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Five years of using insect imaging conveyor system at the Finnish Museum of Natural History (LUOMUS), and future perspectives

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The challenge –
Ten million insect specimens

- One systematically arranged collection
- Integrated from hundreds of original collections in the past 200 years
  - Physically heterogeneous
- Re-housed in modern, cooled hall built underground in 2008
- Transparent, plastic unit trays

Technological and funding opportunities

FUNDING AND COORDINATION OPPORTUNITIES

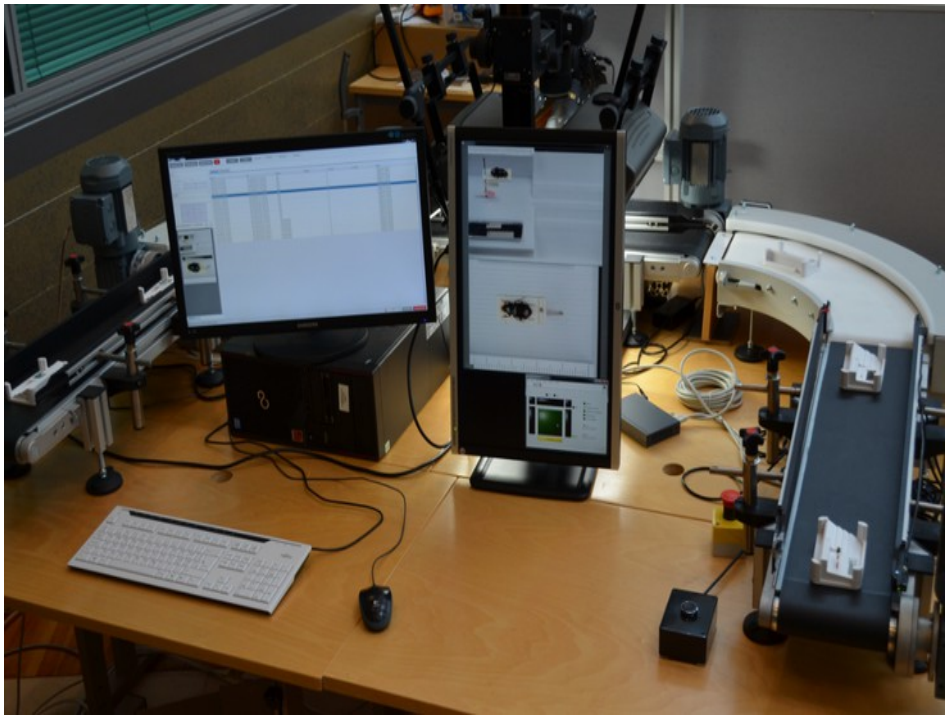
- National digitization strategy was determined in 2009-2010.
- Over €2 million European Union structural funds were used.
- Digitization center DIGITARIUM operated 2010-2017. Then spun out to company Bioshare Digitization Ltd.
- The ICEDIG.EU project explored new technologies in 2018-2020.

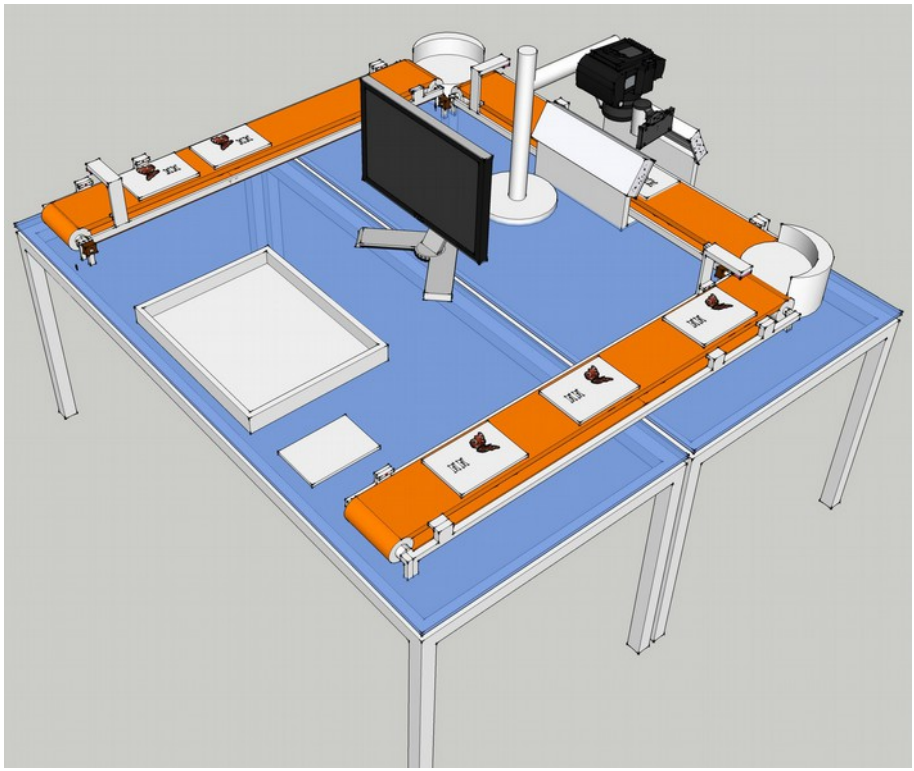
TECHNOLOGICAL OPPORTUNITIES

- Adopt mass-digitization technology first developed for herbarium sheets; develop related workflows and software.
- Package hardware, software, and workflows in integrated products.
- Explore 3D, AI, ML, ...

Conveyor-driven imaging system for pinned insects

- Designed and built by DIGITARIUM in 2013-2014; still available on the market.
- Fits in a normal office. Fully automatic, single user system with multiple cameras.
- Data transfer rate is 250 specimens/hour (if there was no specimen handling...)





Output

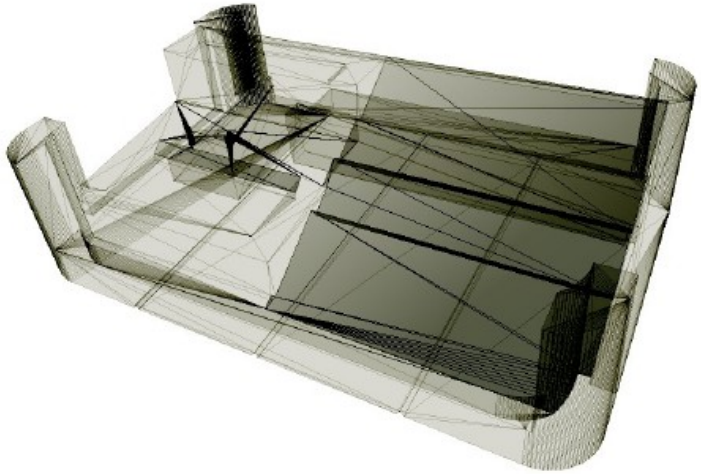
- In 5.5 years, some 420,000 pinned insect specimens have been digitized. Average annual amount of samples processed is 76.000 specimens.
- Sustained performance is 345 specimens/day = 43/ specimens/hour = 83 seconds/specimen.
- Almost all of the material has been Lepidoptera, but pilot projects of Coleoptera and Symphyta have also been done.
- Each specimen was photographed using dorsal or lateral view depending on the specimen (spred = dorsal | not spred = lateral)
- Labels were detached and a separate picture was taken of the labels.
- Basic data entry was done concurrently with the imaging, when time allowed (locality, time, collector, taxon name); this worked for about 90% of the specimens.
- After data review and georeferencing, the data was uploaded into the Finnish Biodiversity Information Facility (FinBIF).

Workflow

- Specimen handling and data entry is all done by a sole operator.
- The system is in use eight hours a day, divided in four two-hour work shifts. (Three-hour shifts were tried at first but the rate of user mistakes increased significantly during the third hour.)
- Process starts with the pinned sample being mounted on a 3D-printed imaging tray, with separate spaces for the specimen and the labels.
- Labels are removed from the pin if possible. A label with a *CETAF Stable Identifier* is added (URL as text and as QR code).
- The samples on the imaging trays are then circulated through the imaging conveyor system.
- Quick data entry (of the previous samples) is done while samples are being imaged on the conveyor system. Priority is, however, given to the imaging system: In case the operator does not have time to enter all available collecting data, the sample is tagged as not completed.
- Post-processing includes spelling and typo check, and automatic georeferencing if there are no collector-provided coordinates.

Imaging trays

- Modelling and 3D printing (ABS) by Digitarium
- Place for specimen
- Places for ID and taxon labels
- Mirror to expose the underside of labels
- Built-in scale



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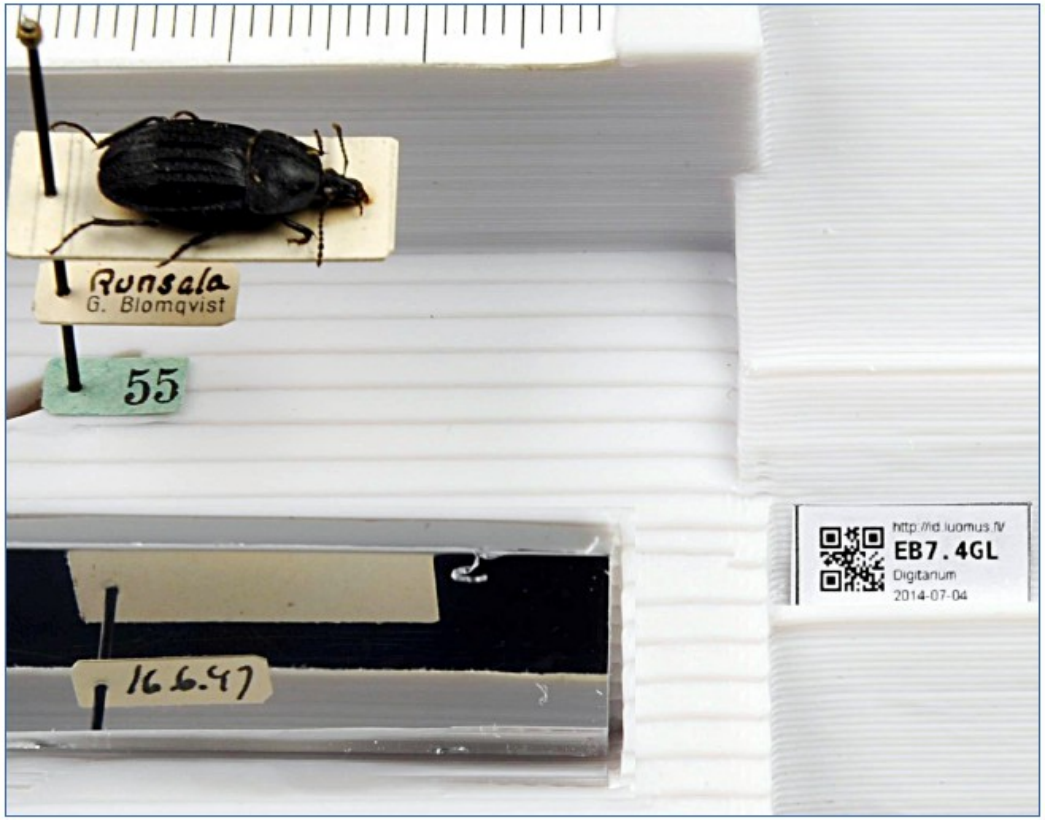
Outcome images

Digitarium

Top image

Side image



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Software

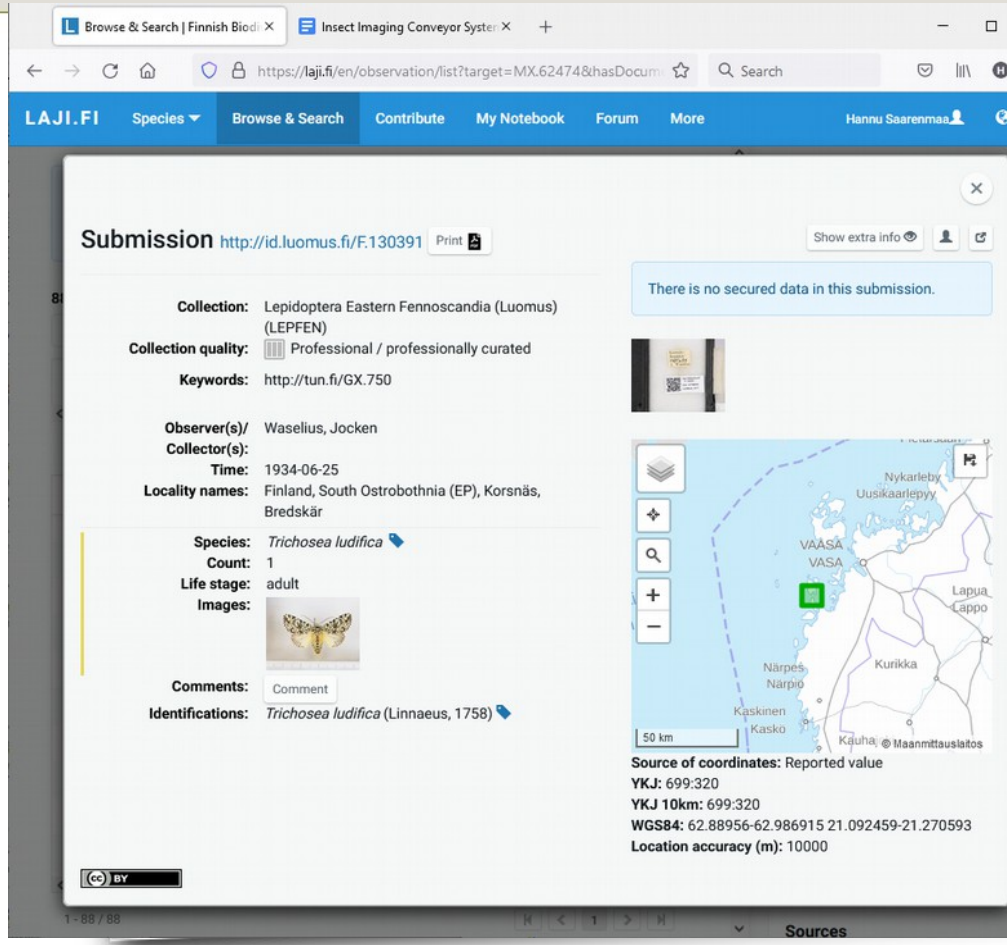
Digitarium

Digitisation software

- Labeling UI & DB
- Specimen setting assistant
- Conveyor control
- Camera interface

Server software

- Image post processing



Export functions

- FinBIF Portal www.laji.fi
- Collection Management System (Kotka)

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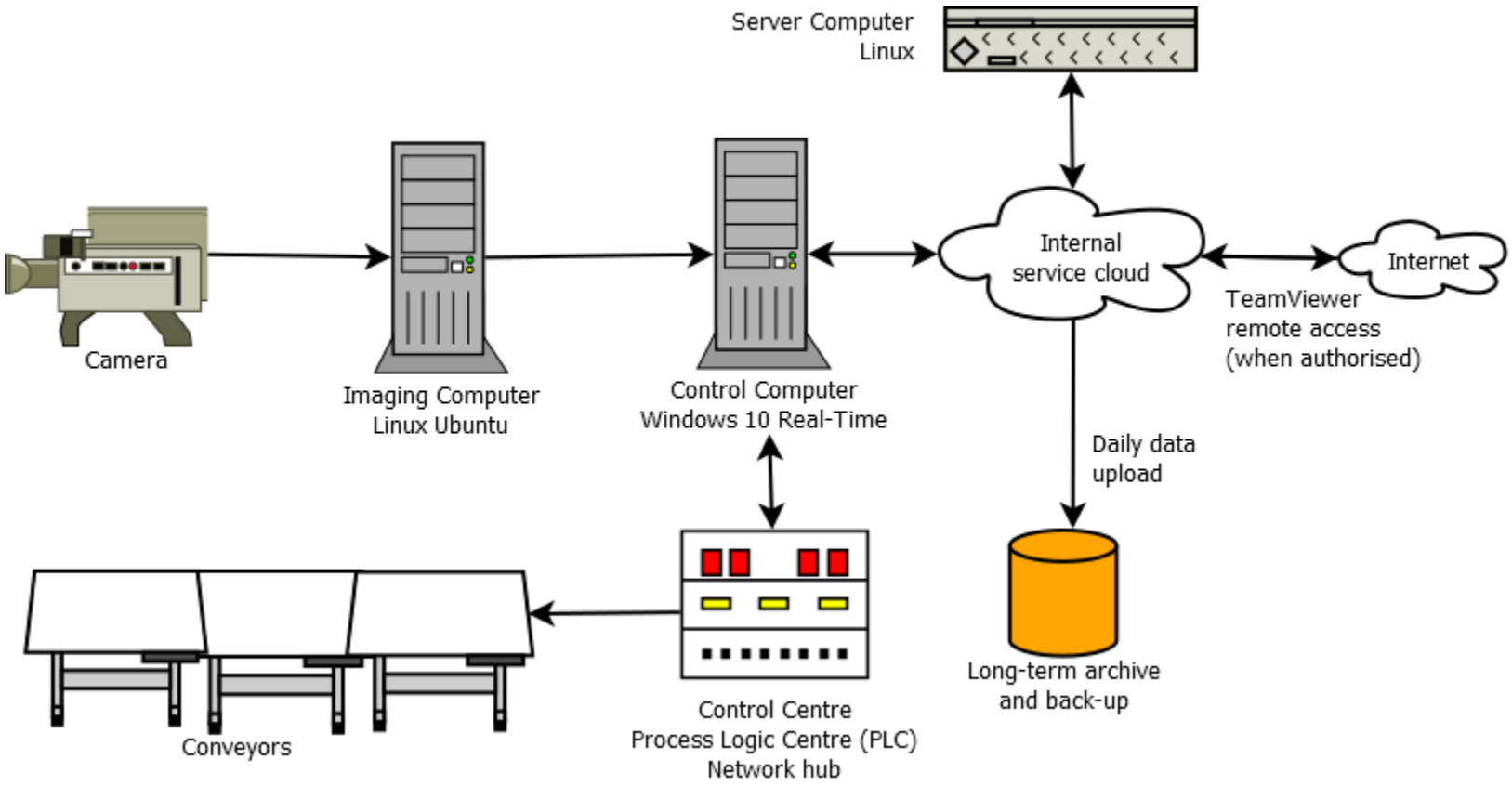
Component architecture



Lessons learnt and what's next?

- The approach works and output is satisfactory for a single user system.
- This is optimal for medium-size collections (~1 million specimens)
- Considering the magnitude of insect collections, and if we want get done in the next 25 years of so, needs scaling up by a factor of 10.
- However, installing 10 personal systems next to each other would scale only linearly.
- The ICEDIG.EU project 2018-2020 investigated the alternatives. There are several, very different options, which are currently being tried.

- Get rid of handling the labels:
  - Multi-angled photography and use OCR and ML to grab label data from many partial images.
  - Use 3D imaging combined with cameras in robot hands.
- Use a large, multi-user system. See http://www.bioshare.com/high-performance-digitization-of-pinned-insects/

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Large, multi-user system for pinned insects

- Use a large conveyor, originally designed for herbarium sheets, but use small imaging trays
- Conveyor length 9 meters, width 0.6 meters, which fits 6 or more operators (4 loading operators, 2 unloading operators)
- Web page and video available through http://www.bioshare.com/high-performance-digitization-of-pinned-insects/

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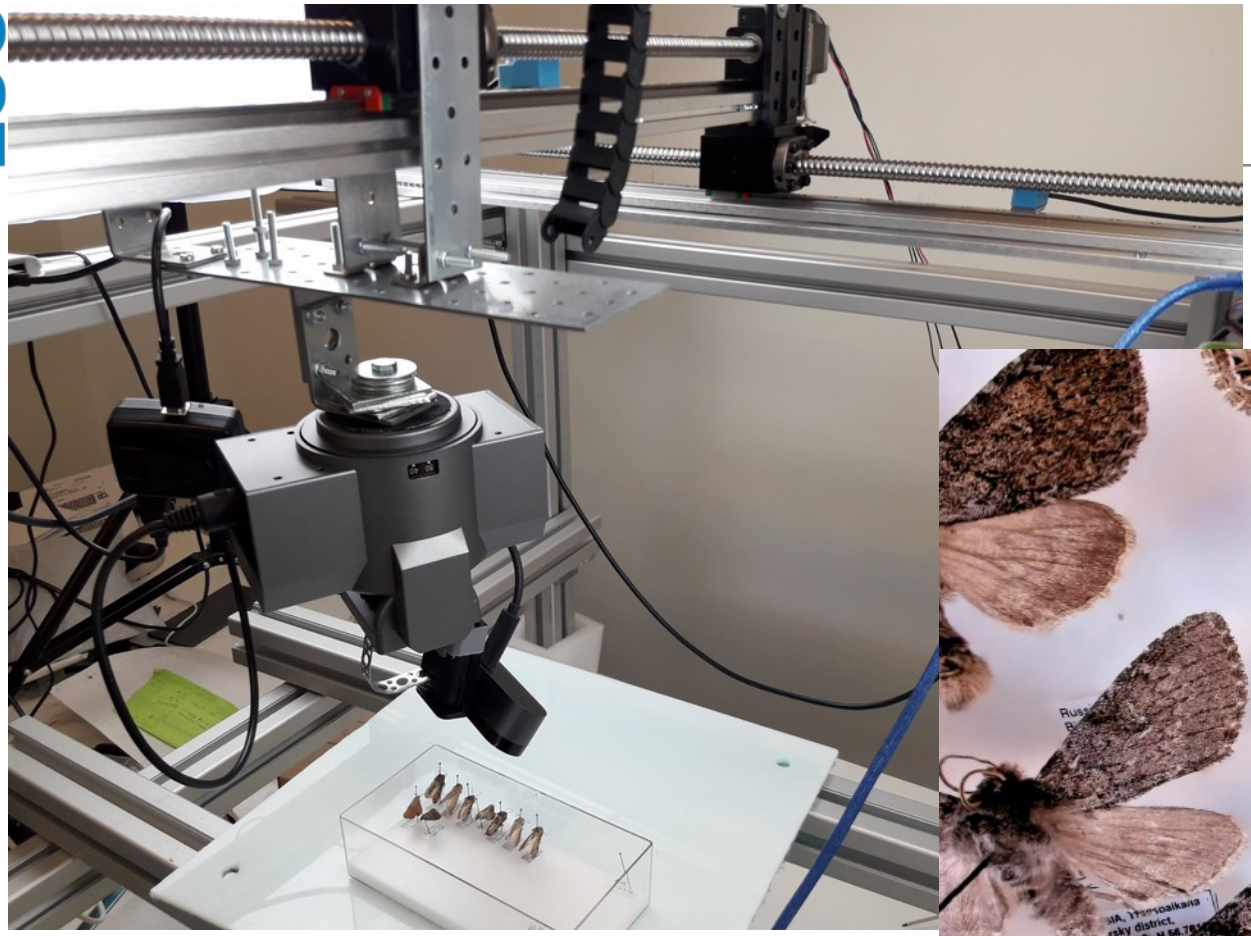
NATURHISTORISKA CENTRALMUSEET
FINNISH MUSEUM OF NATURAL HISTORY

ENTODIG-3D prototype: 3D imaging



Below is view into a 3D-model of a unit tray, the specimens, and their labels

Motorized webcams on rails look under the specimens and see the labels.

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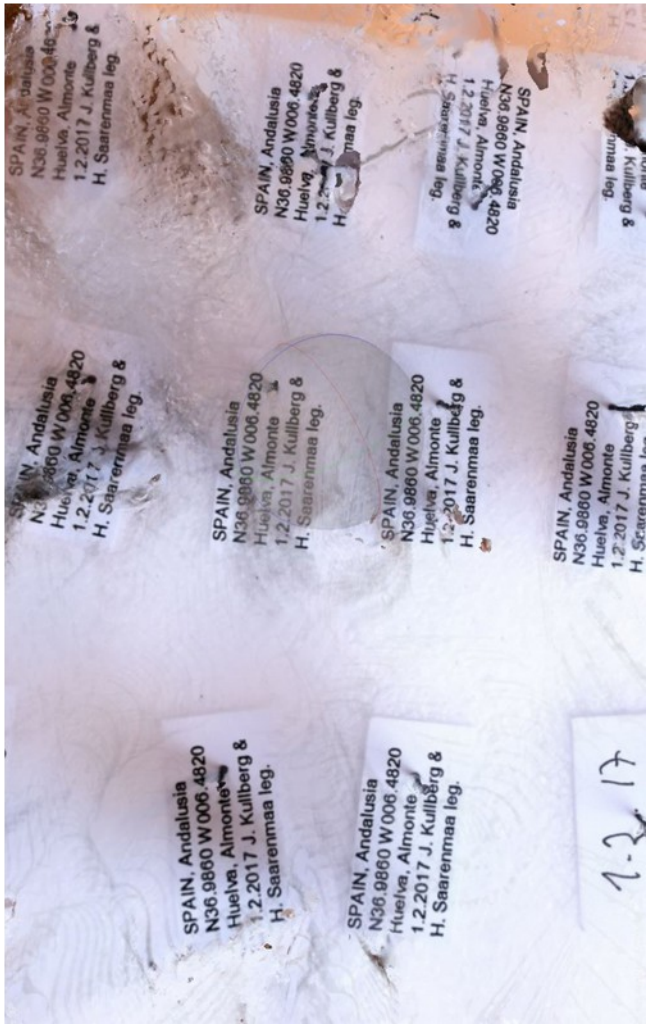
Vertically crop the insects away from the 3D model which gives unobstructed view to the labels



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ENTODIG-3D prototype video: Webcams on rails picture from multiple angles all insects in an entire drawer

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Conveyor-driven systems are available for worldwide delivery

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BIOSHARE Digitization