

# *Lithobius*: a big genus of a small subphylum (Myriapoda), phylogeny and evolutionary history



- Project report -

Anne-Sarah Ganske

# Myriapoda - the leggiest arthropods

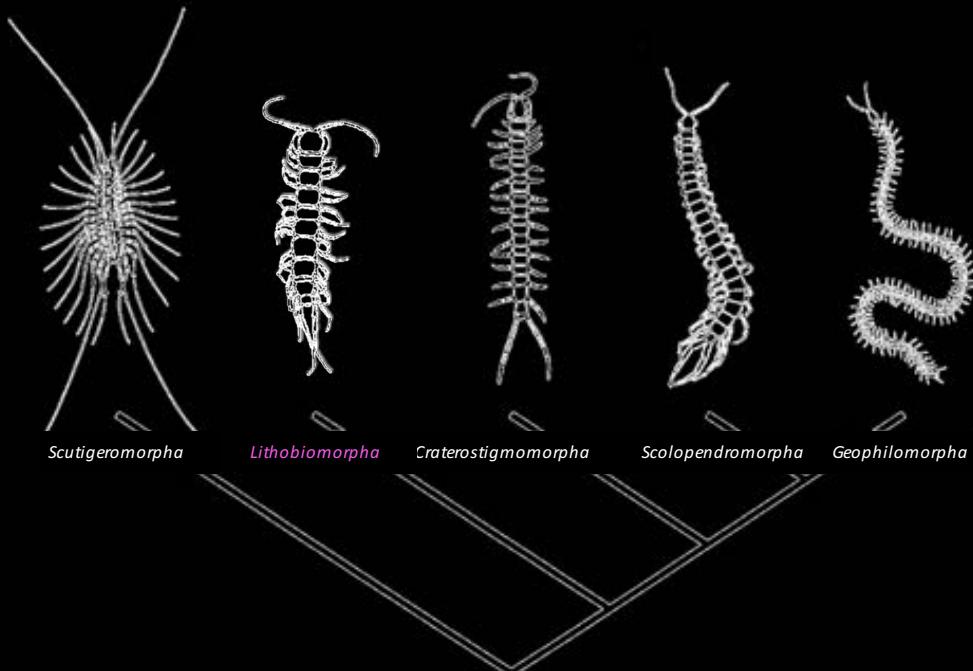


Symphyla

Diplopoda

Paupropoda

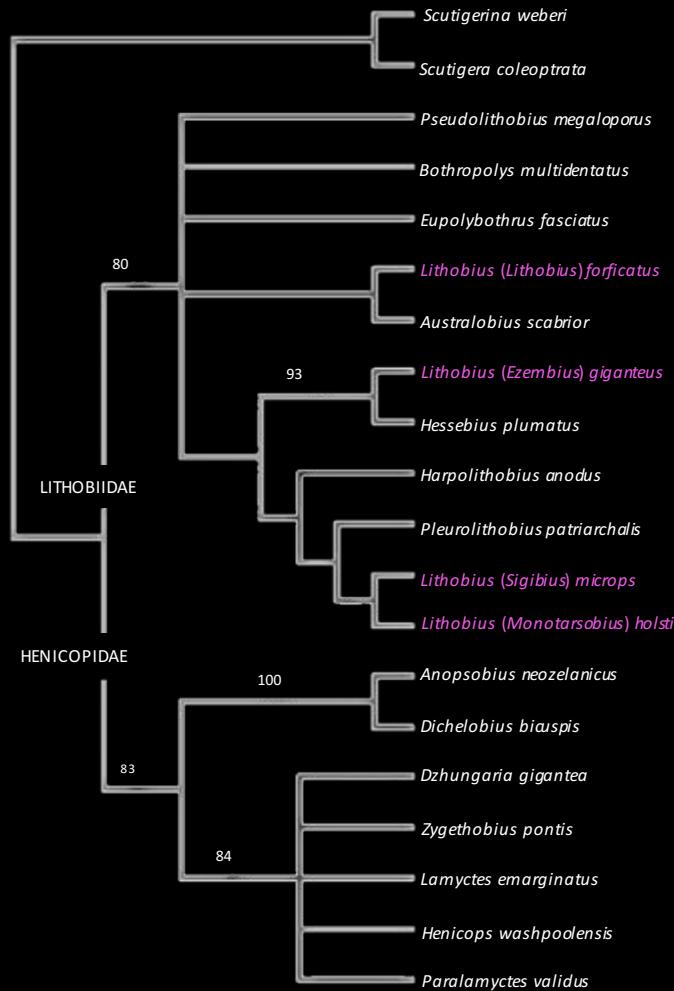
Chilopoda



Edgecombe & Giribet 2002

430 genera with more than 3200 valid species  
130 genera/subgenera with 1100 valid species

# Genus *Lithobius* Leach, 1814



► > 500 species/subspecies

► species inter-relationships not clear

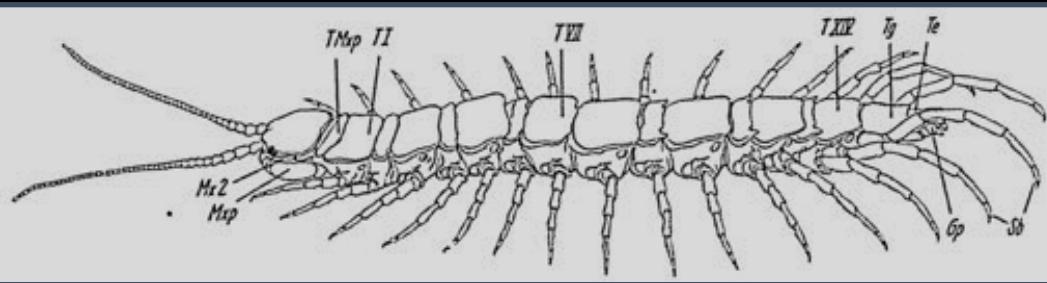
► non-monophyletic



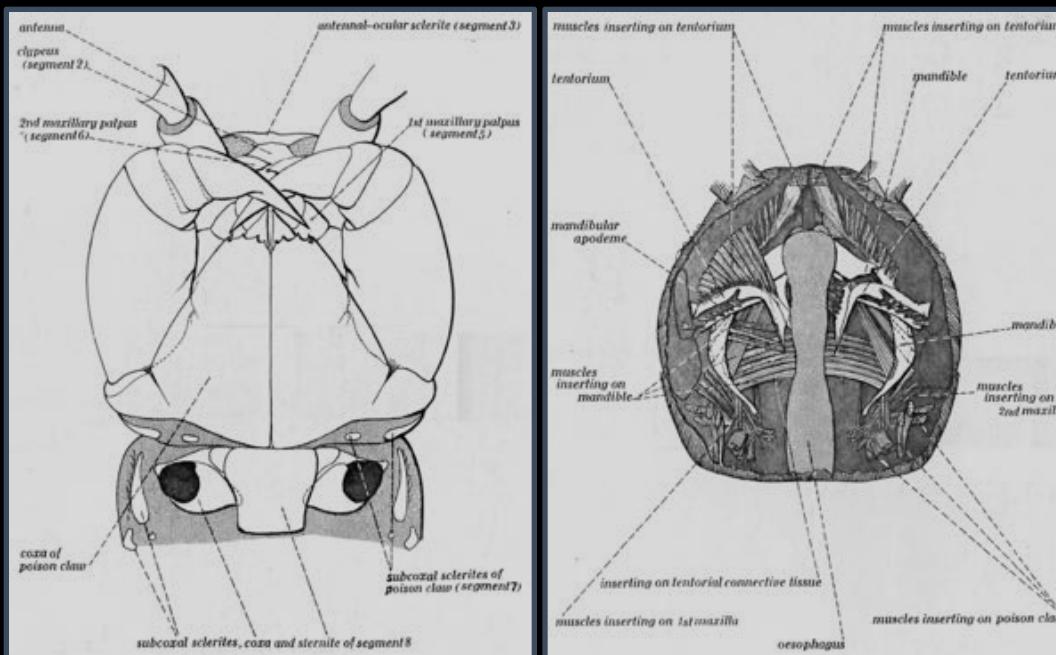
# Systematics of genus *Lithobius*?



## Morphological analysis

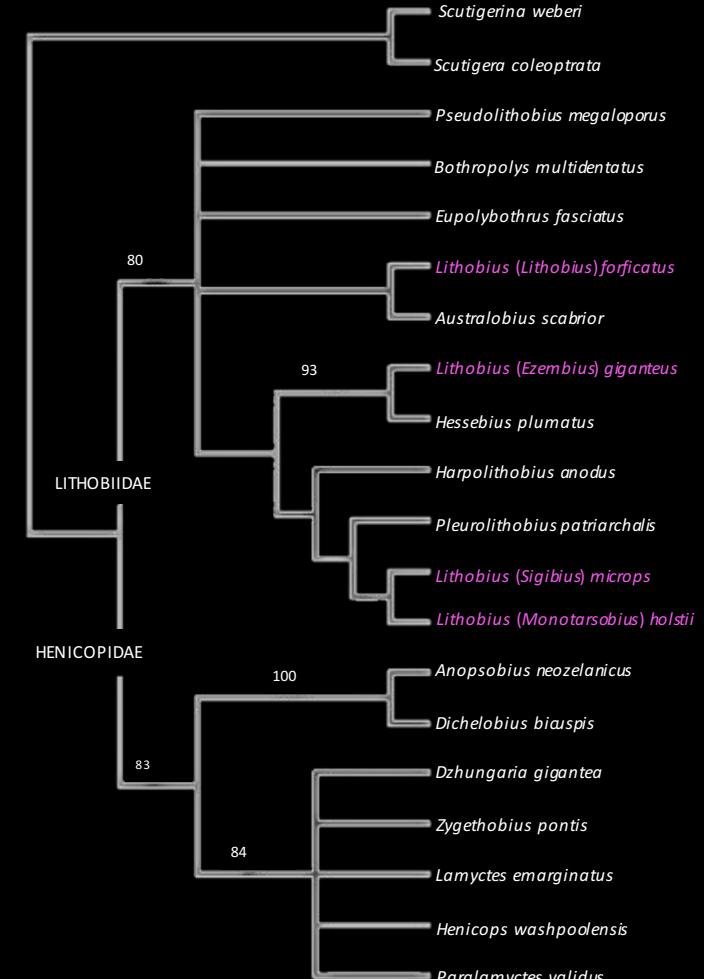


Line drawings of *Lithobius forficatus* Linnaeus, 1758 (Rilling 1960)



Line drawings of *Pseudolithobius megaloporus* (Stuxberg, 1875) (Applegarth 1952)

## Molecular analysis

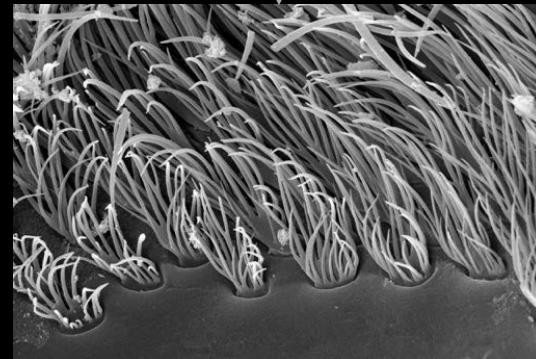


Koch & Edgecombe 2008

# Imaging methods



Multifocus light-micrograph  
*L. forficatus*, head, ventral view

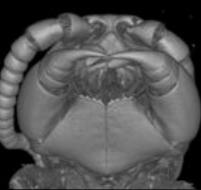


SEM-photograph  
bristles on epipharynx



Volume rendering, *L. forficatus*  
voxel size 15.3 µm

# Peristomatic structures - overview



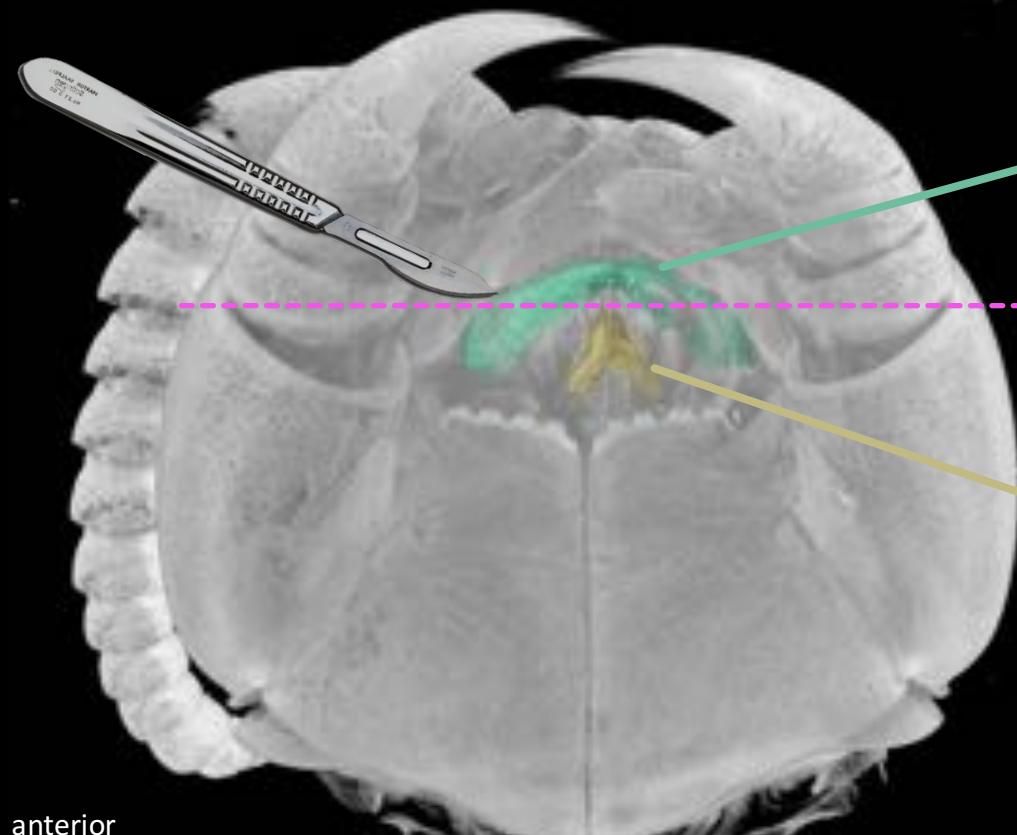
35 species of lithobiid genera:

*Lithobius* Leach, 1814

*Neolithobius* Stuxberg, 1875

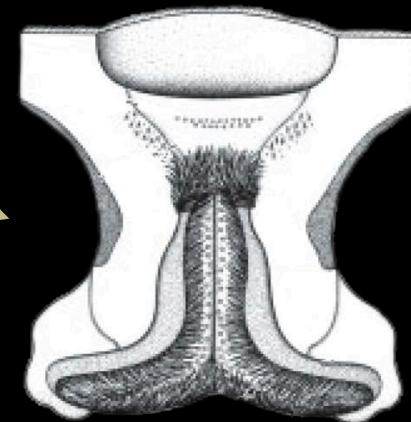
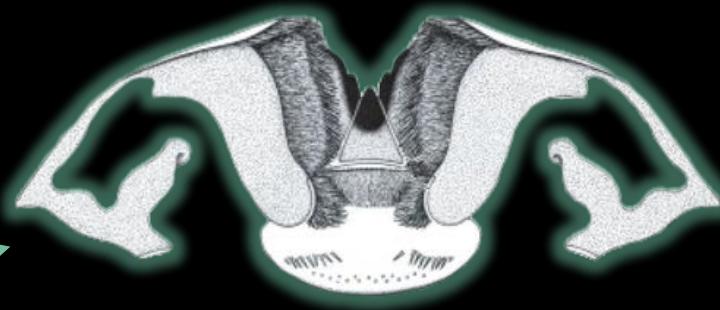
*Disphaerobius* Attems, 1926

*Eopolybothrus* Verhoeff, 1907



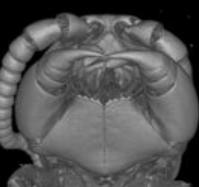
Head of *Lithobius forficatus* (ventral view)  
Volume rendering, voxel size 5.0  $\mu\text{m}$

epipharynx

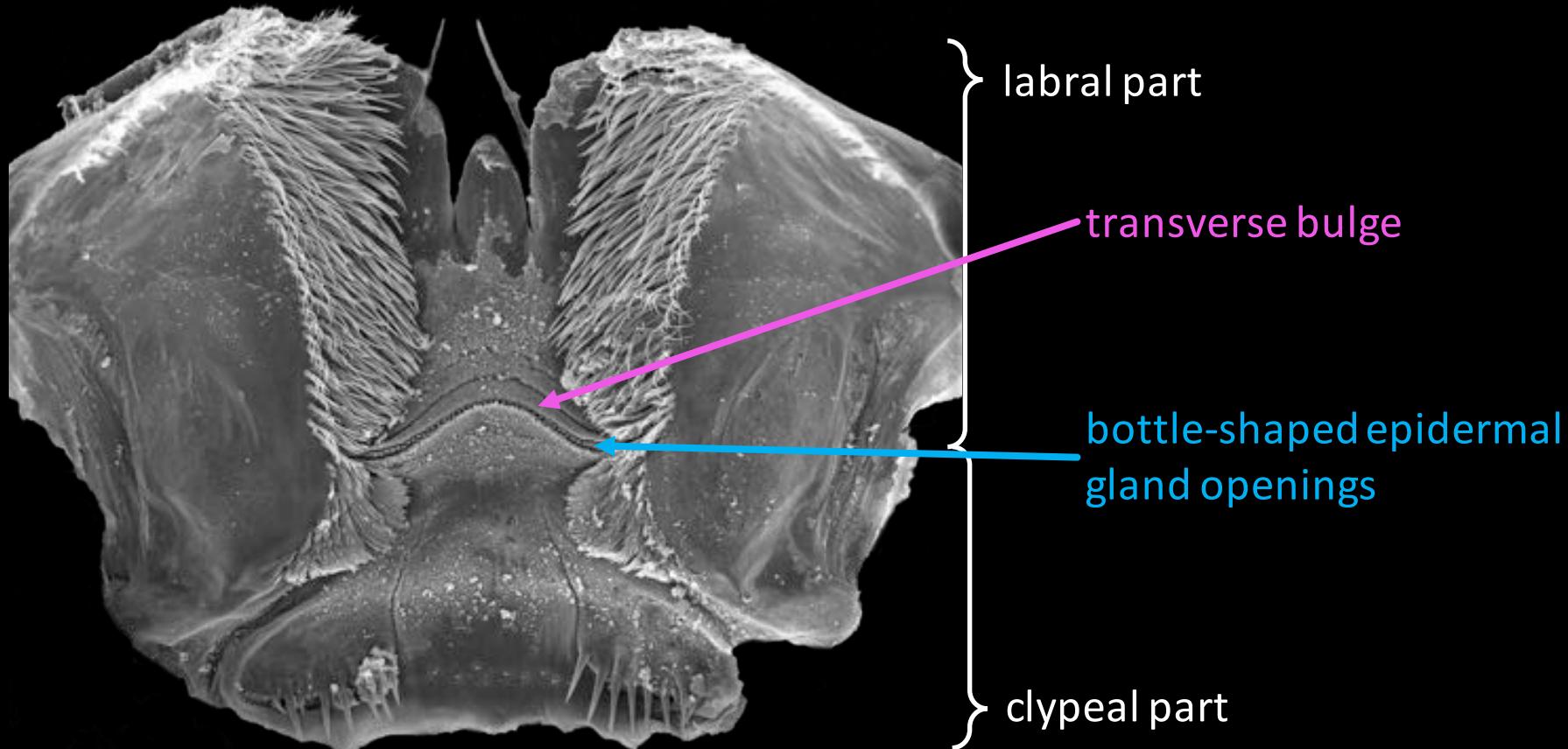


hypopharynx

# Epipharynx - overview



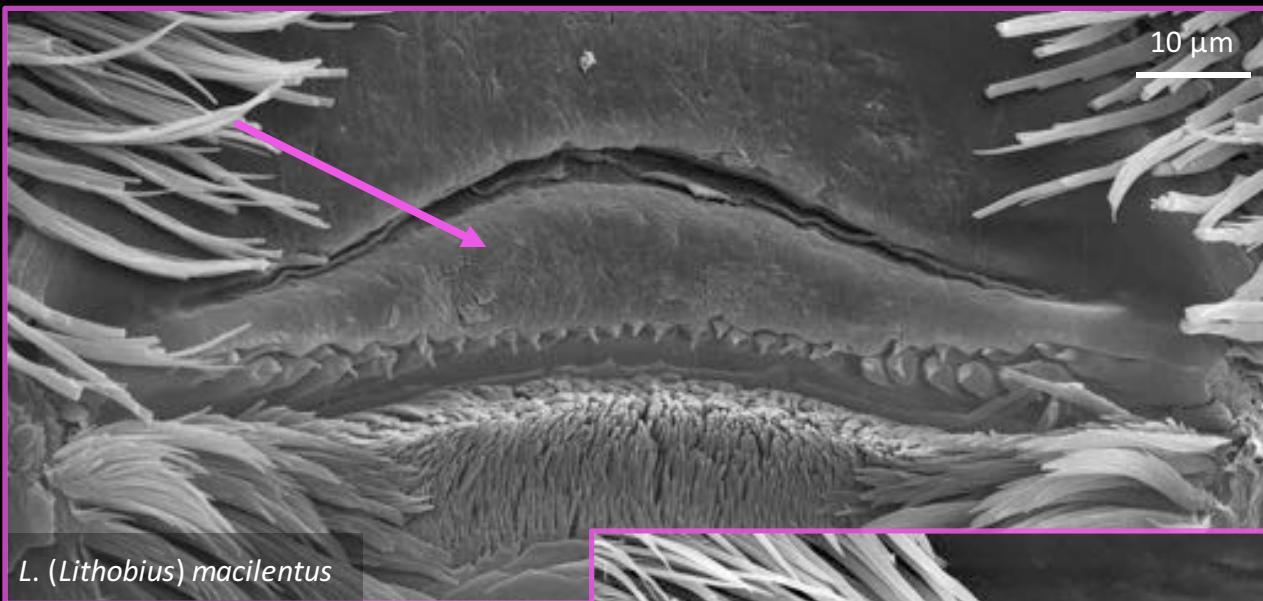
ventral



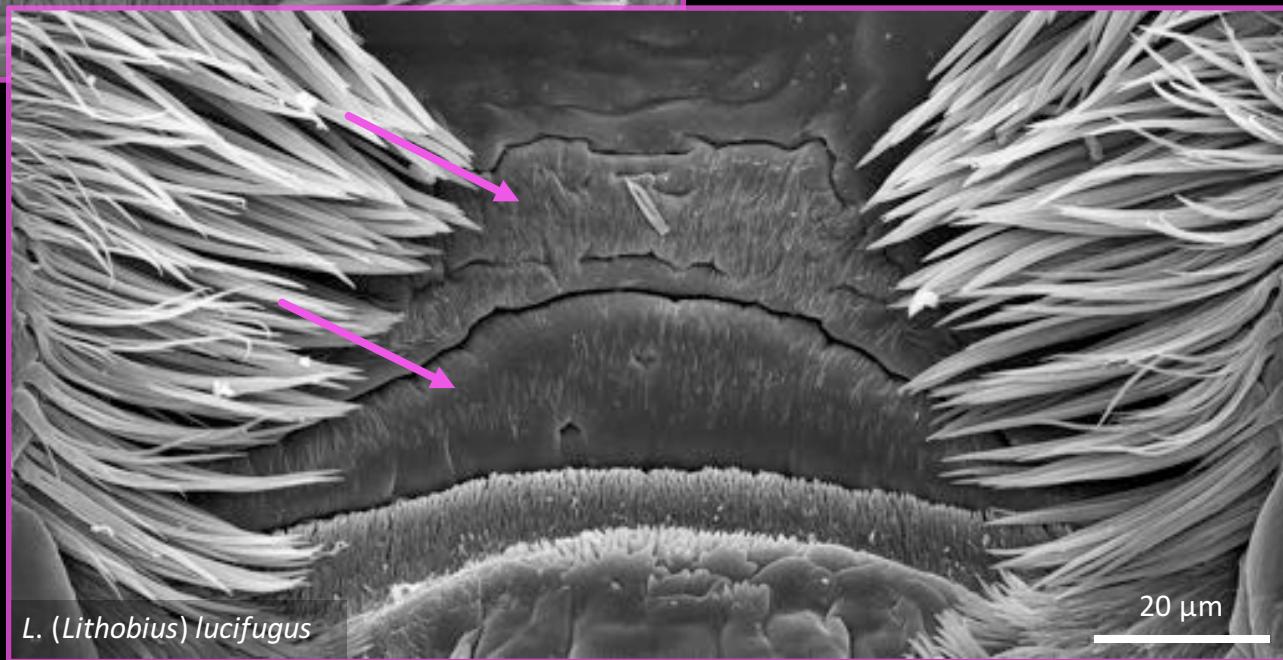
100 µm

SEM, *L. pyrenaicus*

# Transverse bulge



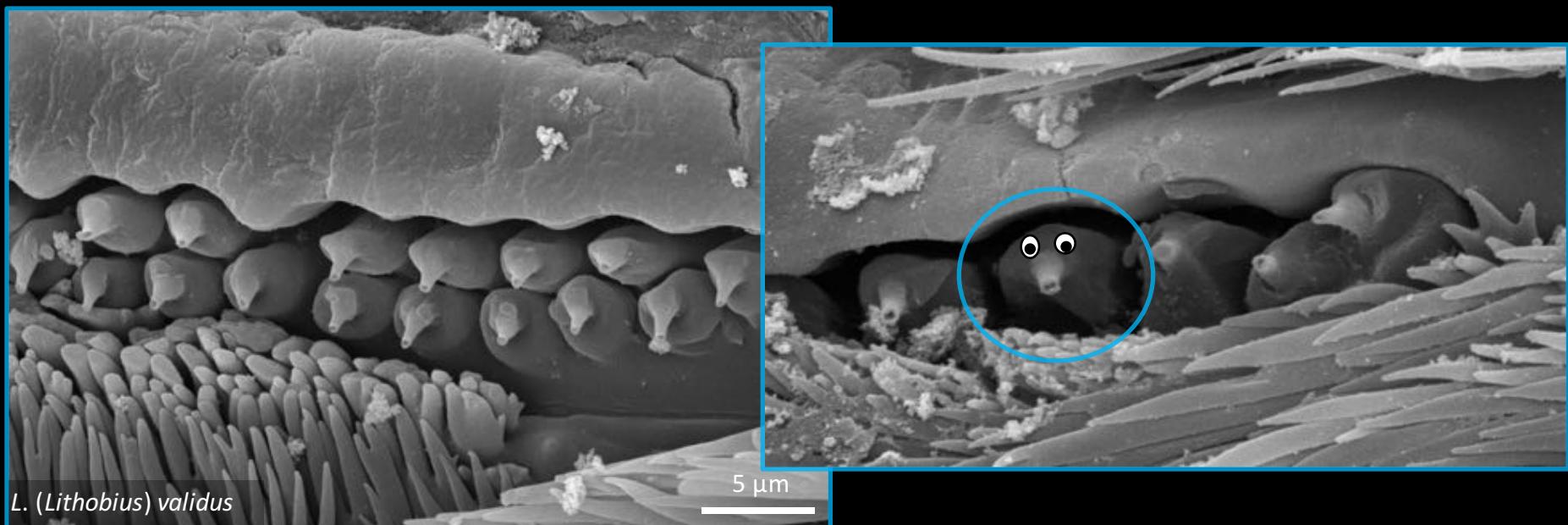
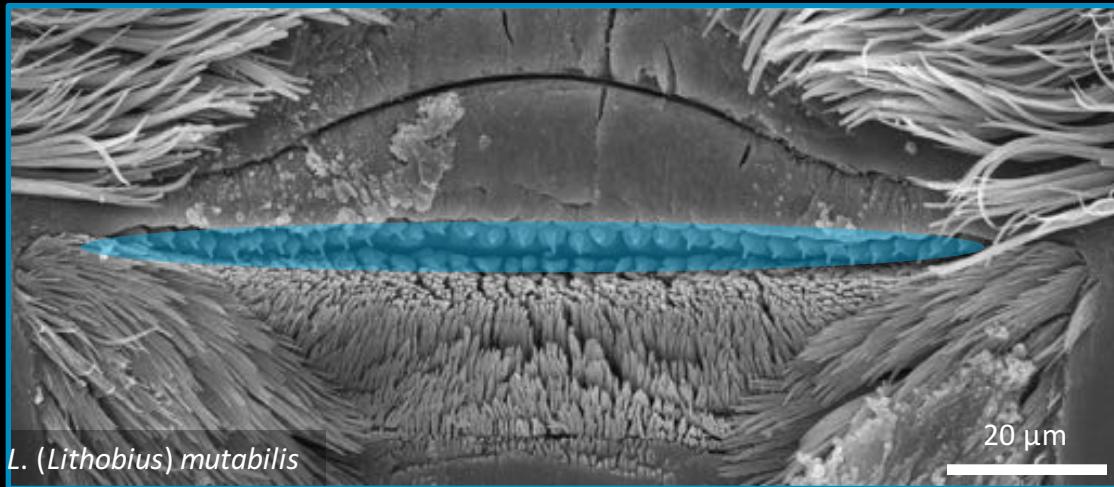
*L. (Lithobius) macilentus*



*L. (Lithobius) lucifugus*



## Bottle-shaped epidermal gland openings



# Peristomatic structures - overview



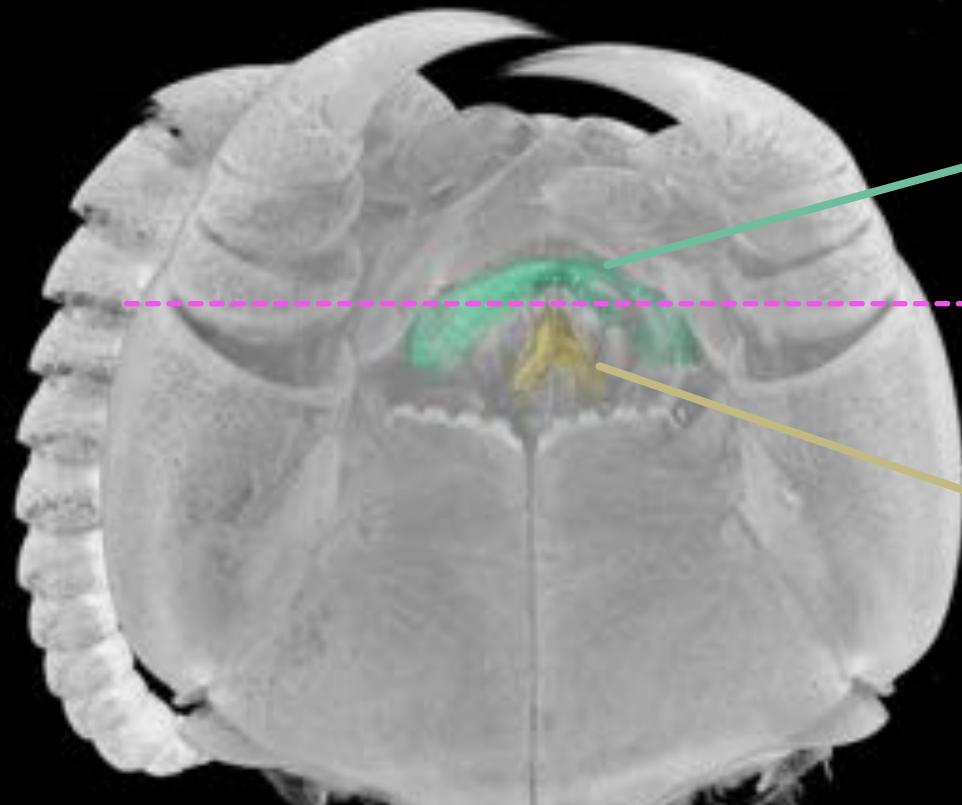
35 species of lithobiid genera:

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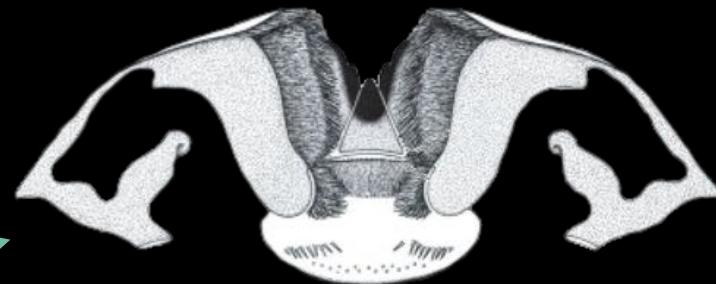
*Disphaerobius* Attems, 1926

*Eopolybothrus* Verhoeff, 1907



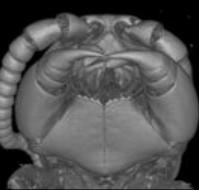
Head of *Lithobius forficatus* (ventral view)  
Volume rendering, voxel size 5.0  $\mu\text{m}$

epipharynx

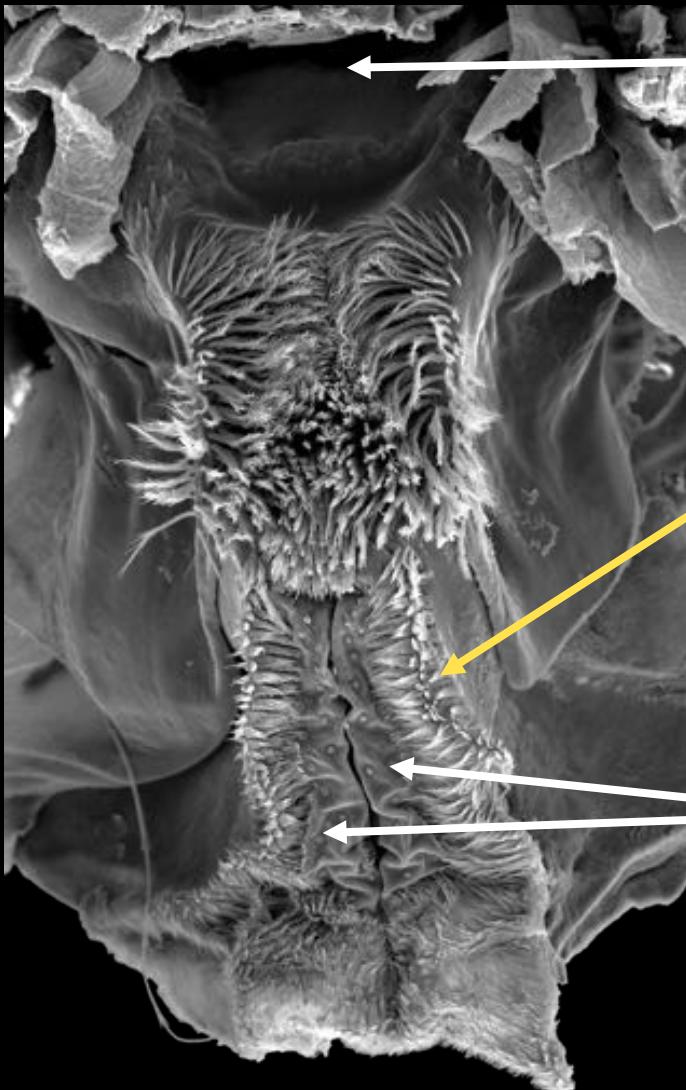


hypopharynx

# Hypopharynx - overview

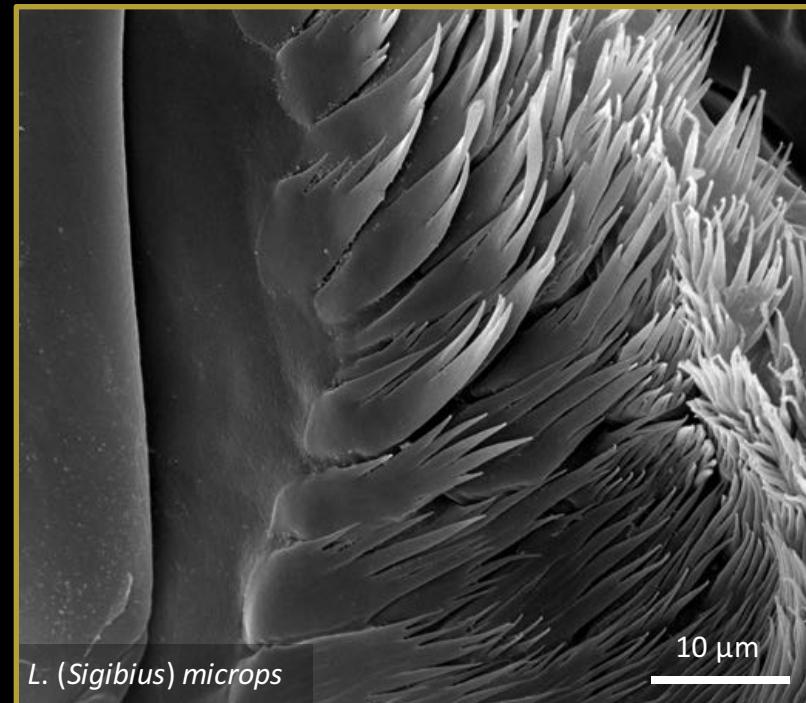
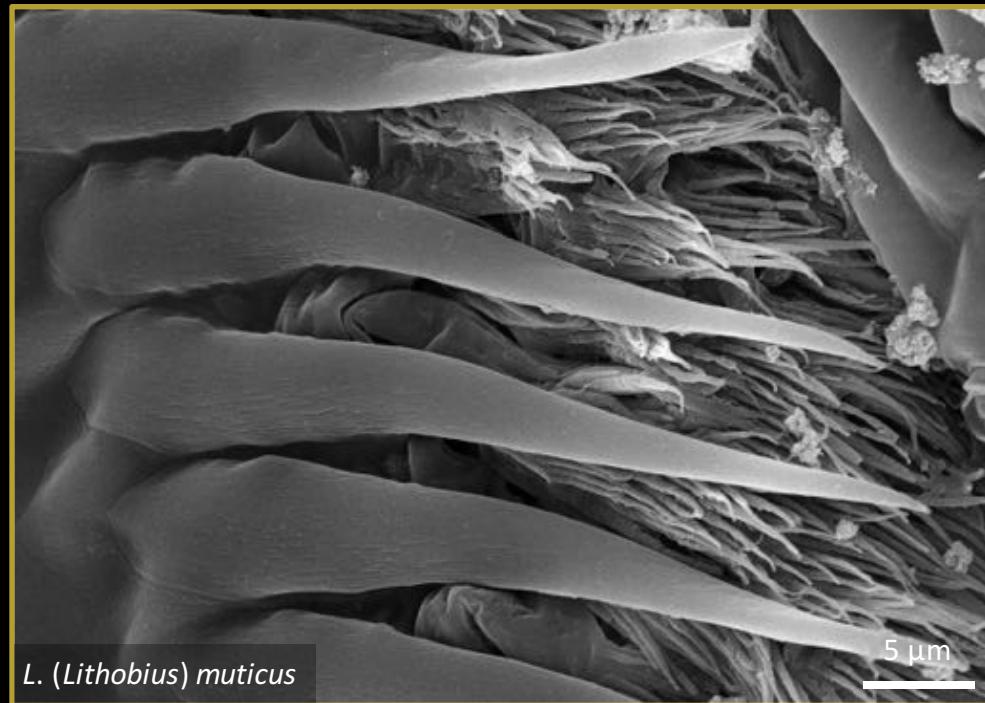
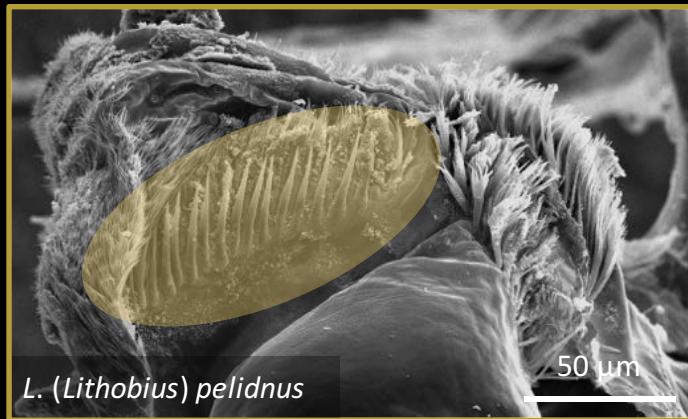
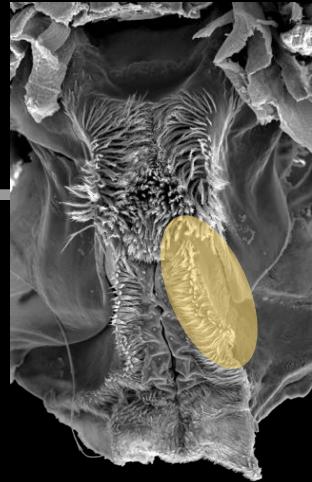


ventral



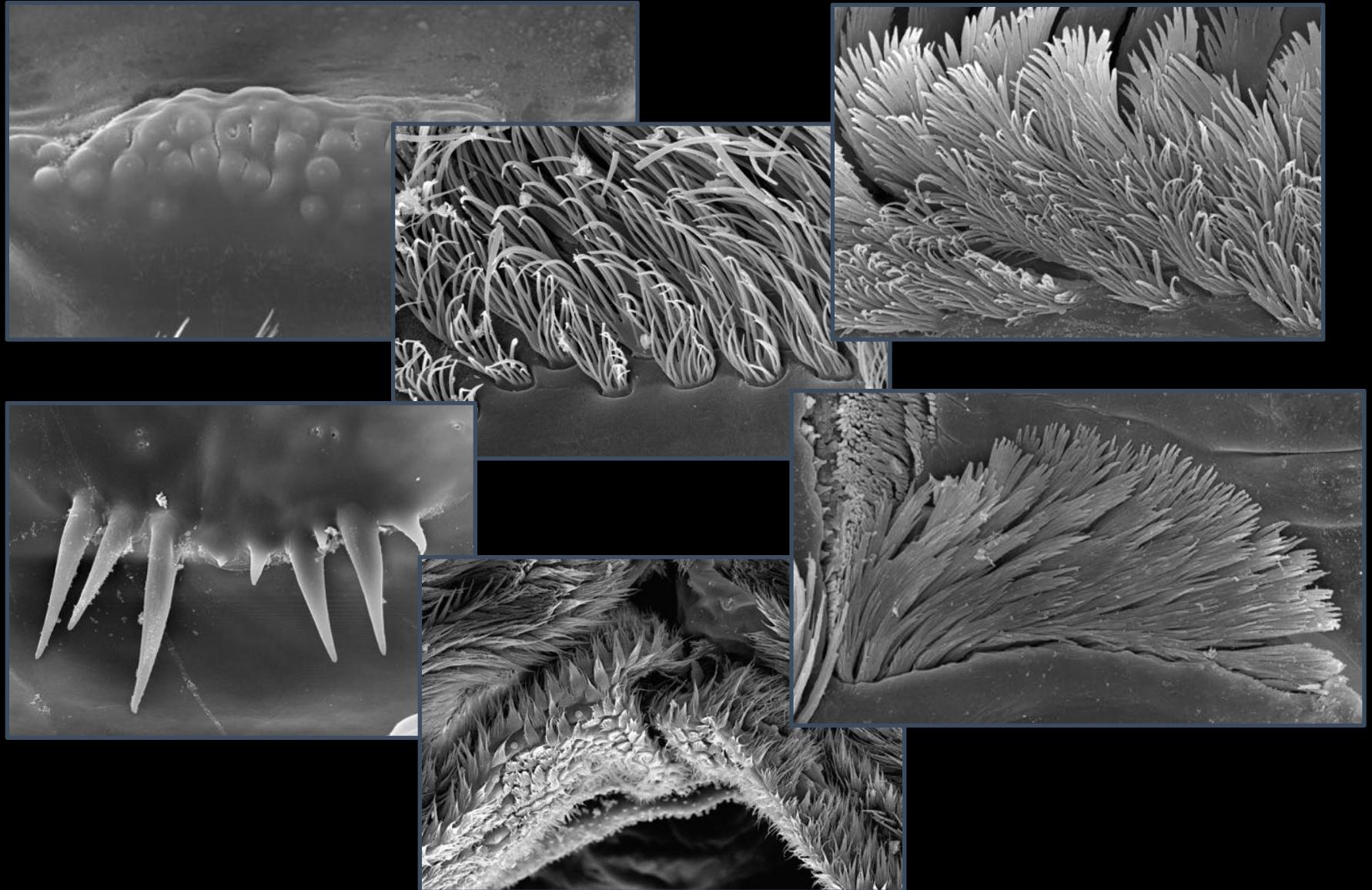
100  $\mu\text{m}$

# Spines of the median crest margin

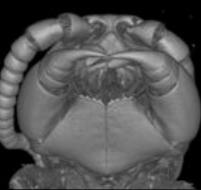




## Peristomatic structures - further characters...



# Peristomatic structures - conference contributions



8 peristomatic characters with systematic/phylogenetic potential

high variability of microstructures

## Talk at 17<sup>th</sup> International Congress of Myriapodology Krabi, Thailand

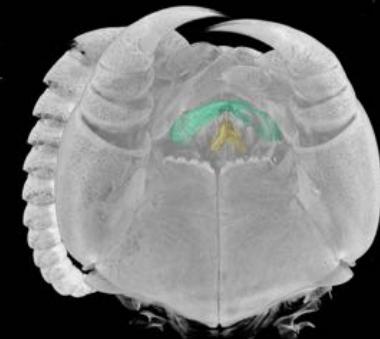
Ganske A-S, Edgecombe GD, Akkari N

Exploring the peristomatic structures as a source of potential phylogenetic characters for the highly diverse genus *Lithobius* (Lithobiomorpha: Lithobiidae)

## Talk at 4<sup>th</sup> International Congress on Invertebrate Morphology Moscow, Russia

Ganske A-S, Edgecombe GD, Akkari N

Using traditional and innovative imaging techniques to investigate internal cephalic structures in the highly diverse genus *Lithobius* (Chilopoda, Myriapoda) for phylogeny



Exploring the peristomatic structures as a source of potential phylogenetic characters for the highly diverse genus *Lithobius* (Lithobiomorpha: Lithobiidae)



Anne-Sarah Ganske<sup>1</sup>, Gregory D. Edgecombe<sup>2</sup> & Nesrine Akkari<sup>1</sup>

<sup>1</sup> Natural History Museum Vienna, 3<sup>rd</sup> Zoological Department, Austria

<sup>2</sup> The Natural History Museum London, Department of Earth Sciences, UK

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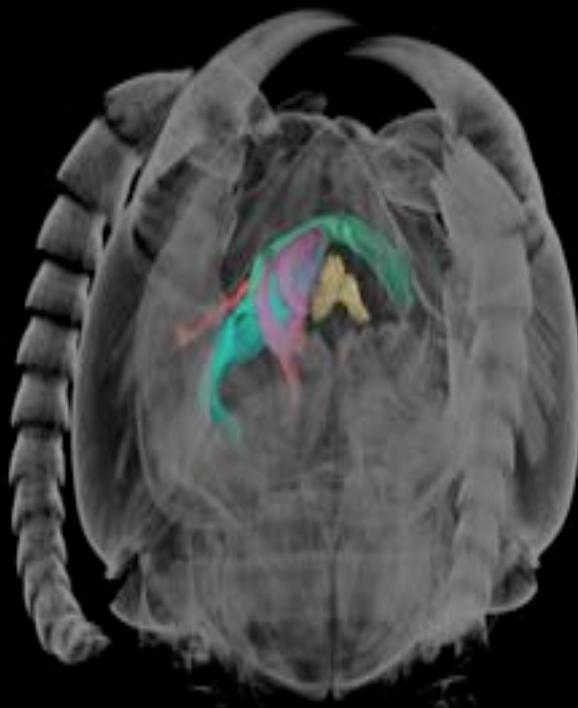


Ganske A-S, Edgecombe GD, Akkari N (submitted) The peristomatic structures as a source of systematic characters in the genus *Lithobius* Leach, 1814 (Myriapoda, Chilopoda) ZooKeys



# Internal cephalic structures

Head of *Lithobius forficatus* (ventral view)  
Volume rendering, voxel size 5.0  $\mu\text{m}$



anterior  
A coordinate system arrow pointing upwards, indicating the anterior direction of the head.

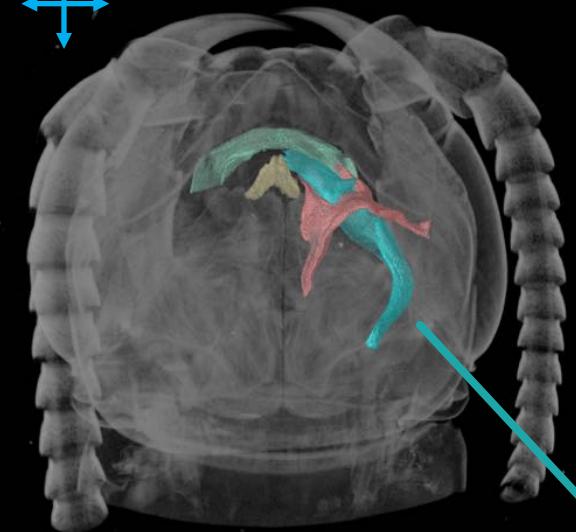
Tentorium  
Epipharynx  
First maxillae

Mandible  
Hypopharynx

# Mandible - overview

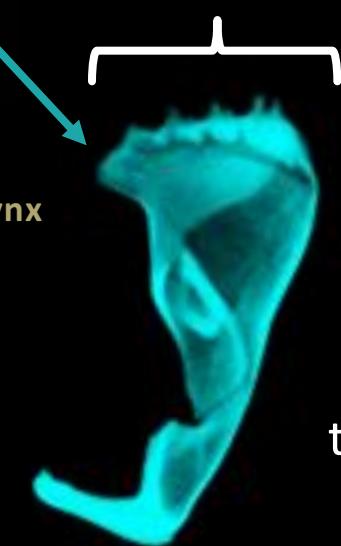


anterior  
A blue coordinate system arrow pointing upwards and to the left, labeled "anterior".

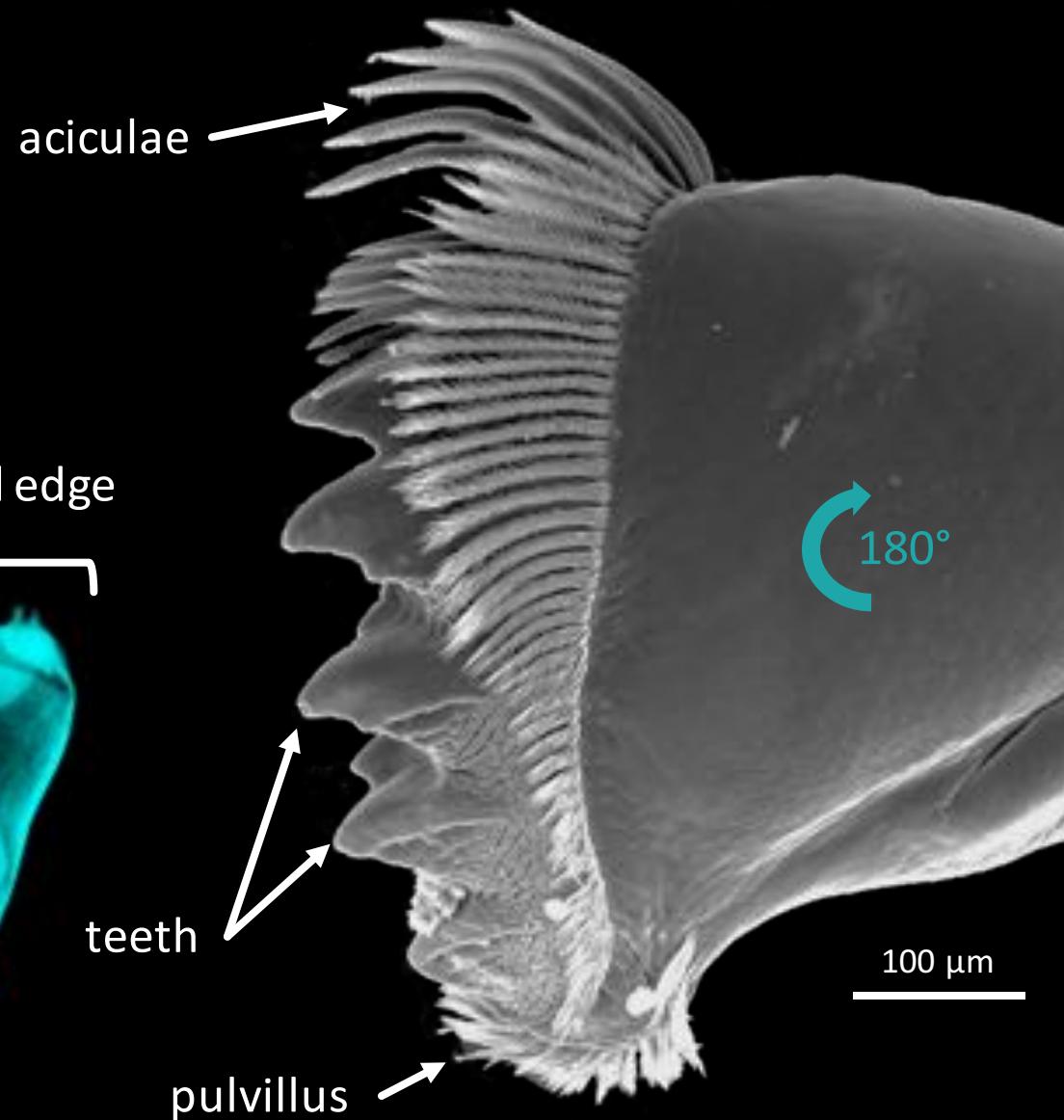


Tentorium  
Epipharynx

Mandible  
Hypopharynx



gnathal edge



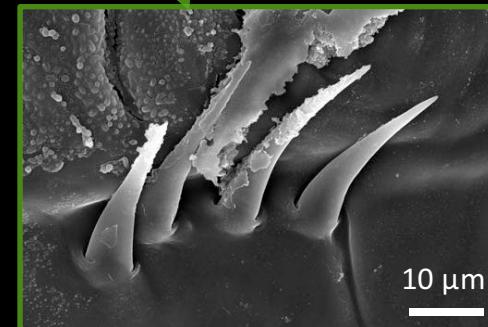
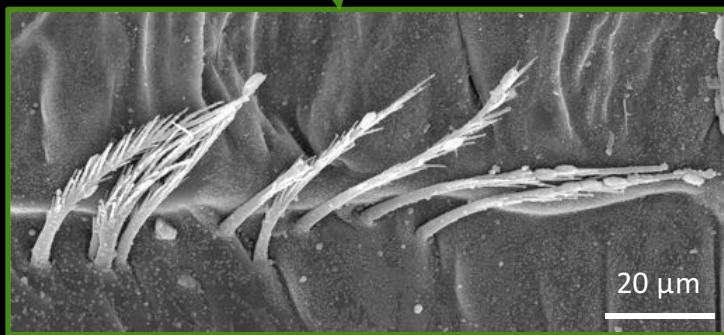
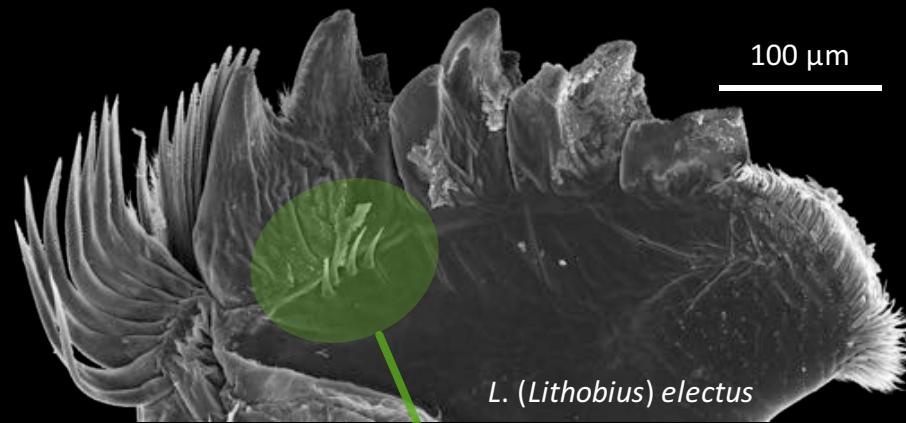
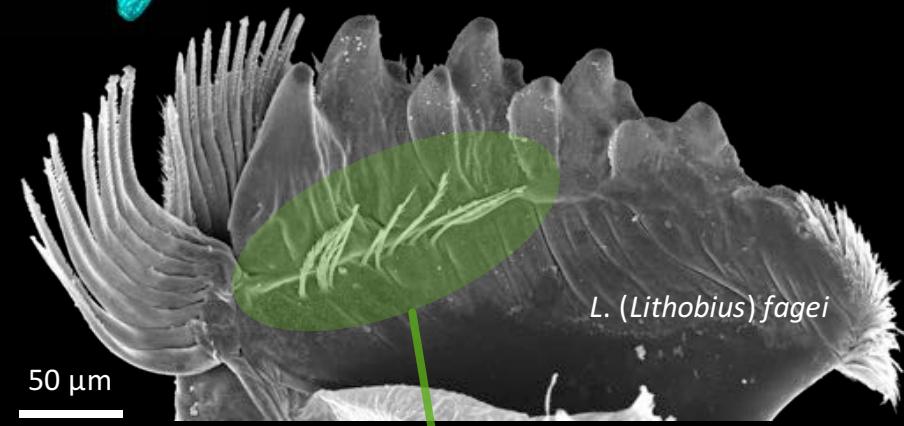
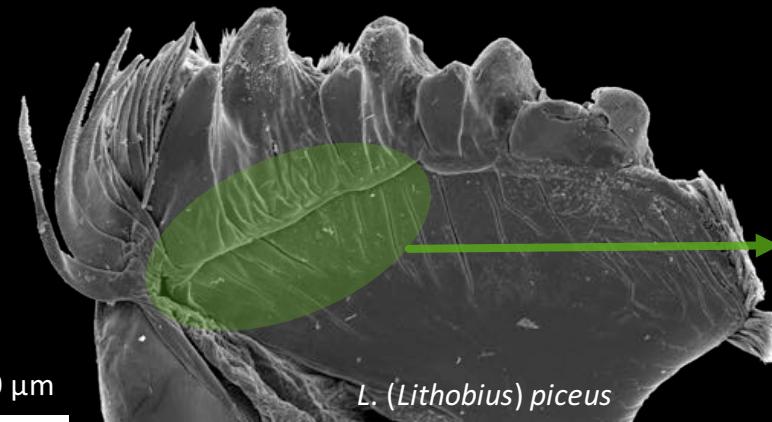
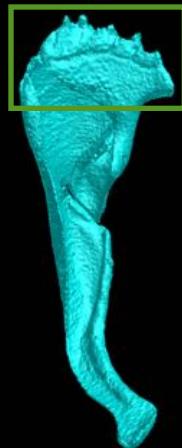
teeth

pulvillus

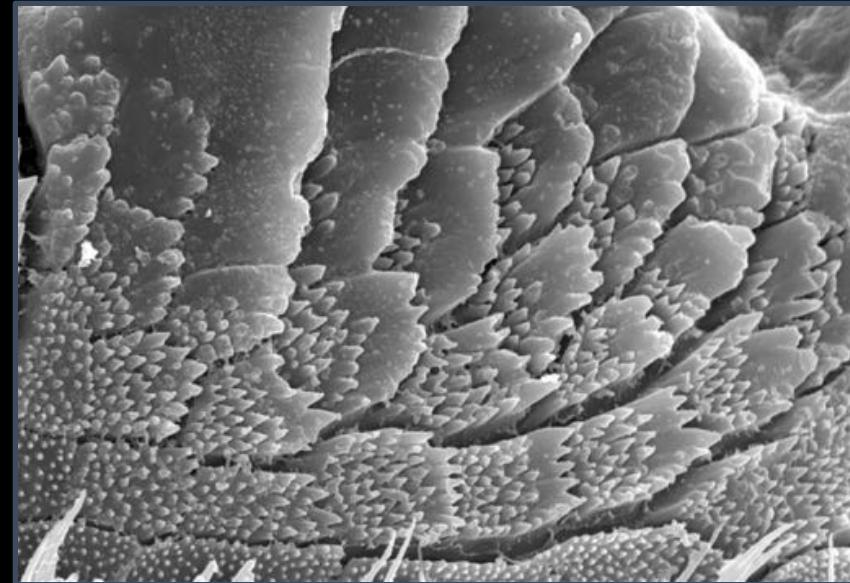
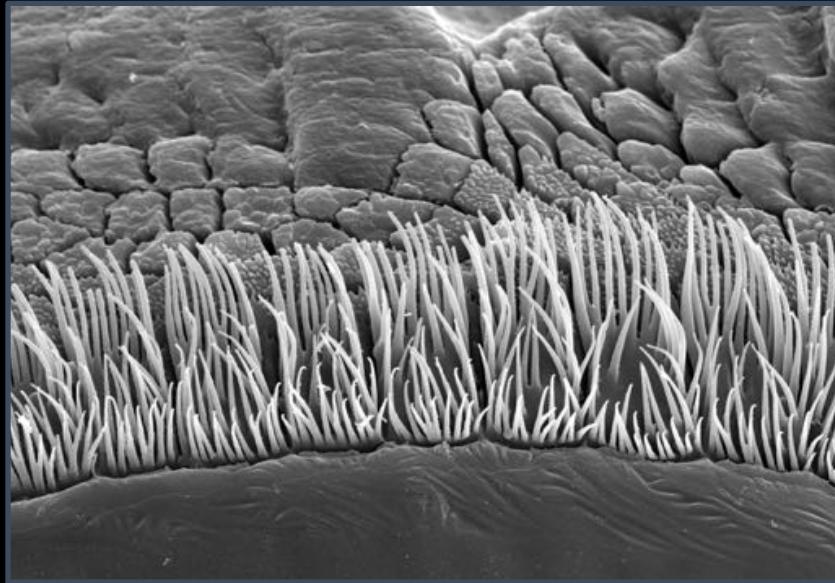
100  $\mu\text{m}$

SEM, *L. erythrocephalus*

## Spines on internal side



# Mandibular gnathal edge- further characters...



# Mandible - conference contribution



## Investigation of the mandibular structures and evaluation of their phylogenetic significance in the genus *Lithobius* (Lithobiomorpha: Lithobiidae)

Anne-Sarah Ganske<sup>1\*</sup>, Gregory D. Edgecombe<sup>2</sup> & Nourine Akkari<sup>1</sup>

<sup>1</sup>Natural History Museum Vienna, 3rd Zoological Department, Austria

<sup>2</sup>The Natural History Museum London, Department of Earth Sciences, UK

\*anne-sarah.ganske@nhm-wien.ac.at

### Introduction

The mandibles of Lithobiidae arthropods carry specialized microstructures, which might bear phylogenetic information. In this study, we used a multi-method approach to the genus *Lithobius* Latreille, 1814 focusing on their mandibular structures, using X-ray microtomography (XCT) and scanning electron microscopy (SEM), respectively to unveil new and useful characters that might serve the phylogenetic study of the group.

### Results

A 3D model of *Lithobius forficatus* (Linnaeus, 1758) is the first model obtained using high resolution pCT. Here, we present the microtomographic model of the head with a detailed description depicting its main structures, i.e. the mandibular teeth, the maxillula, the mouth and the gnathal edge, all in their natural position below the cephalic capsule.

The SEM illustrations of the mandibular gnathal edge provided in these revision *Lithobius*-species (Latreille, 1814; Montrouzier, 1862; Hermann, 1905; Sjöstedt, Chambonnière, 1913; Krammer, Chambonnière, 1919) show variability in the studied structures with regard to the following characters:

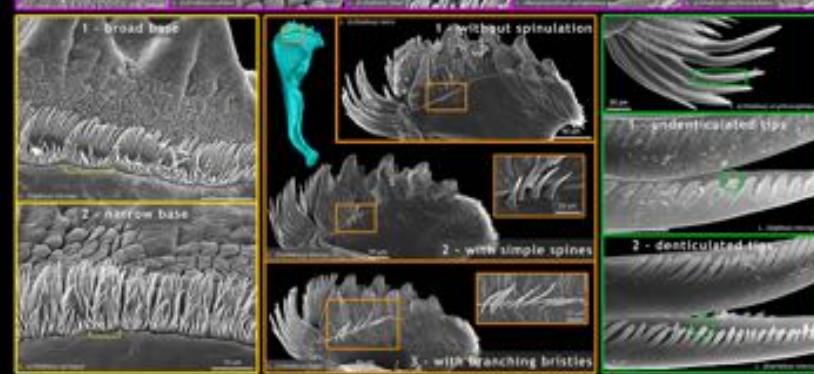
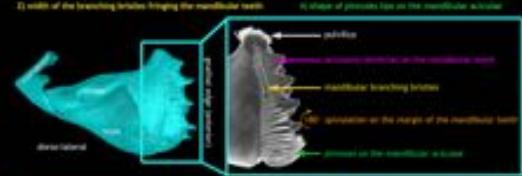
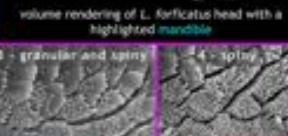
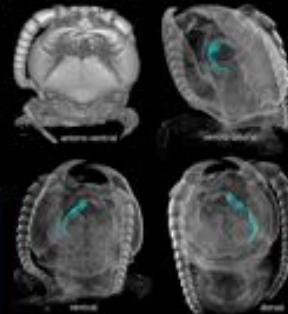
- Intermediate character states

1) surface texture of the anterior dentition with the mandibular teeth

2) width of the branching bristles facing the mandibular teeth



phm



### Conclusion

Two new informative characters are depicted in this preliminary study:

- margin of mandibular teeth without or with spinulation (posterior/internal view)
- granules with undentate or denticulated tips

Whether these mandibular microstructures bear a real phylogenetic signal or are related to different feeding preferences is still to be determined. More specimens per species need to be additionally examined to test the reliability of the characters presented herein.



## Poster at 17<sup>th</sup> International Congress of Myriapodology Krabi, Thailand

Ganske A-S, Edgecombe GD, Akkari N

Investigation of the mandibular structures and evaluation of their phylogenetic significance in the genus *Lithobius* (Lithobiomorpha: Lithobiidae)



## Publications

### Submitted

Ganske A-S, Edgecombe GE, Akkari N: The peristomeric structures as a source of systematic characters in the genus *Lithobius* Leach, 1814 (Myriapoda, Chilopoda), ZooKeys

### Close to submission

Akkari N, Ganske A-S, Komerički A, Metscher B: New avatars for Myriapods: 3D reconstructions of the holotype and the paratype as cybertypes for the species *Eupolybothrus liburnicus* Akkari, Komerički, Weigand, Edgecombe, Stoev 2017 (Chilopoda, Lithobiomorpha, Lithobiidae), PlosONE

### In progress

Exploring the mandibular structures and evaluation  
of their phylogenetic significance in the genus *Lithobius*  
(Lithobiomorpha: Lithobiidae)



Volume rendering with highlighted eggs

*Eupolybothrus liburnicus* Akkari, Komerički, Weigand, Edgecombe, Stoev 2017  
voxel size 21 µm

## Conferences

### Oral presentations

Ganske A-S, Edgecombe GD, Akkari N: Using traditional and innovative imaging techniques to investigate internal cephalic structures in the highly diverse genus *Lithobius* (Chilopoda, Myriapoda) for phylogeny (ICIM4, Moscow; August)

Ganske A-S, Edgecombe GD, Akkari N: Exploring the peristomatic structures as a source of potential phylogenetic characters for the highly diverse genus *Lithobius* (Lithobiomorpha: Lithobiidae) (17<sup>th</sup>ICM, Krabi; July)

### Poster presentation

Ganske A-S, Edgecombe GD, Akkari N: Investigation of the mandibular structures and evaluation of their phylogenetic significance in the genus *Lithobius* (Lithobiomorpha: Lithobiidae) (17<sup>th</sup>ICM, Krabi; July)



## Workshops & Courses

BIG4-Workshop: Morphology of Invertebrates – 3D Imaging and Novel Approaches for Biosystematics, NHM-Wien, Austria (May)

Molecular Phylogenetics Course, Cambridge University, UK (April)

EU ABS Regulation Training Workshop, Budapest, Hungary (February)



## Museums visits

The Natural History Museum, London, UK (April)

Hungarian Natural History Museum, Budapest (February)

## Field trips

Collecting trip, La Palma, Spain (October)

Collecting trip (Myriapoda), Carinthia, Austria (June)

## Conferences & Events

### Oral presentation

Ganske A-S, Akkari N: On the significance of morphological characters of head structures for the systematics of the centipede genus *Lithobius* (Myriapoda) (NOBIS Young Researchers' Day, Vienna, Austria) (November 2017)

### Poster presentation

Ganske A-S: Klein, kleiner, mikro – filigrane Strukturen in den Köpfen der Steinläufer (Carl von Schreibers Forschungspreis, Vienna, Austria) (December 2017)

### Secondment

Research stay at the University of Turku, Molecular analysis of genus *Lithobius* (spring 2018)

### Others

Departmental Seminar Integrative Zoology, University of Vienna, Austria

Soon enrolled as PhD-student at University of Vienna, Integrative Zoology, Prof. Dr. Andreas Wanninger



Thank you for your attention!

