needs to be withheld or obscured (e.g., location information of protected habitat or species)?

[3] There are some fields (organismQuantity, individualCount) that can be used to record some information about populations, but these fields are mostly used for sampling (i.e., collection) events.

4. Where/how will the records be shared? Is there a larger database to which these data should be uploaded?

Metadata Standard and Core Elements

To reiterate, the DwC metadata standard is essentially a vocabulary used to describe *an occurrence* of a lifeform in a specific place and time. There are 10 points of guidance in the section, *Are there any rules? (Normative)* in the *Simple Darwin Core* document found at http://rs.tdwg.org/dwc/terms/simple/. These rules constitute eight "shoulds" and two "must nots", and cover such matters as which terms may be used where and suggestions for how to populate various fields.

As there are no required fields in Simple DwC, choosing which fields to populate can be challenging; there are over 150 fields organized among the seven classes addressed in this primer (omitting GeologicalContext, explained later) and one category, which are thematic groupings of fields (Table 1). The nature of the resource being described (i.e., observation, specimen, etc.) and what is known about it will determine which fields in each class will be populated. It would be highly unusual to use all fields and entire classes may end up being omitted. As previously mentioned, integration with biodiversity repositories/databases (see Appendix B) also may determine the final selection of fields.

***Table 1**. Summary of the eight classes and one category used in Simple Darwin Core. Each class/category contains multiple descriptive fields except for Material Sample which has just one field.*

Class/Category	Summary
Record-level (category)	Describes the DwC record itself as well as information on the institution(s) issuing the record and/or in possession of the specimen or data from which the record was derived
Organism	Describes the type of organism or organismal group
Occurrence	Temporal information associated with an organism (e.g., time, life stage, count)
Event	Describes actions performed by a human or machine such as the collection of samples, observations, or evidence
Location	Spatial information associated with an event and/or occurrence
GeologicalContext	Geological context information (primarily for *fossil specimens*)
Identification	Information on how the organism was identified

Class/Category	Summary
Taxon	Information regarding the scientific classification of the organism
Material Sample	The URI of a material sample associated with an event

Simple DwC cheat sheet

As many of the official DwC class and field descriptions (see *Darwin Core Quick Reference Guide*, https://dwc.tdwg.org/terms) are presented with brief definitions or assume a high familiarity with biodiversity or natural history data, we developed a "cheat sheet" (available at https://bit.ly/simpleDWC-cheatsheet) in conjunction with this primer to help users without these literacies.

The cheat sheet is not authoritative and the authors cannot guarantee that it is 100% accurate, up-to-date, or conforms with how different communities or databases have implemented DwC. Specific notes about how the cheat sheet is formatted, as well as its limitations, are noted below. Always consult and defer to the DwC Quick Reference Guide for the most current and authoritative information.

2023-24 cheat sheet release notes:

- Disclaimers:
    - The cheat sheet has not been fully vetted by the DwC community and should be considered a work in progress. Comments to help with its development are welcome and can be submitted to the DCN Contact Form.
    - There are many fields in DwC and we do not cover them all. For example, the Geological Context class has been omitted because the official documentation does not include recommendations for controlled vocabularies and neither author has the geological background to provide recommendations.

Using the cheat sheet

The cheat sheet is a spreadsheet file consisting of three tabs:

1. **DwC_Fields:** The cheatsheet. Contains DwC field definitions, details, recommendations, formatting requirements, etc.
2. **Values:** The data dictionary for DwC_Fields. Contains information that explains each column and the controlled vocabularies used.
3. **DwC_Classes:** A quick reference guide with a definition of each of DwC's eight classes and one category (also see Table 1).

Tips and Tricks for Simple DwC

Identifiers

Every field with a name that ends in “ID” should be populated with a Uniform Resource Identifier (URI), Uniform Resource Locator (URL), or an unique ID code (data or project-specific, or geographic; see Example 1) . These fields are coded as “URI or ID” in the Requirement column of the cheatsheet.

Multiple values (lists)

As you cannot repeat fields, separators need to be used when listing more than one value in a field (see Example 1). Fields where this is expected are coded as “list” in the Requirement column of the cheatsheet. The following format is recommended for lists: Separate values in a list with space + vertical bar + space (|). Example: *Apple* | *Orange* | *Kiwi*

Relationships

When representing relationships within a field a “key”:”value” encoding schema is recommended. This can be combined with the list recommendation to enter a list of relationships in one field. Fields where this is expected are coded as “relationship” in the Requirement column of the cheatsheet. The following format is recommended for relationships: The key should represent the relationship and the value should represent the target; enclose both the key and the value in quotes and separate it with a colon (“x”:“y”). Examples: *“parent of”:“x” ; {“wingspan in cm”:“25”* | *“weightInGrams”:“0.5”}*

Resources for Reviewing Data

- Because Simple DwC has no required fields, and most fields lack established vocabularies, validation is best performed against a target dataset or database.[4]
- OpenRefine is an open source tool that curators possibly can use to quality check and explore a Simple DwC dataset.
- Darwin Core Archive Assistant Add-on: An add-on for Google Sheets that guides researchers through the process of creating and publishing data in the Darwin

[4] Note: Some biodiversity databases have adopted custom fields or specific rules for some DwC fields so it is best to contact them and ask which fields they support if you plan to integrate the data with them.

Core Standard and through the Darwin Core Archive format[5].
Note: untested by primer authors.

- GBIF Data Validation Tool: This tool validates against GBIF's standards for DwC (see https://www.gbif.org/standards).
  Note: untested by primer authors.

Software for Viewing or Analyzing Data

As Simple DwC files are flat text files (.txt, .csv), they can be opened and viewed by a wide variety of text editors (e.g., Open Refine, Notepad, Notepad++), spreadsheet software (Microsoft Excel, Calc, Google Sheets) and statistical processing software like R.

Preservation Actions

Plain text files (.txt, .csv) are stable and generally considered appropriate archival file formats for flat file tabular data such as Simple DwC. To ensure the best compatibility, UTF-8 encoding is recommended over ANSI and ASCII.

The majority of biodiversity databases that ingest DwC files are not archival - their purpose is to be a discovery and analysis tool and most do not have long-term access missions. For this reason, it may be wise to archive a copy of the Simple DwC records in an archival data repository. When archiving these data, additional documentation about the data's origin and provenance may be needed.

In some cases, the flat files may have associated or supplemental data (e.g., physical specimens, images, 3-D models). Curation and preservation activities may need to include cross-references to these associated data (e.g., inclusion of persistent identifiers in the record).

Key questions and actions

1. Since DwC does not contain information on the provenance of the data set, make sure to get all of the required information (such as who made it, when, and for what reason) from the researcher.

[5] A Darwin Core Archive is a different way of storing the data contained in a DwC dataset. Instead of a flat-file, it is more akin to a relational database and stores information more efficiently than a flat file. It is the default export format for Symbiota, a popular open-source biodiversity data management software.

2. If not already saved as a UTF-8 encoded plain-text file, can the data be safely exported and stored in this format?
3. Verify if any associated or supplemental digital data associated with these records also will need to be preserved. If so, this may significantly increase the complexity and storage space needed to preserve it.
4. Are the DwC records already publicly available? If not, can they be made publicly available through a data repository and/or through a biodiversity database (see Appendix B)?

Ways in Which Research Fields May Use This Format

Sharing records

The primary reason to use DwC is to share species occurrence records between institutions, organizations, studies, and individuals so that they can be examined and analyzed in new ways. This is primarily achieved through large biodiversity and natural history databases such as those listed in appendix B.

Natural history collections

One of the most common use cases for DwC is to catalog and document natural history collections of animal, plant and fossil specimens.

- Consortium of Midwest Herbaria: The Consortium's catalog uses DwC to provide robust search options and includes specimens from a large number of herbaria and science museums. Note: The user interface does not display records using DwC but rather runs on it.

Archival records

Darwin Core can also be used to report occurrences found in archival records in a standardized format.
Records Committee review for rare bird sighting on Red-throated Loon at Cedar Lake, 1984: A simple DWC record was created based on a documented observation submitted to a local committee to review. Note: the web page also contains fields that are not part of DwC to make the archival collection more accessible.
Iowa Published Records on eBird (free account required to view): Reporting of rare species sightings in Iowa to eBird as documented by the Iowa Ornithologists Union.

Unresolved Issues

- Simple DwC files do not contain metadata explaining the provenance of the data they contain. For this reason a readme file, DublinCore record, or other form of documentation may be helpful for providing the history and context of the data.
- Simple DwC is far from “simple” which has restricted who uses it and in what settings it is applied. For those who are new to the schema, we recommend spending time exploring similar data sets and records to see what fields were included and how they were used (see Examples 1 and 2).

Notes for Curation Process:

Transformations to the data

- Document any actions taken to make the data both FAIR and sharable (e.g., field crosswalking, file format changes, adding new data, etc.).

Decisions about what data to share

- Document how you came to any decisions about which parts of the dataset will or will not be shared publicly.

Provenance

- If archiving a copy of the dataset additional information about where the data came from, who created it, etc. may need to be created.

Appendix A - filetype CURATE(D) checklist

Refer to the Data Curation Network’s CURATE(D) steps, available at https://datacurationnetwork.org/outputs/workflows/.

Appendix B - Examples of common biodiversity repositories

eBird (https://ebird.org) - Managed by the Cornell University Lab of Ornithology, its “data document bird distribution, abundance, habitat use, and trends through checklist data collected within a simple, scientific framework”. Registration for a free account required.

GBIF (Global Biodiversity Information Facility; https://www.gbif.org/) - “An international network and data infrastructure funded by the world's governments and aimed at

providing anyone, anywhere, open access to data about all types of life on Earth". The data document and support continuing research in such areas as agriculture and food security, business, climate change, conservation, DNA barcoding and metagenomics, human health and One Health, and soil. The other named databases on this list are integrated with GBIF which provides a unified search engine for all taxa and geographic regions.

iDigBio (Integrated Digitized Biocollections; https://www.idigbio.org/) - Funded by the U.S. National Science Foundation, "data and images for millions of biological specimens are being made available in electronic format for the research community, government agencies, students, educators, and the general public".

iNaturalist (https://www.inaturalist.org/) - Sponsored by the California Academy of Sciences and the National Geographic Society, it collects citizen scientists' observations and shares these with GBIF.

A "List of Biodiversity Databases" is available via Wikipedia (https://en.wikipedia.org/wiki/List_of_biodiversity_databases; last accessed March 2023).

VertNet (https://vertnet.org/) - an NSF funded database that, despite the name, accepts digital biodiversity and natural history data from many different types of lifeforms.

References

Darwin Core Task Group. 2014. Simple Darwin Core. Biodiversity Information Standards (TDWG). http://rs.tdwg.org/dwc/terms/simple/

Darwin Core Maintenance Group. 2021. Simple Darwin Core. Biodiversity Information Standards (TDWG). http://rs.tdwg.org/dwc/terms/simple/2021-07-15

Global Biodiversity Information Facility. (n.d.) What is Darwin Core, and why does it matter? [website] Available at https://www.gbif.org/darwin-core

Wieczorek J, Bloom D, Guralnick R, Blum S, Döring M, Giovanni R, et al. (2012) Darwin Core: An Evolving Community-Developed Biodiversity Data Standard. PLoS ONE 7(1): e29715. https://doi.org/10.1371/journal.pone.0029715

Additional Resources

Biodiversity Information Standards (TDWG). (n.d.) News. Available at https://www.tdwg.org/news/

gCUBE. (2013). Darwin Core Terms. Available at https://gcube.wiki.gcube-system.org/gcube/Darwin_Core_Terms

Ocean Biogeographic Information System. Manual, Darwin Core. (n.d.) Available at https://obis.org/manual/darwincore/

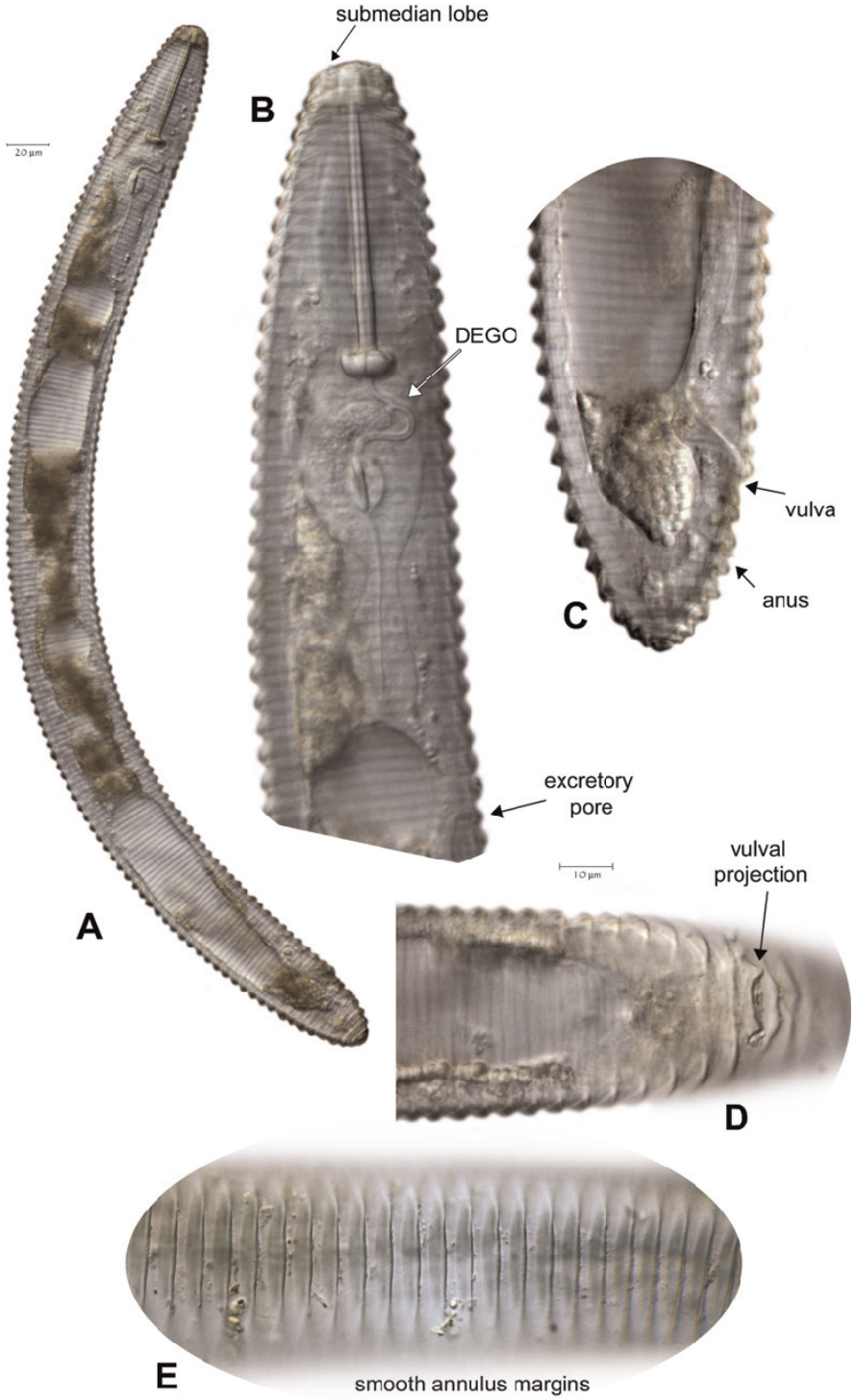
RDA Metadata Directory. Ecology. (n.d.) Available at https://rd-alliance.github.io/metadata-directory/subjects/ecology.html

RDA Metadata Directory. Zoology. (n.d.) Available at https://rd-alliance.github.io/metadata-directory/subjects/zoology.html

Acknowledgements

The authors thank reviewers Sarah J. Wright (Cornell University) and Scout Calvert (University of Nebraska-Lincoln) and mentor/reviewer Jake Carlson (University of Michigan) for their thoughtful insights (and patience) as we completed this primer. Additional thanks are also owed to Heather Campbell and Wesley Teal of the Metadata Department of the Iowa State University Library for their feedback on the usefulness of the cheat sheet.

Example 1 - Application of Simple DwC to a Photomicrograph of a Nematode (Single Occurrence, Single Record)



Used by permission, courtesy of T.O. Powers, P.G. Mullin, and R. Higgins

N.B. In a flat file format, the **bold** field terms would be column headings, and the information after each equal sign would fill one row.

Record-level
type = Image
language = en
license = https://creativecommons.org/licenses/by-sa/4.0/legalcode
rightsHolder = Thomas O. Powers
bibliographicCitation = Olson, M., Harris, T., Higgins, R., Mullin, P., Powers, K., Olsen, S., Powers. T.O. Species delimitation and description of Mesocriconema nebraskense n. sp. (Nematoda: Criconematidae), a morphologically cryptic, parthenogenetic species from North American grasslands. J Nematol 49, 42-66 (2017). https://doi.org/10.21307/jofnem-2017-045
institutionCode = UNL
collectionCode = Criconematidae of the Great Plains
basisOfRecord = PreservedSpecimen

Occurrence
recordedBy = M. Olson
sex = female
lifeStage = adult
preparations = glass slide mount | photograph
disposition = voucher elsewhere
otherCatalogNumbers = HWML 99848

Event
year = 2013
habitat = remnant tall-grass prairie

Identification
identifiedBy = M. Olson, P.G. Mullin, T.O. Powers

Organism
organismID = NID 7028
organismName = Mesocriconema nebraskense n. sp.
organismRemarks = holotype

Taxon
scientificName = Mesocriconema nebraskense n. sp.
kingdom = Animalia
phylum = Nematoda

class = Secernentea
order = Tylenchida
family = Criconematidae
genus = Mesocriconema
specificEpithet = nebraskense
taxonRank = species
nomenclaturalCode = ICZN

Location
higherGeographyID = 8724947
higherGeography = North America | United States | Nebraska | Lancaster
continent = North America
country = United States
countryCode = US
stateProvince = Nebraska
county = Lancaster
municipality = Denton
locality = Spring Creek Prairie
locationAccordingTo = Getty Thesaurus of Geographic Names | T.O. Powers
decimalLatitude = 40.6920460
decimalLongitude = 96.8532120

Example 2 - Iowa Lakeside Laboratory Avian Collection - Simple DwC Records

https://doi.org/10.25380/iastate.19787314.v2

A Simple DwC CSV file containing 362 occurrences associated with specimens held by Iowa Lakeside Laboratory.

- Images of the specimens associated with the records can be found at: https://doi.org/10.25380/iastate.c.5981629.
- The collection can be explored on GBIF at: https://www.gbif.org/dataset/738de9a9-1871-4fc9-a755-8ca3724bec46
- The GRSCICOLL Record for the collection is https://www.gbif.org/grscicoll/collection/0e9a25a7-4075-4749-94a0-6ead07a1c4d8

Note: Many of the original identifications are wrong or incomplete. Updated identifications have been obtained but need to be processed and uploaded to both the repository and GBIF.