

Image Metadata Standards and Practices

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Image metadata may be thought of comprising three somewhat distinguishable parts: technical, content, and curatorial metadata. Technical metadata consists of information about the image acquisition system, including enough information to assist in colour and other image manipulations. Some technical metadata is typically determined by the acquisition system itself and available either embedded in the image file or available to external applications. Content metadata describes the image itself and is not usually produced by the image acquisition system, with the exception of date, time, and for GPS enabled cameras, the location of the acquisition. Curatorial metadata refers to information that assists in the location of the image, intellectual property rights, and similar such issues of concern to the storage and distribution of the image. There are a number of image metadata standards presently accepted by one or another standards body. In the next section we will present recommendations for minimal metadata for images, and then examine the prevailing standards with respect to those data. In a later section we will discuss each standard in greater detail.

Summary recommendation for minimal metadata representation:

Use the information represented either in DIG35 or Z39.87, including encoding of metadata captured by the imaging device.

Exchange this metadata in XML form using the corresponding schema.

Minimal metadata:

Technical metadata

- Original digitization resolution
- Original digitization resolution units
- Original digitization size
- Original digitization units
- Image acquisition system manufacturer and model

Colour data

Colour model or ICC Profile. See MORRIS on "Colour Management", in this book.

Curatorial metadata

- Date of data acquisition
- Time of data acquisition
- Intellectual Property Information

Content metadata

- Biota of interest

Representation of metadata:

In this section we focus on a number of existing image metadata standards briefly.

EXIF. The EXIF standard EXIF.org is a popular metadata representation often used by digital camera manufacturers to encode camera technical data and, typically, date and time of the exposure. The cameras usually embed the data in the header of jpeg files and TIFF files. Many image processing applications can retrieve and edit it, and there is programming support for embedded EXIF in most widely used programming environments, include Java, .NET, PHP, Perl, and Python. An example of EXIF data is shown below. As illustrated after that example, most of the data encoded in EXIF can

also be represented in the DIG35 and Z39.87 standards, so we do not dwell on it here.

DIG35. The “Digital Image Group” was an industry association now absorbed by the International Imaging Industry Association (I3A, International Imaging Industry Association). It promulgated an extensible image metadata standard called “DIG35” which has emerged as DIG35 v 1.1. Many DIG35 elements are optional, so do not present a burden for systems that cannot represent its rich collection of metadata objects. In addition the standard provides for the embedding of DIG35 <METADATA> elements in arbitrary XML documents.

A DIG35 document consists of a root <METADATA> and a sequence of six types of optional subelements, the last of which are 0 or more <METADATA> elements which provide for a recursively defined tree of metadata.

The second level DIG35 elements:

BASIC_IMAGE_PARAM. This includes optional metadata about the image file format, a Unique Identifier, image size, preferred rendering size, and colour model.

IMAGE_CREATION. This includes optional technical data about the image acquisition system, but also about the human and organization responsible for the creation of the image. The technical data can be quite extensive, including data about the optics and colour models in play and other information for sophisticated characterization of the imaging device, as well as details of the imaging event itself, such as exposure data, the name and organization of the creator, etc.

CONTENT_DESCRIPTION. Content description element contains detailed optional information about the location of the scene and the date, time and season of its acquisition. Location information can be encoded as a place name (including postal address) or as detailed GPS information, including map datum. Of most potential interest are several subobjects which describe parts of the picture in greater detail. There are a number of potential overlaps with the SDD

schema, which is beyond the scope of this work. These subobjects can be 0 or more PERSON items, 0 or more THING items, and 0 or more ORGANIZATION items. Each can have its position and extent within the picture given and also its geolocation specified in the same manner as the location of the original scene. The THING objects are recursively defined, so that it is possible to describe a complex decomposition of an object in the image. Of particular interest for field photography is an element EVENT, which can describe events depicted in an image, including the participants, (as PERSONs, THINGs, etc.) and to a limited degree, the relations of the events to one another. Finally, there is support for property lists - more or less characters/state pairs - which can also be mapped into Descriptions in the SDD schema. These lists have a limited form of name scoping by the use of a subobject called a DICTIONARY that essentially is a namespace for the PROPERTY, which is provided with a reference to a DICTIONARY object

HISTORY. This element provides for the image manipulation history of the image. It allows the recording of the fact that a small number of particular manipulations have taken place, and for human-targeted free text describing what that manipulation was.

IPR. Besides the rather detailed, but expected, specification of IPR ownership and usage requirements, this element has a HISTORY subelement which is a sequence of IPR elements, providing for a tree of IPR objects.

METADATA. At the end of a METADATA element there is an optional list of METADATA objects, providing for a recursively defined tree of METADATA objects.

Z39.87 (NISO 2002) is a draft standard of the U.S. National Information Standards Organization (NISO). Its concern is almost entirely with technical metadata of the acquisition system and it is extremely sophisticated about issues such as colour management and image quality analysis. In addition, it is somewhat stronger about technical metadata for scanners than is DIG35. Finally, it has an expression, MIX, (Library of Congress and NISO 2004), in the Metadata Exchange and Transmission Standard (Library of

Congress 2005), which is widely used in the Digital Library community. The standard has been receiving attention in cultural heritage image collection management communities where faithful rendition of non-digital art is of great importance. Z39.87 provides for the identification and location in the image of one or more standardized targets (e.g. colour or grayscale cards; see MORRIS on "Colour Management", in this book). Projects with scientific imaging for which faithful colour is of high importance should examine Z39.87. Adobe's eXtensible Metadata Platform (XMP), a metadata standard implemented across many of the company's products is based in part on Z39.87. It is likely that Z39.87 will be a supported metadata type for JPEG2000. Because Z39.87 does not provide for content metadata, its use would need to be augmented by elements from another standard.

Most of the element names of DIG35 are global. MIX has a single top level global element, *mix*, but its XML complexType definitions are all global, this makes it slightly easier to embed DIG35 elements in multiple schemas, since they will all have the same name and not require any mapping between element names, which, however, is not difficult.

The second level Z39.87 elements:

BasicImageParameters. Documents the file structure with sufficient parameters to insure a reasonable image can be rendered for viewing.

ImageCreation. Describes how, when and by whom the image was created.

ImagingPerformanceAssessment. Contains the metadata pertaining to the image quality, such as colour management, digitization resolution

ChangeHistory. Supports tracking of image processing that has been applied to the image.

Other significant metadata standards

IPTC. The International Press and Telecommunications Council has promulgated a standard for the representation of technical and content metadata. The content metadata is aimed at describing topics of interest to news media. One interesting aspect of the IPTCv4 standard is that it has representation of limited ontology information by providing enumerated subjects and categories of content (i.e., a “kind-of”), such as “Forecast”, “History”, “Summary”, etc. Attempting to extend this for biological data does not seem profitable since other ontology standards have evolved for the Semantic Web and are likely to be more widely adopted.

TDWG UBIF and SDD. The Taxonomic Data Working Group (TDWG, <http://www.tdwg.org>) has a number of standards presently in the review process which may serve the interests of those wishing to provide image curation and content metadata expressed in XML. The most general of these is the Unified Biological Information Schema (UBIF) proposed for the general metadata concerns of biological data exchanged on the internet. UBIF is discussed at <http://wiki.cs.umb.edu/twiki/bin/view/UBIF/WebHome>. A second standard, SDD (the Structure of Descriptive Data) is meant to address a large class of problems about describing objects. SDD (which uses UBIF for some of its concerns) supports the representation of community controlled vocabularies that can be shared among users concerned with a similar group of taxa, sufficiently similar that common terminology can be used for descriptive characters and states and the relations between them. SDD is discussed at <http://wiki.cs.umb.edu/twiki/bin/view/SDD/WebHome>.

JPEG2000. A new ISO standard, JPEG2000 is a complex multipart standard using a compression scheme that supports the ability to decode parts of an image without decoding all of it. More important, JPEG2000 supports more structured embedded metadata than classical JPEG. Parts of the standard are rapidly being adopted by camera and graphics arts vendors such as Adobe. Although tools for the manipulation and decoding of JPEG2000 are not yet widely available, it is likely that this will change over the next few years. The

groups managing Z39.87, DIG35 and other existing standards are, or soon will be, in the process of registering to be an optional embedded metadata type for JPEG2000.

TABLE 1. Correspondence of some common metadata elements in Z39.87 (MIX) and DIG35. Upper level XML elements containing these are omitted.		
Metadata Item	Z39.87	DIG35
Creation date/time	DateTimeCreated	GENERAL_CREATION_INFO/CREATION_TIME ^{a)}
Image pixel width	ImageWidth	IMAGE_SIZE/WIDTH
Image pixel length	ImageLength	IMAGE_SIZE/LENGTH
Source width	Source_Xdimension	N/A ^{b)}
Source width units	Source_XdimensionUnit	N/A ^{b)}
Image length	Source_Ydimension	N/A ^{b)}
Source length units	Source_YdimensionUnit	N/A ^{b)}
MIMEType	MIMEType	FILE_FORMAT/MIME_TYPE
Color Space ^{c)}	ColorSpace	COLOR_INFO/COLOR_SPACE
ICC Profile ^{c)}	ProfileName	COLOR_INFO/COLOR_SPACE
Image Producer	ImageProducer	
Imaging Device	DeviceSource	
Scanner parameters		
Manufacturer	ScannerManufacturer	SCANNER_CAPTURE/SCANNER_INFO/MANUFACTURER
Model	ScannerModelName	SCANNER_CAPTURE/SCANNER_INFO/MODEL
	ScannerModelNumber	SCANNER_CAPTURE/SCANNER_INFO/MODEL
SerialNumber	ScannerModelSerialNumber	SCANNER_CAPTURE/SCANNER_INFO/SERIAL
Software	ScanningSoftware	SCANNER_CAPTURE/SOFTWARE_INFO
Pixel Size	PixelSize	SCANNER_SETTINGS/PHYSICAL_SCAN_RES/SCAN_RES
Physical Resolution	XphysScanResolution	SCANNER_SETTINGS/PHYSICAL_SCAN_RES/WIDTH
	YphysScanResolution	SCANNER_SETTINGS/PHYSICAL_SCAN_RES/HEIGHT
Digital Camera Parameters		
Manufacturer	DigitalCameraManufacturer	CAMERA_CAPTURE/CAMERA_INFO/MANUFACTURER
Model	DigitalCameraModel	CAMERA_CAPTURE/CAMERA_INFO/MODEL
Serial Number		CAMERA_CAPTURE/CAMERA_INFO

TABLE 1. Correspondence of some common metadata elements in Z39.87 (MIX) and DIG35. Upper level XML elements containing these are omitted.		
Metadata Item	Z39.87	DIG35
		/SERIAL
Exposure Data		
F Number	FNumber	CAMERA_SETTINGS/F_NUMBER
Exposure Time	ExposureTime	CAMERA_SETTINGS/EXP_TIME R_EXP_TIME ^{d)}
Subject distance	SubjectDistance	CAMERA_SETTINGS/SUBJECT_DISTANCE
Illuminant	SceneIlluminant	CAMERA_SETTINGS/SCENE_ILLUMINANT
Lens Focal Length	FocalLength	CAMERA_SETTINGS/FOCAL_LENGTH
Flash type	Flash	N/A ^{e)}

Notes:

a) Also supported in attribute `TIMESTAMP` on element `CAMERA_SETTINGS`

b) DIG35 provides for recording the subject distance but no way to record the size of the field of view for cameras. For scanners, this can be computed from the scanning resolution, but for cameras it is good practice to include a ruler in the scene.

c) DIG35 permits only the name (or URL) of an ICC Colour Profile, whereas Z39.87 provides for detailed specification of the colour space in terms of the CIE model (see MORRIS, "Colour Management", in this book) as well as an ICC Profile. This is not a major difference because most users will prefer to acquire an ICC Profile for their device and use that, since many image processing tools support it directly.

d) May be either a double (`EXP_TIME`) or a rational number (`R_EXP_TIME`)

e) Z39.87, but not DIG35 provides for recording the flash model, but for scientific photography, the scene illuminant is what is important. Most modern flashes are pulsed Xenon lights and correspond closely to the D65 standard daylight illuminant. See MORRIS, "Colour Management", in this book, for further information.



The XML at the right represents the portion of the EXIF from the above image which is extracted by the widely used *jhead* program (Wandel 2005), enhanced with *jhead-xml* (LA POUTRÉ 2004). Below we exhibit metadata for the same image, including further content metadata, represented in both Z39.87 and DIG35. Original image by Jennifer Forman Orth, available at <http://gallery.cs.umb.edu/gallery/NFSP/Plants/IrisVersicolor3> under a Creative Commons Attribution-ShareAlike 2.5 license.

```
<?xml version="1.0" encoding="ISO-8859-1" ?>
<ImageList>
  <ImageInfo fname="IrisVersicolor3.jpg">
    <FileName>IrisVersicolor3.jpg</FileName>
    <FileSize units="bytes">1003189</FileSize>
    <FileDateTime isodate="20050516T002848Z">
      Mon, 16 May 2005 00:28:48 %z
    </FileDateTime>
    <CameraMake>NIKON</CameraMake>
    <CameraModel>E995</CameraModel>
    <DateTime isodate="20040602T094021">
      Wed, 02 Jun 2004 09:40:21
    </DateTime>
    <Resolution>
      <Width>2048</Width>
      <Height>1536</Height>
    </Resolution>
    <IsColor>true</IsColor>
    <FlashUsed>>false</FlashUsed>
    <FocalLength units="mm">19.3</FocalLength>
    <ExposureTime units="s" equiv="1/189">
      0.005
    </ExposureTime>
    <ApertureFNumber>f/4.4</ApertureFNumber>
    <ISOequivalent>100</ISOequivalent>
    <Whitebalance>cloudy</Whitebalance>
    <MeteringMode>matrix</MeteringMode>
    <ExposureProgram>program (auto)
  </ExposureProgram>
  <JpegProcess>Baseline</JpegProcess>
</ImageInfo>
</ImageList>
```

Below is shown the representation of this in both DIG35 and Z39.87 (MIX) form. The latter supports no content metadata, but for specimens one might consider augmenting it by use of DarwinCore Species Analyst or ABCD TDWG metadata. Both standards support extensive description of Intellectual Property Rights, not shown here.

DIG35 Representation

```
<?xml version="1.0" encoding="UTF-8"?><METADATA
xmlns="http://www.digitalimaging.org/dig35/1.1/xml"
xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xsi:schemaLocation="http://www.digitalimaging.org/dig35/1.1/xml
DIG35v1.1RAM.xsd" xmlns:dig35="DIG35v1.1RAM.xsd">
  <BASIC_IMAGE_PARAM>
    <BASIC_IMAGE_INFO>
```

```

<FILE_FORMAT>
  <FILE_NAME>IrisVersicolor3.jpg</FILE_NAME>
  <MIME_TYPE>image/jpeg</MIME_TYPE>
</FILE_FORMAT>
<IMAGE_SIZE>
  <WIDTH>2048</WIDTH> <HEIGHT>1536</HEIGHT>
</IMAGE_SIZE>
</BASIC_IMAGE_INFO>
</BASIC_IMAGE_PARAM>
<IMAGE_CREATION>
  <GENERAL_CREATION_INFO>
    <CREATION_TIME>2004-06-02T09:40:21.0Z</CREATION_TIME>
    <IMAGE_CREATOR>
      ...
    </IMAGE_CREATOR>
  </GENERAL_CREATION_INFO>
  <CAMERA_CAPTURE>
    <CAMERA_INFO>
      <MANUFACTURER>
        <ORG_NAME>Nikon</ORG_NAME>
      </MANUFACTURER>
      <MODEL>E995</MODEL>
    </CAMERA_INFO>
    <CAMERA_SETTINGS>
      <EXP_TIME>0.005</EXP_TIME>
      <F_NUMBER>4.4</F_NUMBER>
      <METERING_MODE>matrix</METERING_MODE>
      <SCENE_ILLUMINANT>Daylight</SCENE_ILLUMINANT>
      <FOCAL_LENGTH>0193</FOCAL_LENGTH>
      <FLASH>>false</FLASH>
      <EXPOSURE_INDEX>100</EXPOSURE_INDEX>
      <CAMERA_LOCATION>
        <ADDRESS>
          <ADDR_NAME>UMASS Field Station</ADDR_NAME>
          <ADDR_COMP>Nantucket</ADDR_COMP>
          <ZIPCODE>02564</ZIPCODE>
          <COUNTRY>US</COUNTRY>
        </ADDRESS>
        <COMMENT>Virtual Nature Trail Stop 8. See
http://efg.cs.umb.edu/nantucket</COMMENT>
      </CAMERA_LOCATION>
    </CAMERA_SETTINGS>
  </CAMERA_CAPTURE>
</IMAGE_CREATION>
<CONTENT_DESCRIPTION>
  <THING>
    <PROPERTY>
      <NAME>Taxon</NAME>
      <VALUE>Iris versicolor</VALUE>
    </PROPERTY>
    <PROPERTY>
      <NAME>Vernacular</NAME>

```

```

        <VALUE>blue flag</VALUE>
      </PROPERTY>
    <PROPERTY>
      <NAME>Rank</NAME>
      <VALUE>Species</VALUE>
    </PROPERTY>
    <PROPERTY>
      <NAME>Family</NAME>
      <VALUE>Iridaceae</VALUE>
    </PROPERTY>
  </THING>
</CONTENT_DESCRIPTION>
</METADATA>

```

Z39.87 Representation

```

<?xml version="1.0" encoding="UTF-8"?>
<mix xmlns="http://www.loc.gov/mix/" xmlns:xsi="http://www.w3.org/2001/XMLSchema-
instance" xsi:schemaLocation="http://www.loc.gov/mix/.xsd">
  <BasicImageParameters>
    <Format>
      <MIMEType>image/jpeg</MIMEType>
      <PhotometricInterpretation>
        <ICCProfile>
          <ProfileName>sRGB</ProfileName>
        </ICCProfile>
      </PhotometricInterpretation>
    </Format>
    <File>
      <FileSize use="bytes">1003189</FileSize>
    </File>
  </BasicImageParameters>
  <ImageCreation>
    <ImageProducer>Jennifer Forman, University of Massachusetts-
Boston</ImageProducer>
    <DigitalCameraCapture>
      <DigitalCameraManufacturer>Nikon</DigitalCameraManufacturer>
      <DigitalCameraModel>E995</DigitalCameraModel>
    </DigitalCameraCapture>
    <CameraCaptureSettings>
      <FNumber>4.4</FNumber>
      <ExposureTime>0.005</ExposureTime>
      <MeteringMode>Pattern</MeteringMode>
      <SceneIlluminant>Daylight</SceneIlluminant>
      <FocalLength>0.0193</FocalLength>
      <Flash>No</Flash>
      <ExposureIndex>100</ExposureIndex>
    </CameraCaptureSettings>
    <DateTimeCreated>2004-06-02T09:40:21.0Z</DateTimeCreated>
    <Methodology/>
  </ImageCreation>
</ImagingPerformanceAssessment>

```

```
<SpatialMetrics>
  <ImageWidth>2048</ImageWidth>
  <ImageLength>1536</ImageLength>
</SpatialMetrics>
</ImagingPerformanceAssessment>
<ChangeHistory>
  <ImageProcessing>
    <SourceData>IrisVersicolor3.jpg</SourceData>
  </ImageProcessing>
</ChangeHistory>
</mix>
```

Managing image metadata

File names. There is a single best practice for managing media resource metadata that is most important but widely ignored: don't encode metadata in names of files or directories. While one often sees file or directory names that abbreviate taxon names, pixel size, and the like, such names frequently do not survive moves to other operating systems (For example, Windows file names are case insensitive, but Unix and Macintosh file names are case sensitive), or to some kinds of archival storage media. CDROM and DVD file system requirements now or in the future may impose yet different restrictions on the character sets, name and directory path lengths which may be incompatible with your current names. Finally, when used as keys to queries made across the internet, log names may interfere with some of the mechanisms that transport those queries. Although file systems are often thought of as though they were databases, it is preferable to use almost any kind of database to store your image metadata. From an information management point of view, images are just another kind of specimen, and a database similar in spirit and technology to your specimen management database should be your first consideration.

Globally Unique Ids (GUIDs). As with specimens, your media resources should have a globally unique identifier that can be used as a primary key into your image management database. An excellent introduction to requirements for GUIDs by DAVID THAU is at http://www.tdwg.org/2004meet/EV/TDWG_2004_Papers_Thau_1.zip. It has a brief description of the Life Sciences ID (LSID) system for GUIDs, and if you are adopting this for your specimens, your support

for that will serve you well for GUIDS for your images. Whether your specimen GUID scheme (e.g. institution code + accession number) is sufficient for adopting as an image GUID may depend on whether your present scheme is satisfactory in an internet environment. It should meet at least these requirements:

- Global across the Internet.
- Persistent for all time. That is, if the image moves to another location or institution, the GUID should not change
- Resolve to a unique media resource.
- Provide a key to metadata as well as media data.

Databases A small set of data may be adequately served by a flat file database such as a spreadsheet or a low-end database system, but such systems are not generally robust enough for large collections. They are difficult to interface to internet services, and are subject to the kinds of data entry errors that enterprise-level systems protect against. For example, if the location of the specimen acquisition is a named place that you wish to have in your metadata, and your images represent many specimens from the same location it is better to have a separate database table with the attributes of those locations and use database relations to insure that simple data entry errors, e.g. different spellings of the same place name, do not pollute the data. In addition, if you have such tables in your specimen database, you can integrate the specimen records and image metadata and insure further integrity. Commercial enterprise-level relational databases including Oracle, Microsoft SQL-Server, and IBM DB2 are often available to academic and cultural institutions at very reduced pricing. Two popular open-source relational databases, MySQL and PostgreSQL also can serve as well as the commercial products in many cases, and have large communities supporting them. No database solution will be without support costs, and it is important to budget for them.

When considering a database system for storage of your metadata, it is important to keep in mind whether you intend to provide some or all of your metadata as a web service. This is the contemporary way of sharing data of any kind on the internet, and the recommended way to do this entails offering your metadata in XML form using an

agreed-upon XML controlled vocabulary conforming to a published XML Schema. This is discussed elsewhere, but here it should be noted that you should plan for this service at the time you plan your metadata database and make technical and budgetary plans for such a service. All of the above-mentioned enterprise-level databases have, or can be connected to, mechanisms for providing XML, and you can share expertise (and perhaps expense) if you collaborate with others in your institution who also have need to offer web services, even if unconnected to media resources or specimens. Commercial relational databases typically have high-performance XML support, but there are also a number of open source “native” XML databases, including eXist (<http://exist.sourceforge.net/>), BerkeleyDB XML (<http://www.sleepycat.com/products/xml.shtml>), and Xindice (<http://xml.apache.org/xindice/>). These could be used if you wish to store your XML metadata in native format. Such a solution requires more sophisticated programming at the moment, because these systems typically are not complete solutions, but rather something to be built into an integrated data management system custom built.

Representing time and date. Use UTC-referenced times for all your time-based metadata. It is otherwise difficult or impossible to know the time and date at which the image was acquired except to within 24 hours. This may entail setting the date and time on the imaging equipment or providing for the conversion in the software implementing the metadata storage. The Worldwide Web Consortium recommends storing dates and times in the ISO 8601 standard, and this is common in interchange formats, so should be used where possible in image metadata. ISO 8601 dates contain self describing timezones, e.g. 2005-01-16T19:20+01:00 to indicate January 16, 2005 at 19:20 in the time zone UTC+1. 2005-01-16T18:20Z designates the same time UTC. Thus, the ISO 8601 standard permits you to use local time, while at the same time insuring that the actual time can be known independently of metadata about the location of the media resource acquisition. See <http://www.w3.org/TR/NOTE-datetime> for details.

Storing the metadata in the images. TIFF and JPEG support embedded EXIF metadata and this is used by most digital camera manufacturers to record camera technical data and exposure data in the image file. This has the advantage that the metadata can travel with the media data but brings the risk that embedded metadata will be inconsistent with an external image metadata base in cases where they hold the same metadata such as that imposed by the camera manufacturer including date and time of the image acquisition. To avoid such inconsistency one should extract such metadata from the image as it is intended to store externally. Several simple EXIF extraction programs can assist with this, including JHEAD (<http://www.sentex.net/~mwandel/jhead/>), METACAM (<http://www.cheeseplant.org/~daniel/pages/metacam.html>), and the exiflib package for C programmers (<http://sourceforge.net/projects/libexif>). It is worth experimenting with these and such others as may become available, because none of them extract all the information from every camera model. Some digital scanners also embed EXIF data in the images they provide.

The recent ISO standard JPEG2000 has an extraordinary story about embedded metadata. JPEG2000 is rapidly being implemented by the digital media industry, but easy to use integrated applications are a few years away.

References

- EXIF.org (2004): <http://www.exif.org/> [accessed 11.XII.2004].
- International Imaging Industry Association (I3A-HOME) (2004): <http://www.i3a.org/> [accessed 12.XII.2004].
- LA POUTRÉ, J. (2004): Jhead for xml: <http://www.xs4all.nl/~jlpoutre/BoT/jhead-xml/> [accessed 15.V.2005].
- Library of Congress (2005): Metadata Encoding & Transmission Standard (METS): <http://www.loc.gov/standards/mets/> [accessed 15.V.2005].
- Library of Congress and NISO (2004): MIX: NISO Metadata for Images in XML Schema: <http://www.loc.gov/standards/mix/> [accessed 15.V.2005].

- NISO (2002): Z39.87-2002: http://www.niso.org/standards/standard_detail.cfm?std_id=731 [accessed 15.V.2005].
- Species Analyst (Darwin Core v2) (2002): <http://tsadev.speciesanalyst.net/documentation/ow.asp?DarwinCoreV2> [accessed 2002].
- TDWG (CODATA/TDWG Working Group on Access to Biological Collection Data (ABCD)): <http://www.bgbm.org/TDWG/CODATA/Schema/default.htm> [accessed 2003].
- WANDEL, M. (2005): Exif jpeg header parser and thumbnail remover, version 2.3: <http://www.sentex.net/~Emwandel/jhead/> [accessed 15.V.2005].