Elemental distribution in feathers of the Common Swift: an x-ray fluorescence study

Elettra Sincrotrone Trieste

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Motivation

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Chemical analysis of bird feathers is used to monitor environmental pollution. Advantages: feathers are dead protein, and so are a "snapshot" of heavy metal content in the diet of the bird when the feather was grown. The protein, keratin, has a high sulfur content (cysteine) and so concentrates metals. Non-intrusive.

However: sample is usually destroyed (unsuitable for museum and historical feathers).
Little is known of the distribution of elements within the feather. Can we learn more?

Goal: examine the microscopic distribution of elements in feathers.
Compare microscopic images of feathers from juveniles, adults and birds raised in captivity.

S. Valladares et al, "Evaluating cleansing effects on trace elements and stable isotope values in feathers of oiled birds," Ecotoxicology 19 (2010) 223.
J. L. Lavers et al, "Linking at-sea mortality of a pelagic shearwater to colonies of origin using biogeochemical markers," Mar. Ecol. Prog. Ser. 491 (2013) 265.
S. Jerez et al, "Concentration of trace elements in feathers of three Antarctic penguins: Geographical and interspecific differences " Environmental Pollution 159 (2011) 2412.

Feathers were obtained from the common swift (apus apus). Supplied by the bird recovery centre Liberi di Volare in Trieste.

Three kinds of feather examined:
Adults, who have migrated to Africa several times.
Juveniles, young birds born in Trieste, but have not yet reached maturity
Raised in captivity, nestlings fallen from their nest before first flight.

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Analytical non-destructive methods

- PIXE elemental mapping ➔ Ruder Boskovic institute, Zagreb, Croatia
- Hard X-rays XRF elemental mapping ➔ XFM beamline @ Australian Synchrotron (Melbourne, Australia)
- Soft X-rays XRF elemental mapping ➔ TwinMic beamline @ Elettra Synchrotron (Trieste, Italy)

Basic method: feathers irradiated with a small spot of high energy x-rays.
The elements present emit lower energy x-rays characteristic of the elements present.
These are measured. The spot is scanned and the map of the low energy x-rays shows which elements are present and their concentration.

XRF measurements
Sulfur

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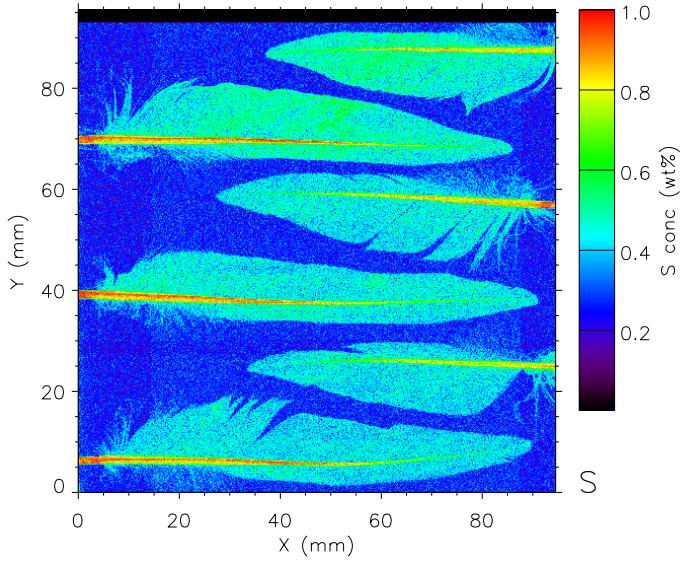
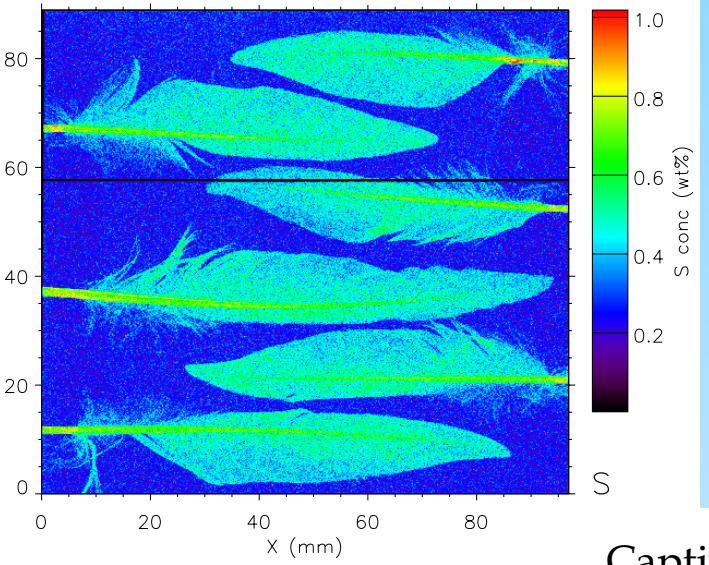
Adult

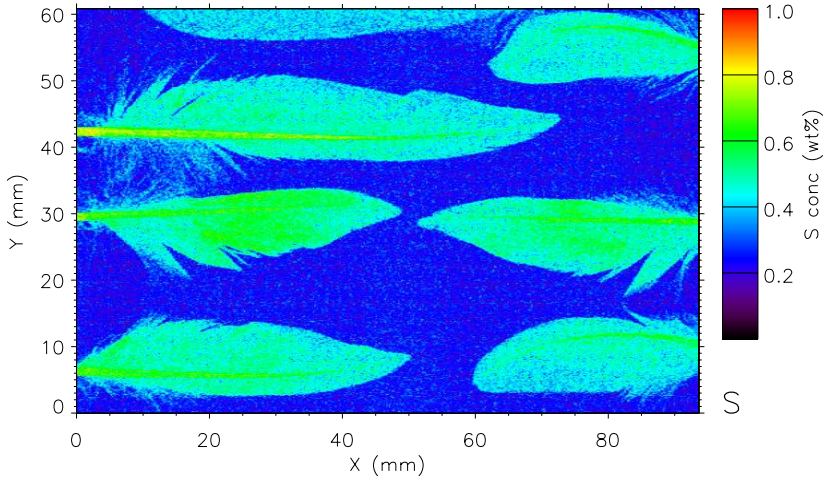


Juvenile



- Same concentration of Sulfur in all type of feathers

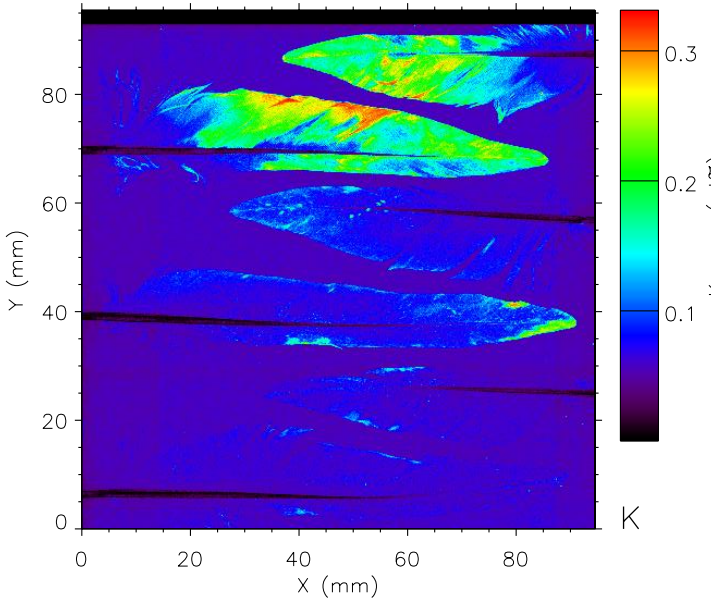
Captivity



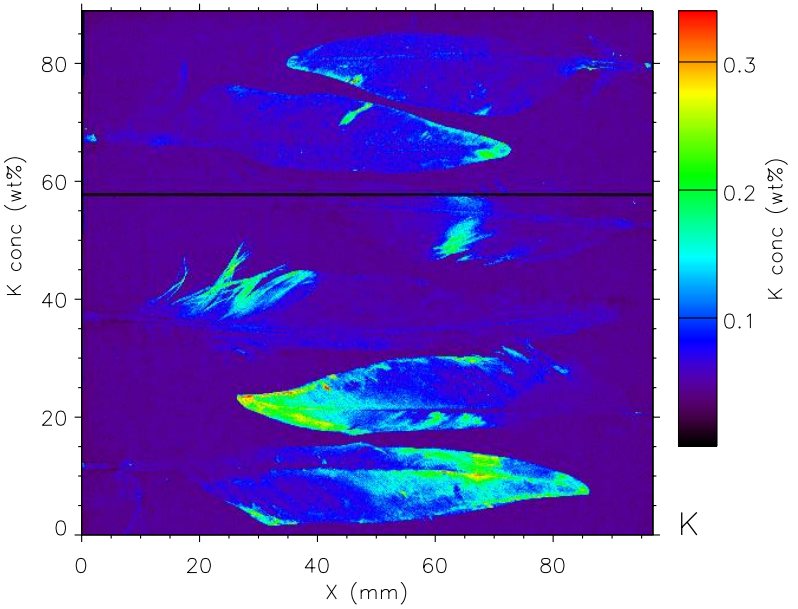
XRF measurements
Potassium

Elettra Sincrotrone Trieste

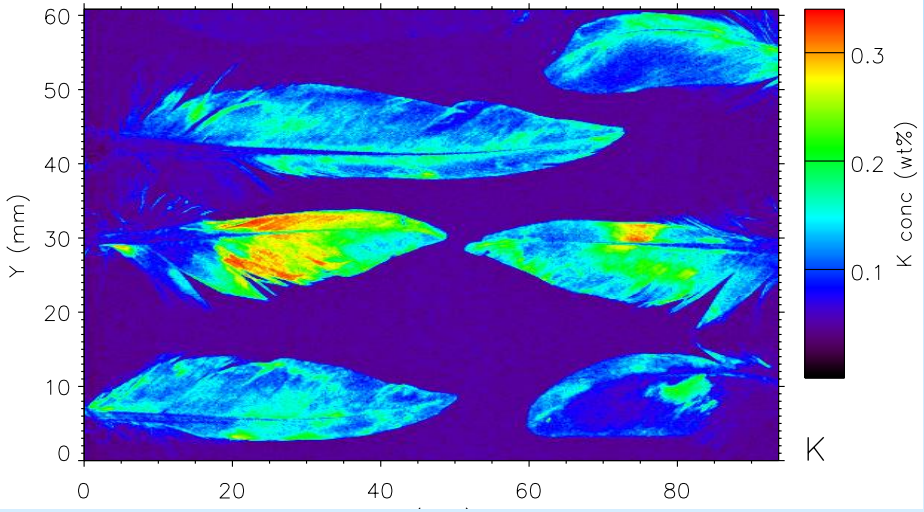
Adult



Juvenile



Captivity



- Same concentration of Potassium in all type of feathers, even though K seems more uniformly distributed in captivity samples.

XRF measurements Calcium

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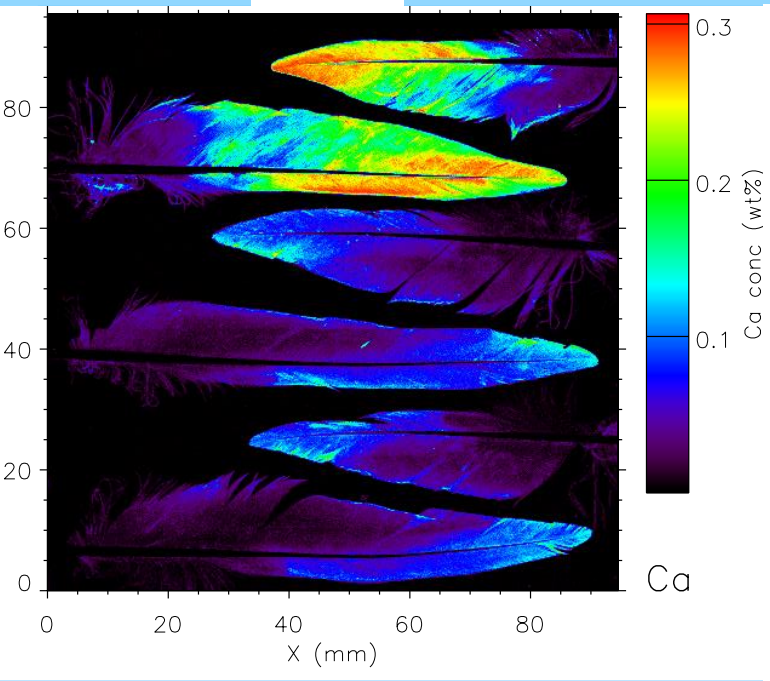
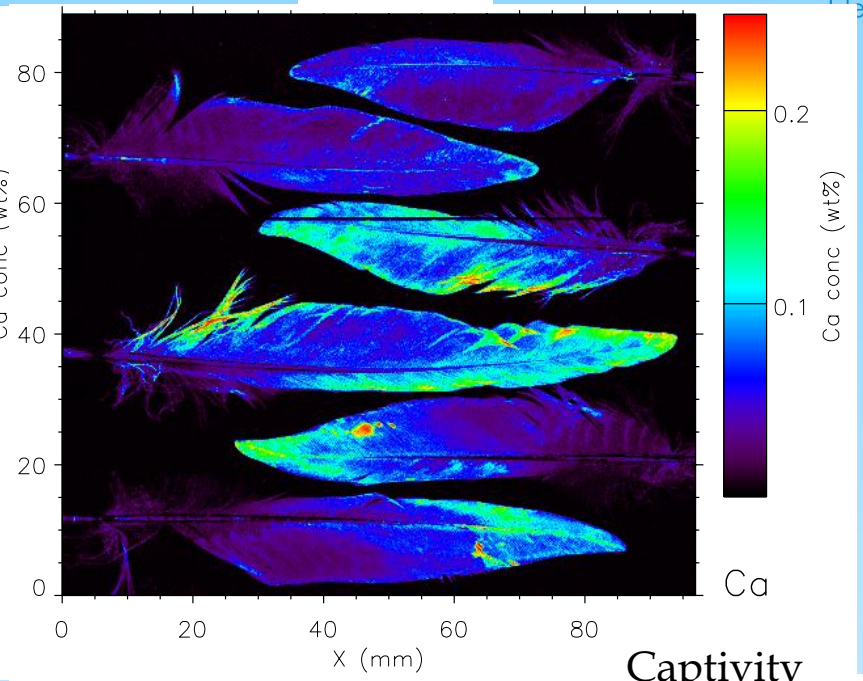
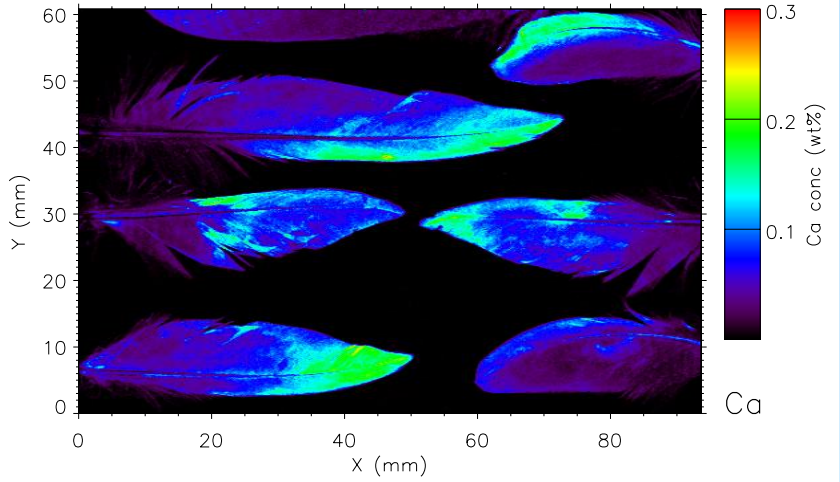
Adult



Juvenile



Captivity



- More Ca in adult feathers, less in juvenile and in Captivity ones.

XRF measurements
Iron

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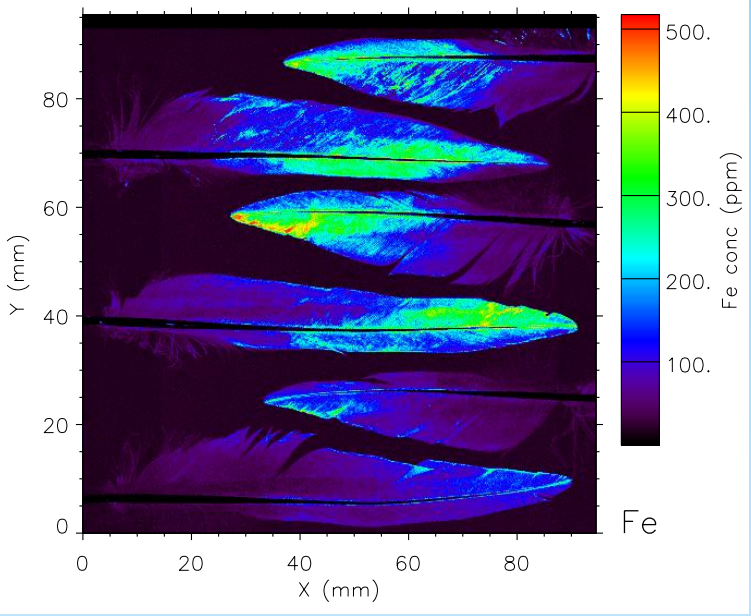
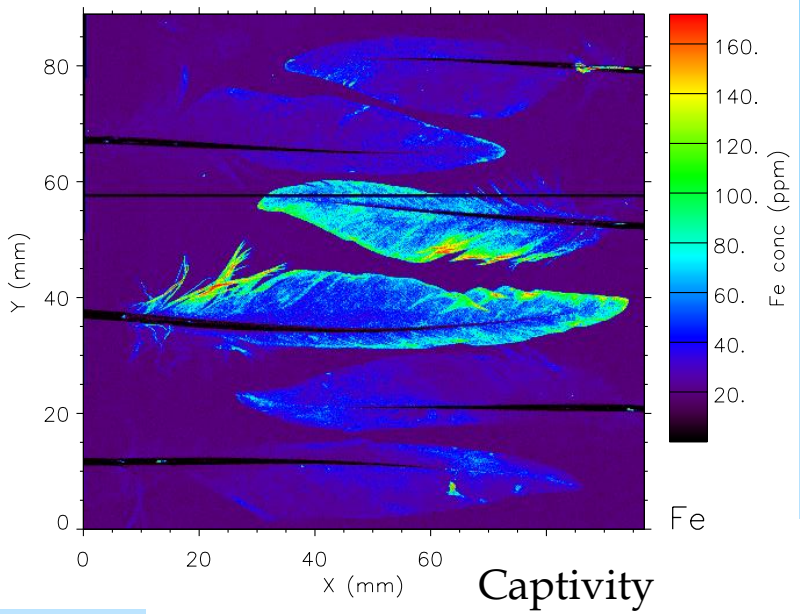
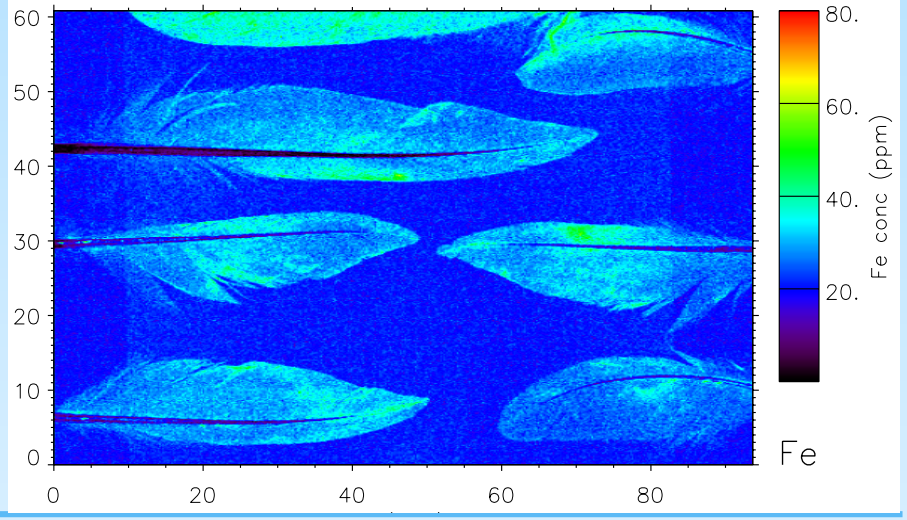
Adult



Juvenile



Captivity



- Fe is present in diffuse and particulate form in adult feathers, a little less in juveniles ones and even less frequent in feathers of birds raised in captivity

XRF measurements Copper

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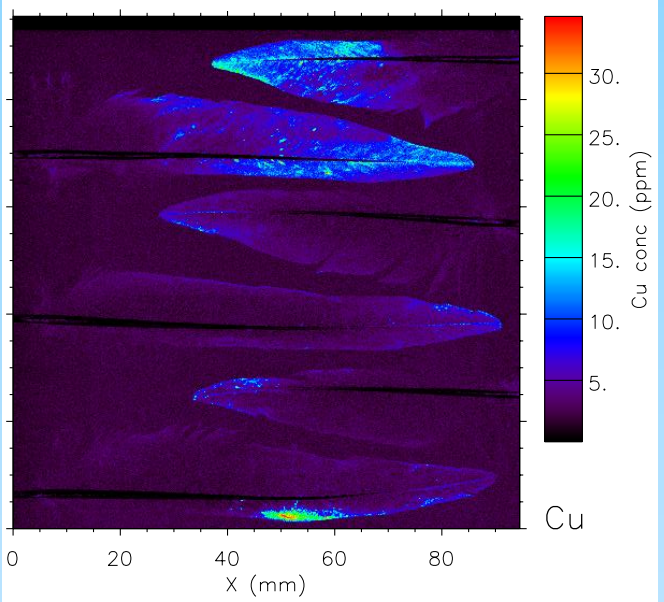
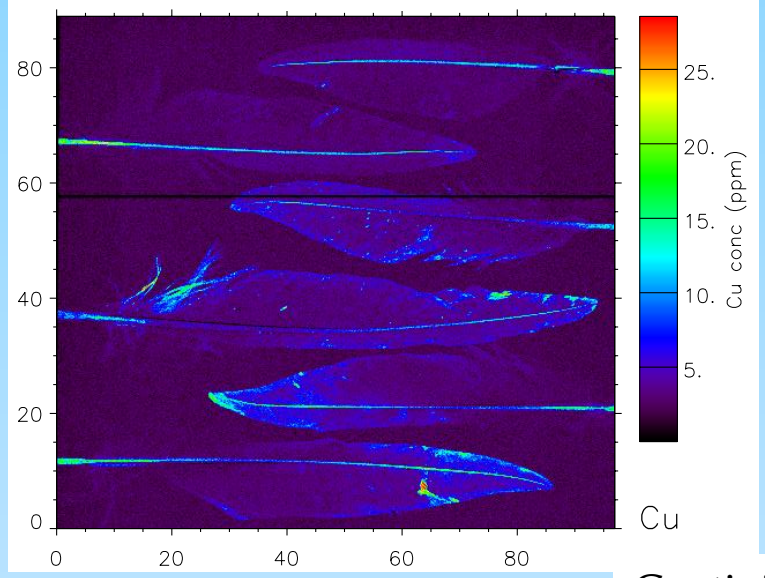
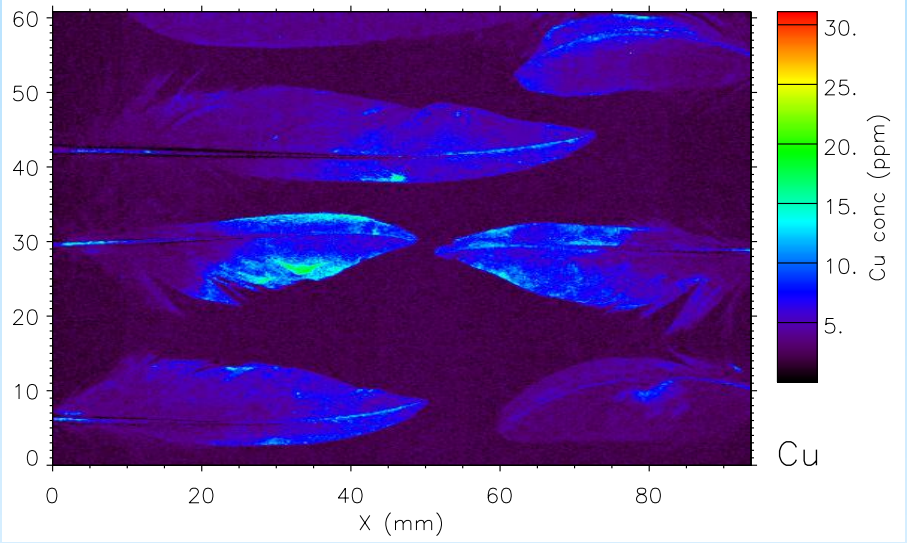
Adult



Juvenile



Captivity



- Cu is present as particulate in adult feathers, a little less in juveniles ones and even less frequent in feathers of birds raised in captivity

XRF measurements
Lead

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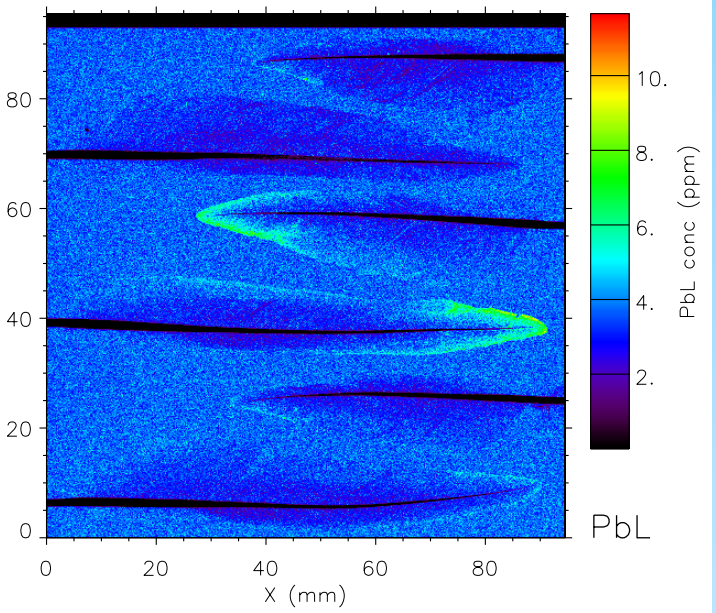
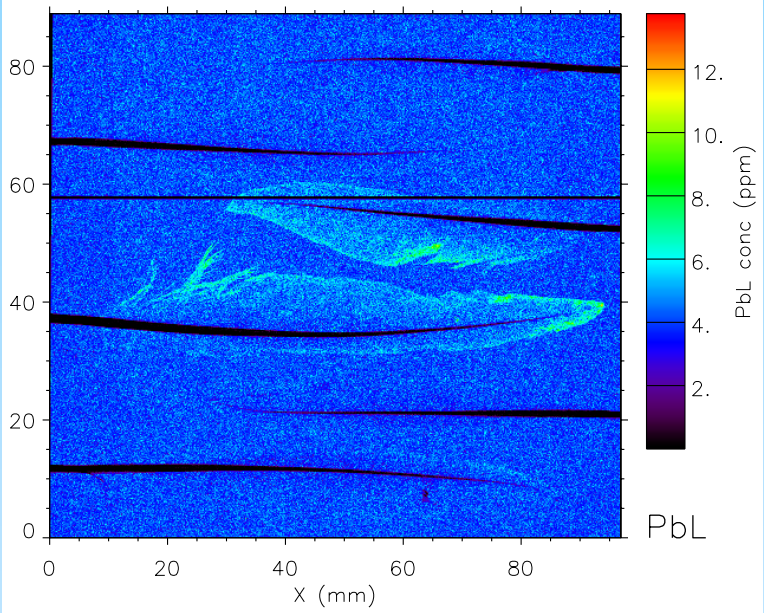
Adult



Juvenile



- A little bit more Pb in adult feathers compared to Juvenile ones
- No Pb found in Captivity (or anyway below detection limits)

XRF measurements
Zinc

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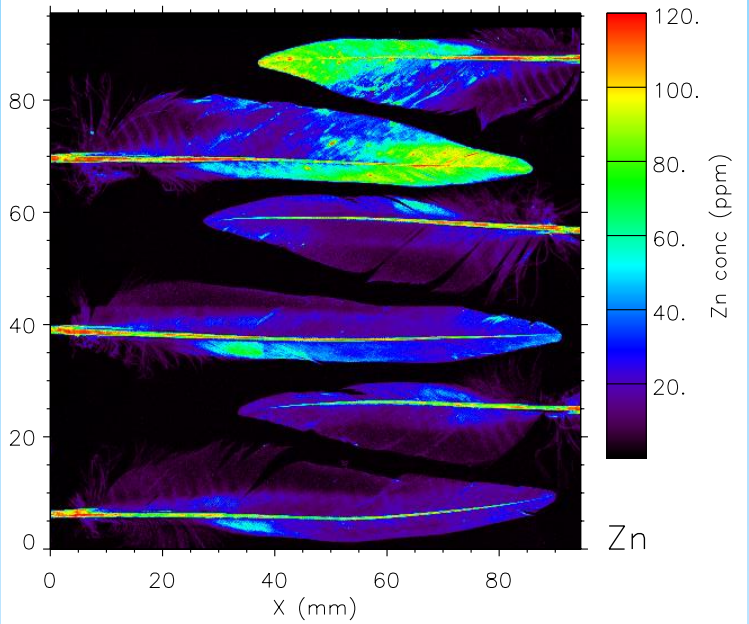
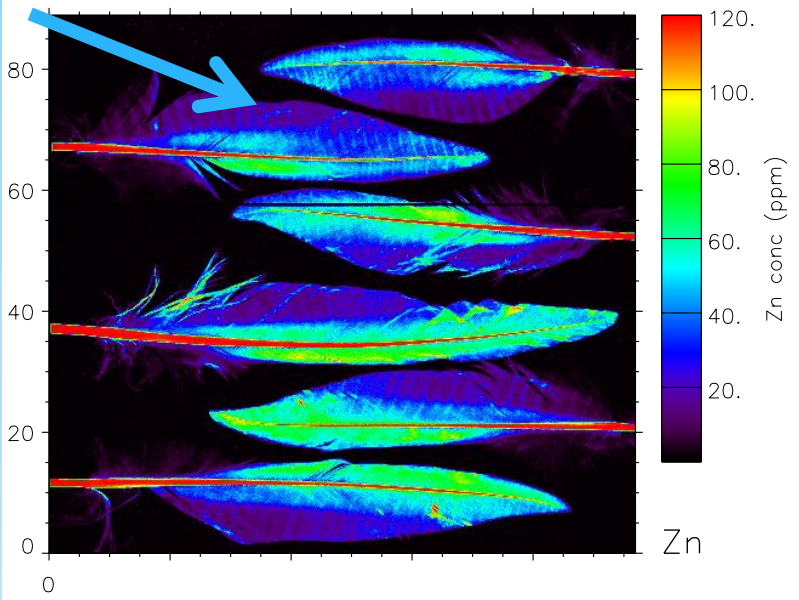
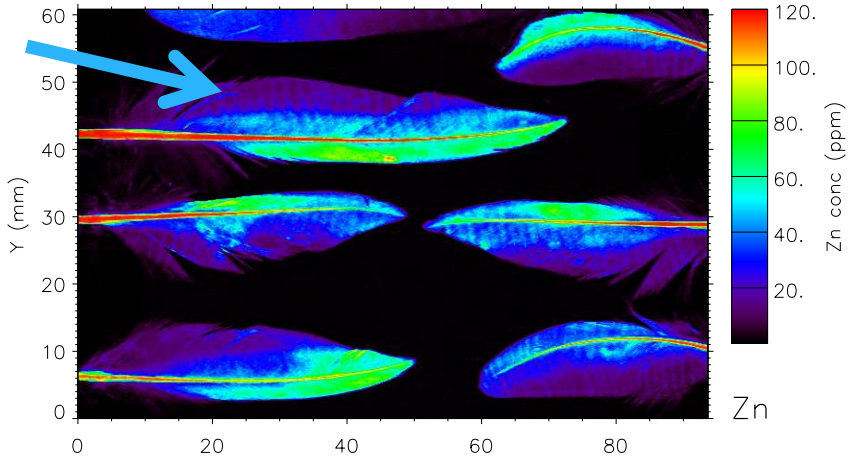
Adult



Juvenile



Captivity



- Juvenile and "captivity" feathers show similar distribution of Zn; in adult ones Zn is less uniform and more particulate-like distributed

XRF measurements
Zinc

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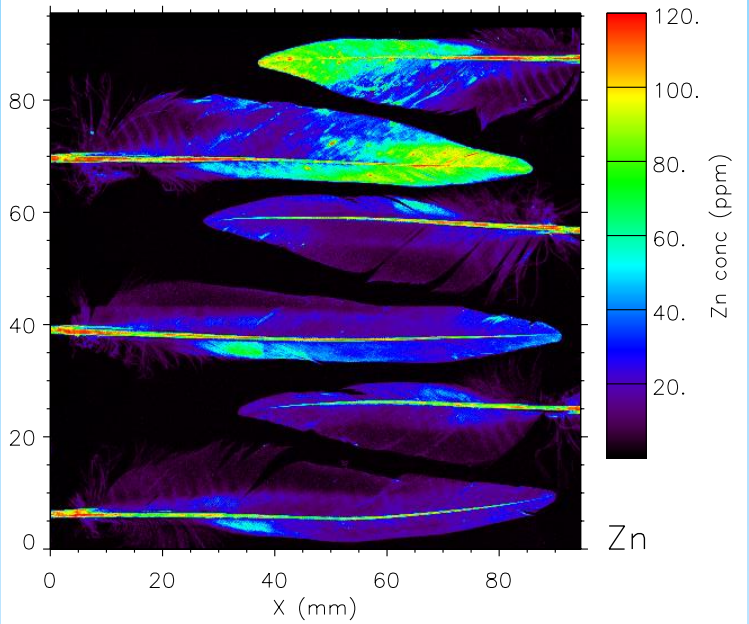
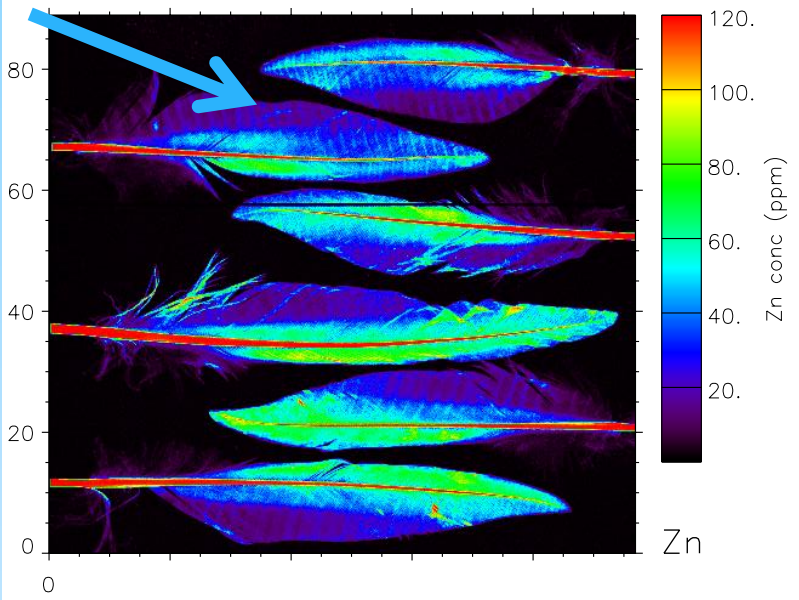
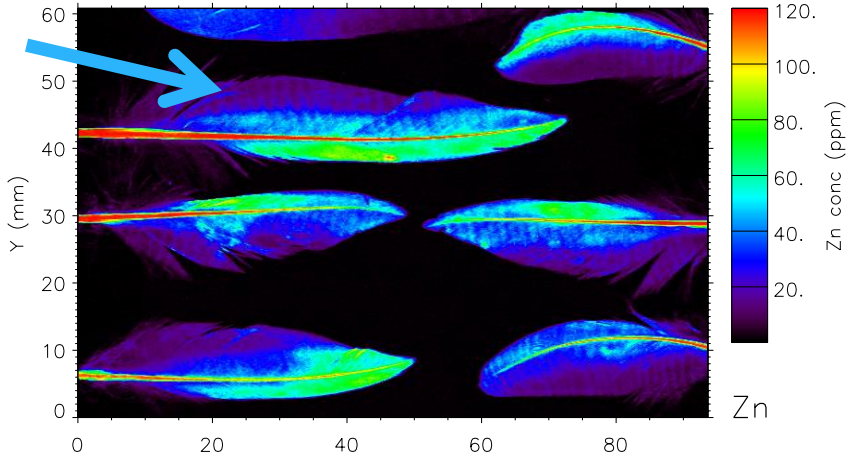
Adult



Juvenile



Captivity



- Bands of Zinc are interpreted as growth bars. These are visible to the naked eye in some species, but not in swifts.

Conclusions

- No fine microstructural features were observed on the micron scale. Zinc shows banding on the mm scale, attributed to growth bars, which are not visible to the naked eye.

- X-ray fluorescence is useful for non-destructive analysis of rare or precious samples, but not suitable for large scale routine analysis.

- The feathers of birds raised in captivity on a diet mainly of crickets is similar in chemical composition to that of birds in their natural habitat. The main differences are in elements arriving from the environment after growth, rather than during growth.

Liberi di Volare thanks the Anglo Italian Society for the Protection of Animals (AISPA) for support.

2020: 6th International Swift Conference: Trieste, Italy, the ideal location!

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"...is recognised as one of the largest and most important places of worship for Jews in Europe."

By Zacqary Adam Xeper - Own work, CC BY-SA 4.0, https://commons.wikimedia.org/w/index.php?curid=35002115

Trieste, also a cultural and linguistic cross-road.

St. Justus cathedral, next to the Roman forum.

St. Spyridion Serbian Orthodox church.

*** In 2020, Trieste will be the City of Science.***

Costs.
Accommodation: there are many small hotels and B&Bs in the zone where we intend to hold the event. Booking.com offers:
25 properties, <50 Euro; 102 properties, 50-100 Euros in City centre.

Meals: a wide range of trattorie, pizzerie and restaurants provide typical Triestine, Italian, seafood and other styles of food, at moderate prices. Three-course meals with drinks can be found for about 25 to 30 Euros; pizza is much less.

Transport: **many low cost flights to Venice (2 hours by train).** Some low cost to Trieste airport, plus Alitalia and Lufthansa flights.

Conference fee: same as for the present conference. We will actively seek sponsorship.

Indications of support from representatives of:
- the City of Trieste
- the Region of Friuli Venezia Giulia
- Gruppo Rondoni Italia
- FVG Veterinary Association
- University of Udine
- etc.

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