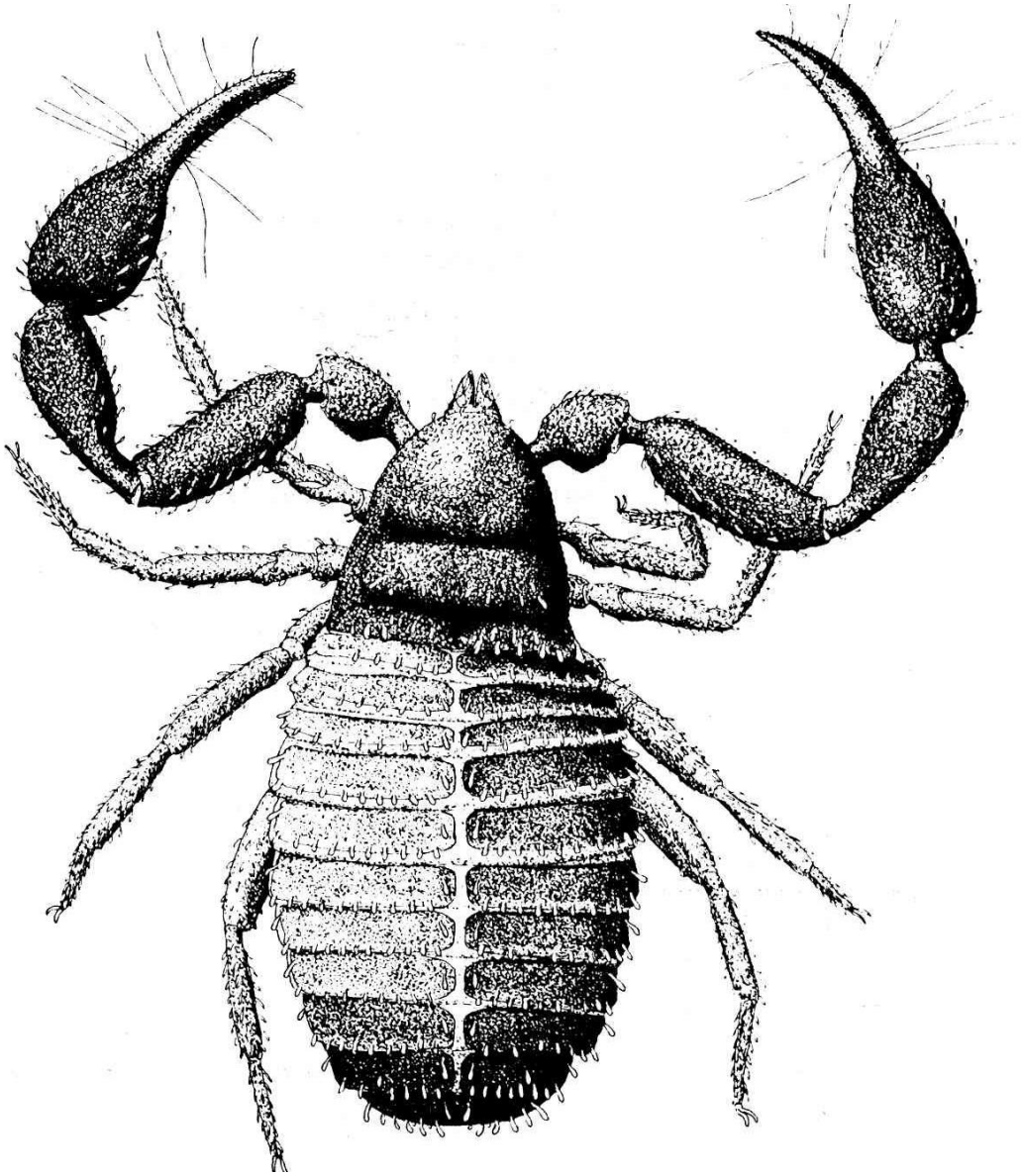


CHELONETHIDA

Pseudoscorpioni

擬蠍目

Afterskorpione

ЛОЖНОСКОРПИОНЫ

Yalancıakrep

Šťúriky

Pseudoscorpions

Zaleszczotki

דמויי-עקרב

False Scorpions

Ebaskorpionilised

كذرب

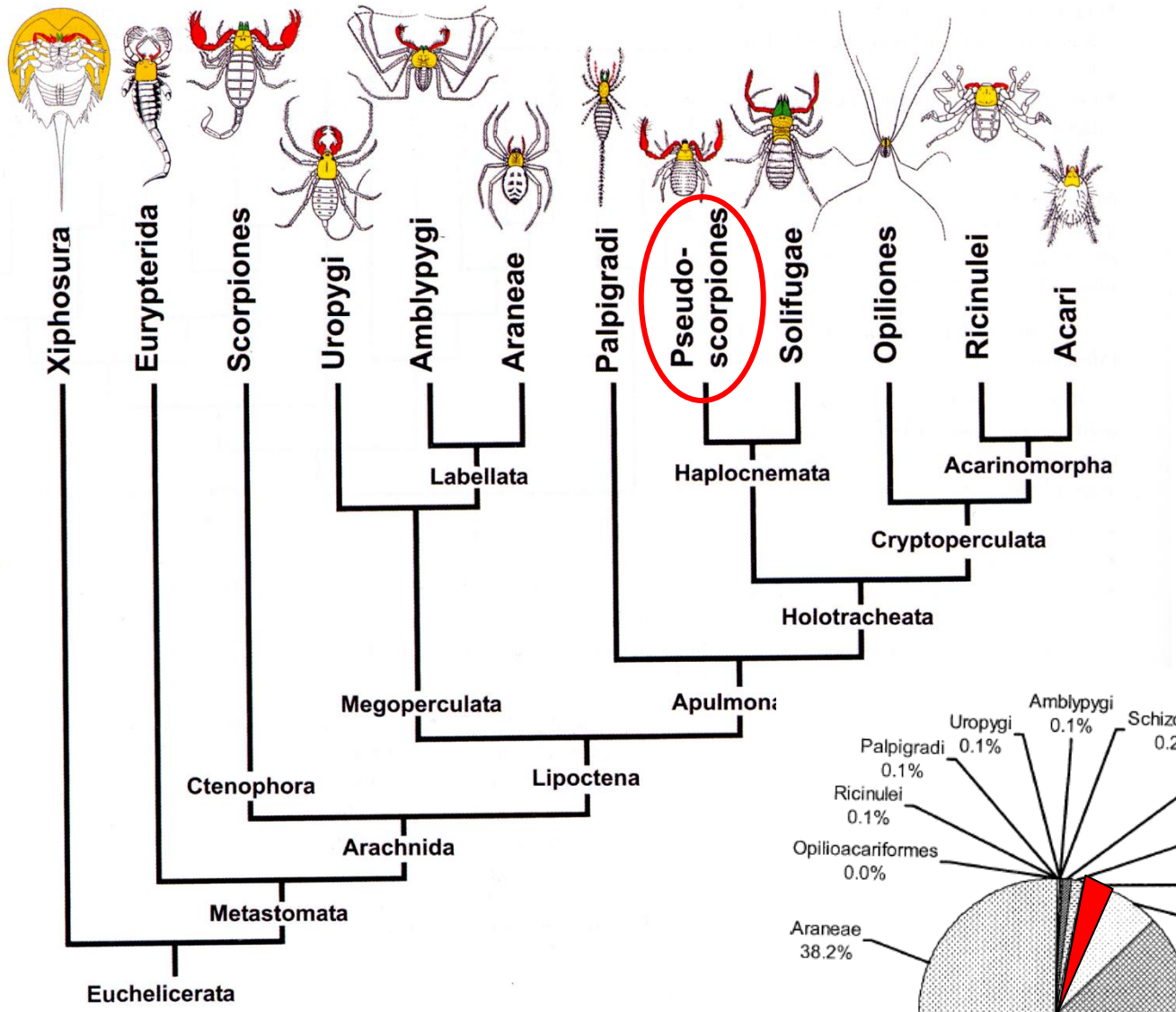
Pseudoescorpiones

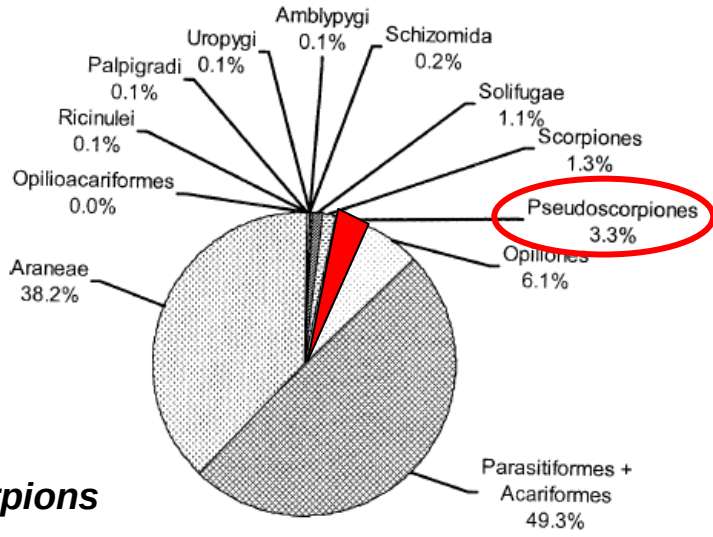
Pseudoschorpioenen

MOSSKORPIONER

Bogskorpioner

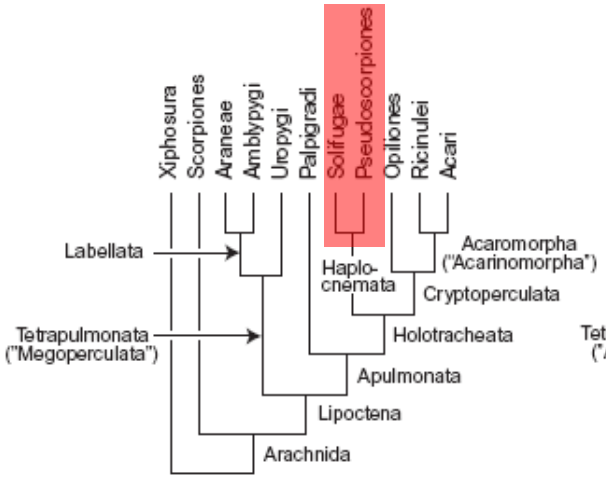
Álskorpiók



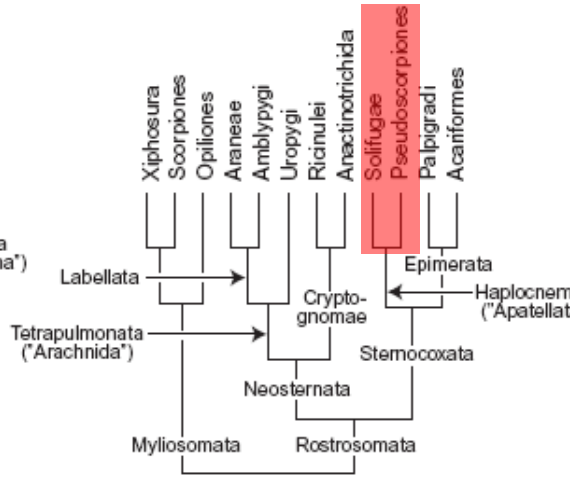


app. <u>3380 species</u> from 25 families

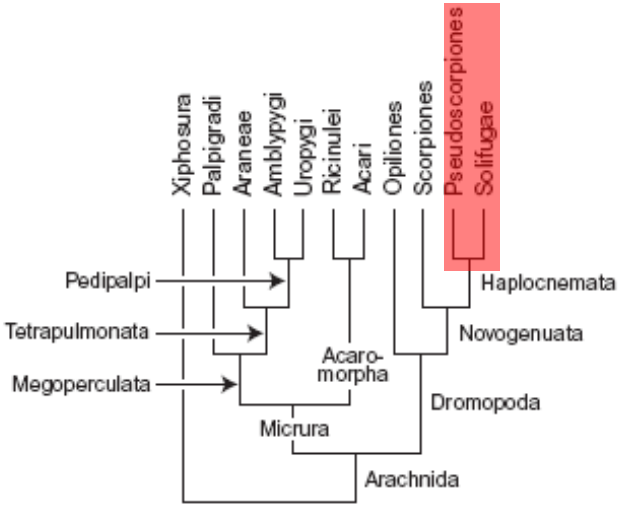
http://www. http://museum.wa.gov.au/catalogues-beta/pseudoscorpions



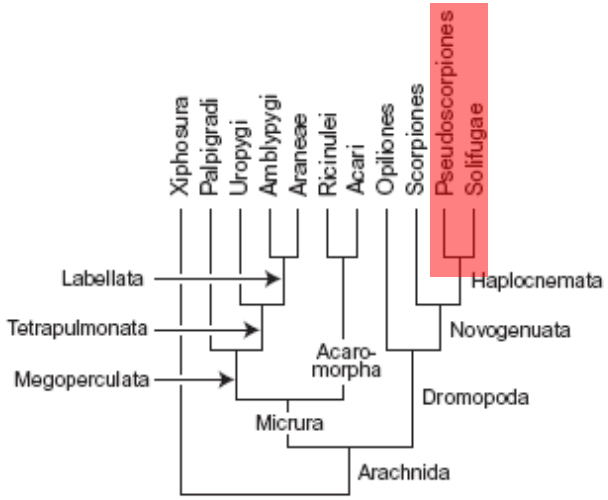
Weygoldt & Paulus (1979)



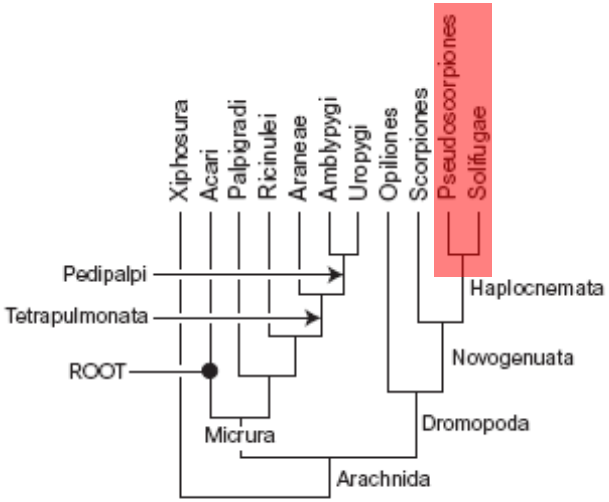
Van der Hammen (1989)



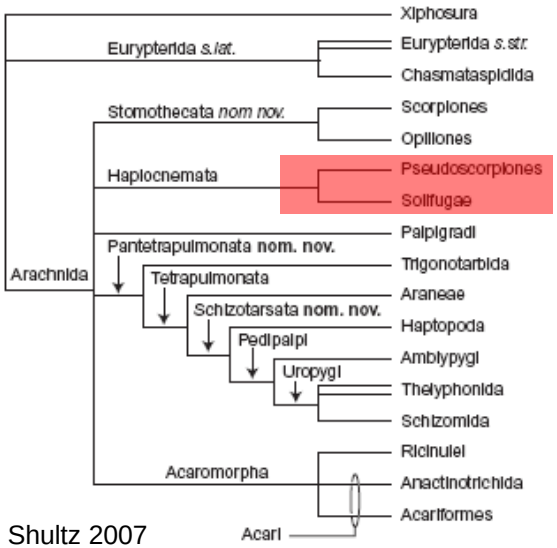
Shultz (1990)



Wheeler & Hayashi (1998)



Giribet *et al.* (2002)

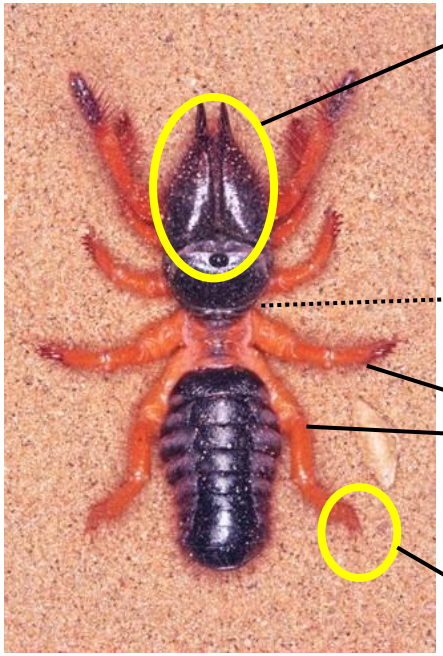


Shultz 2007

Haplocnemata Börner, 1904

Chelicerae – two-segmented pincers
similar articulation in both groups

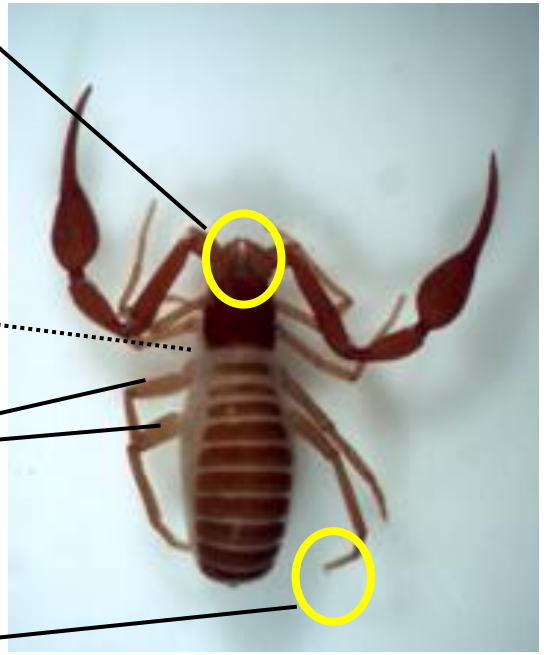
rostrosoma

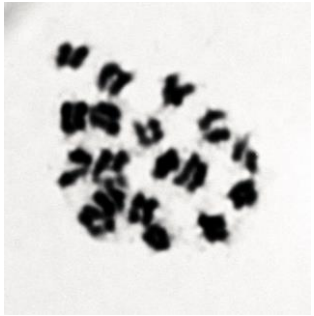


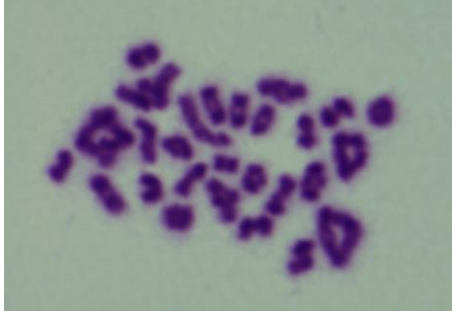
no sternum
coxae in contact

legs III and IV
femur shorter than patella
(patello-tibial articulation)

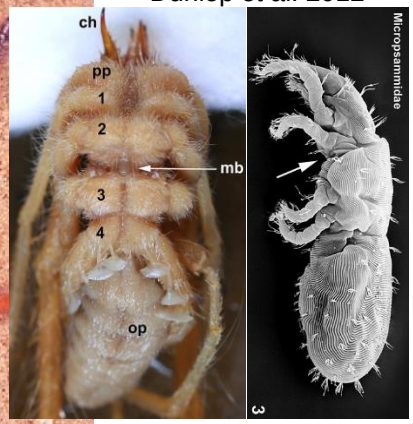
empodium (= pulvillus, arolium)

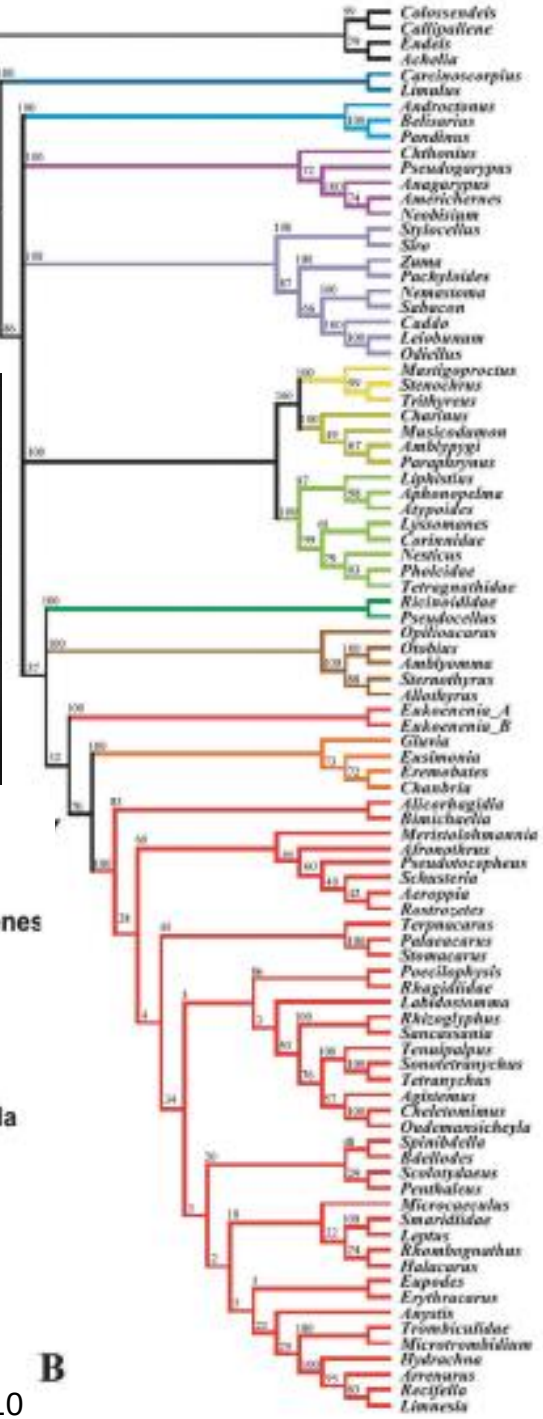


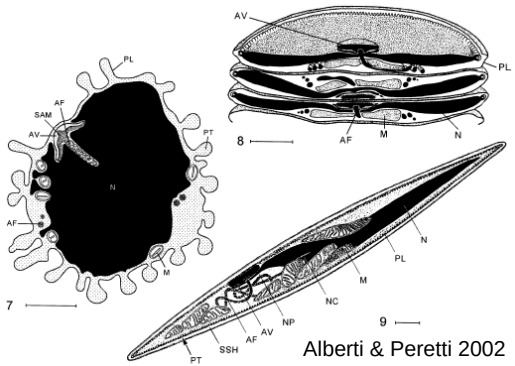




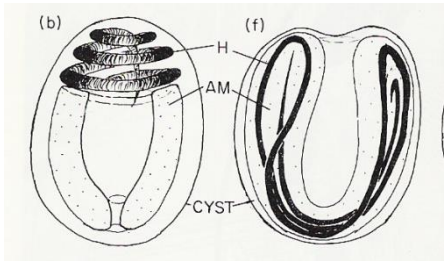
Dunlop et al. 2012





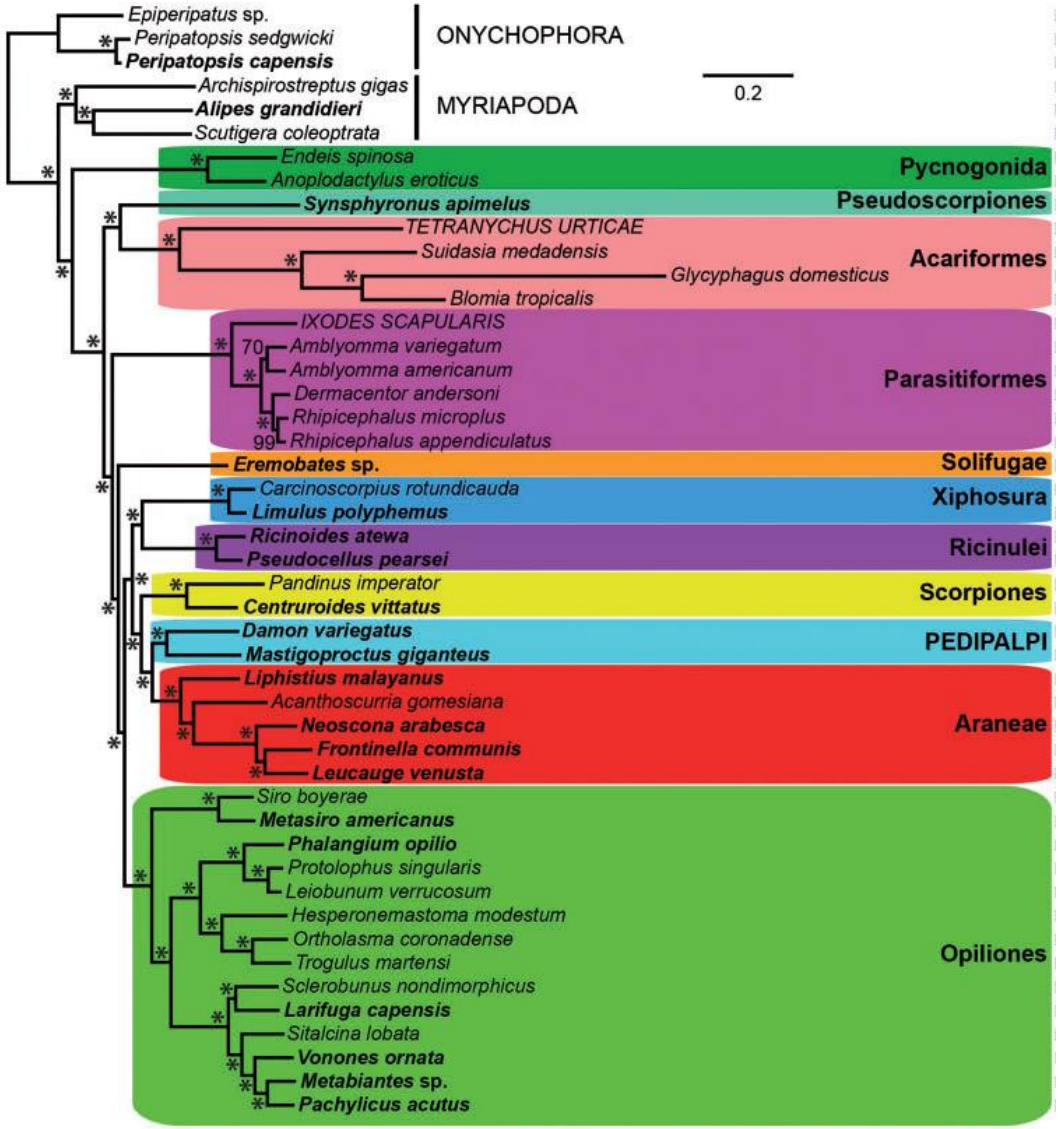


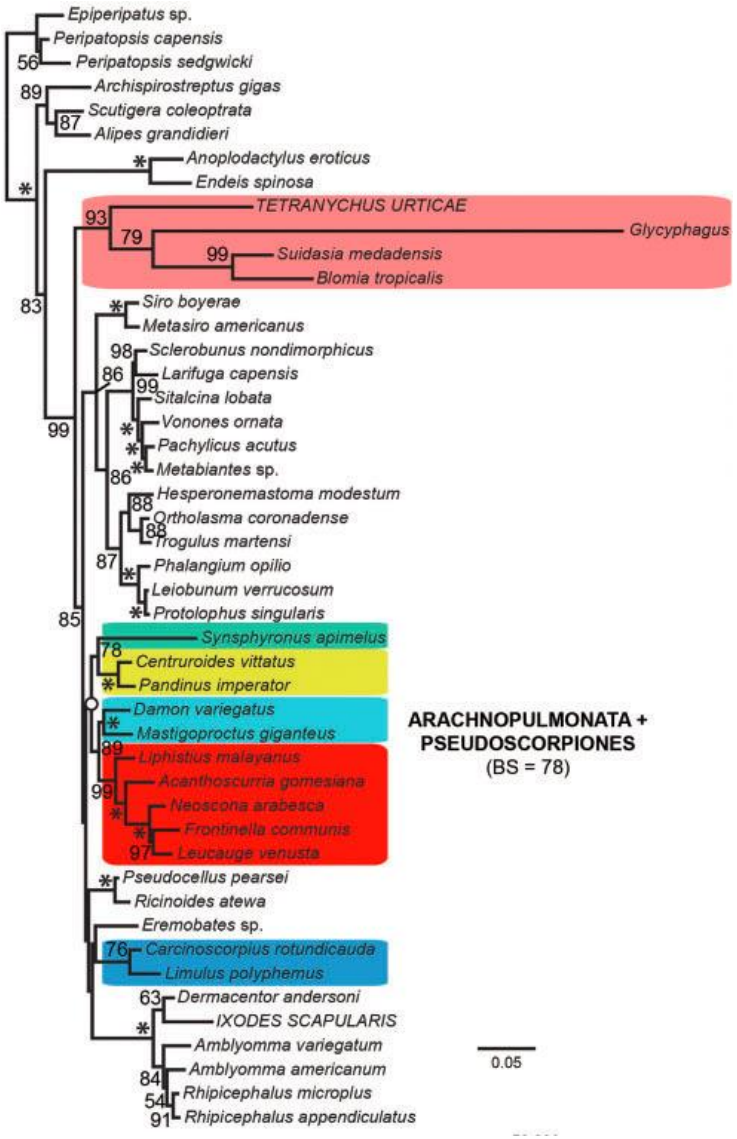
Alberti & Peretti 2002



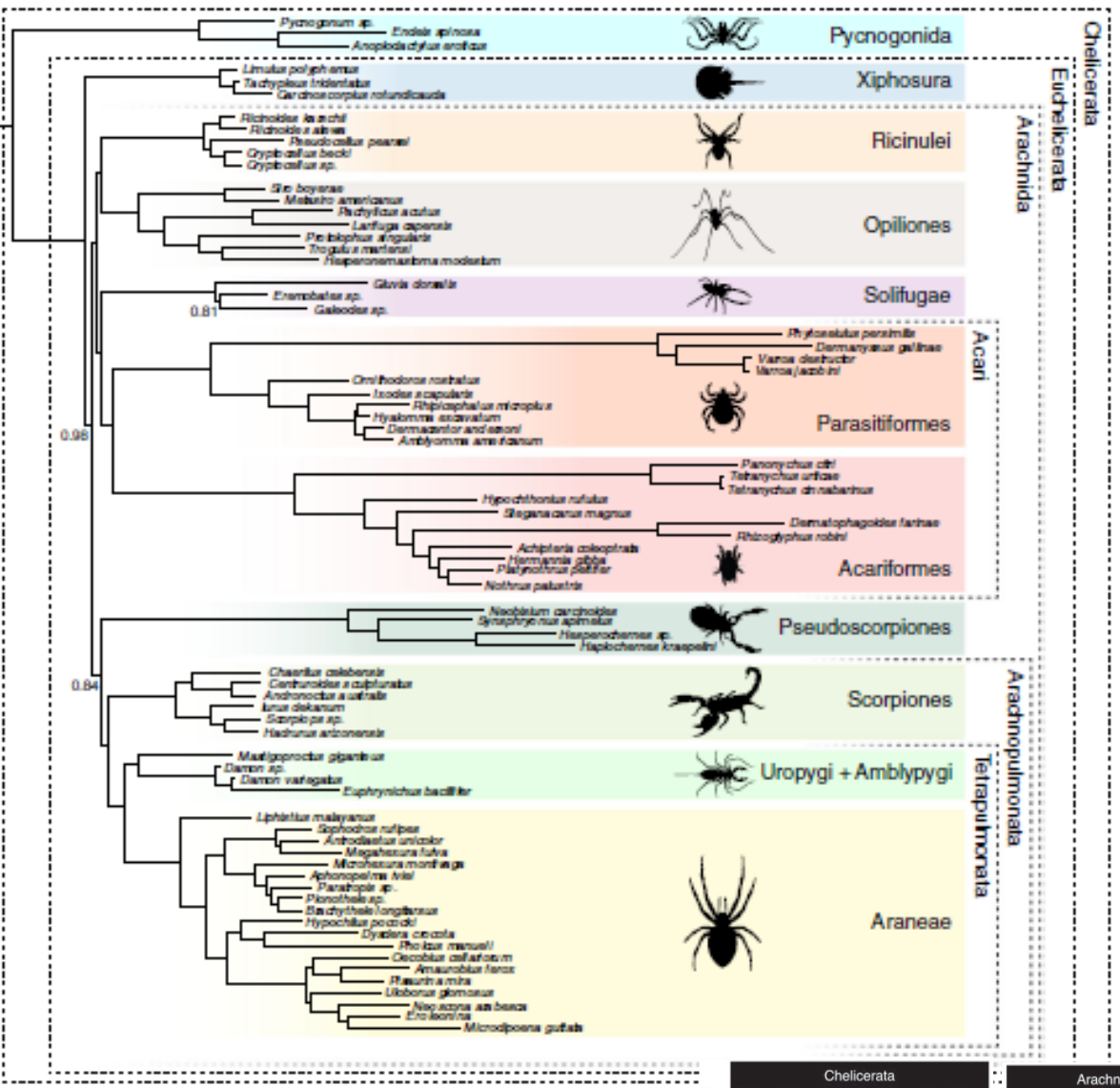
Legg 1973

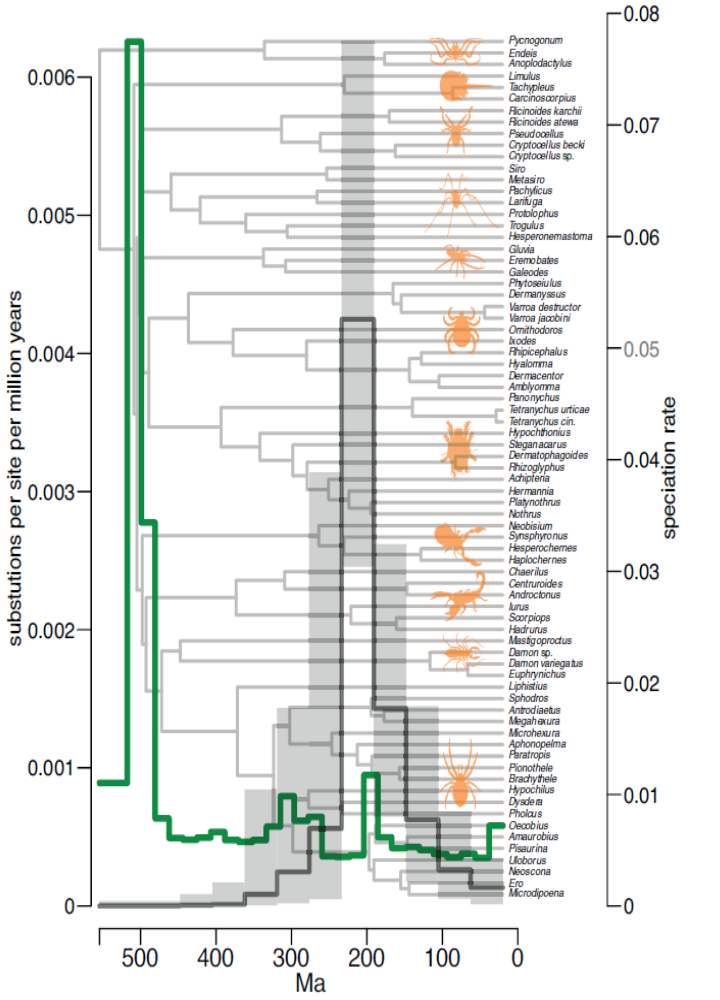
Papato et al. 2010



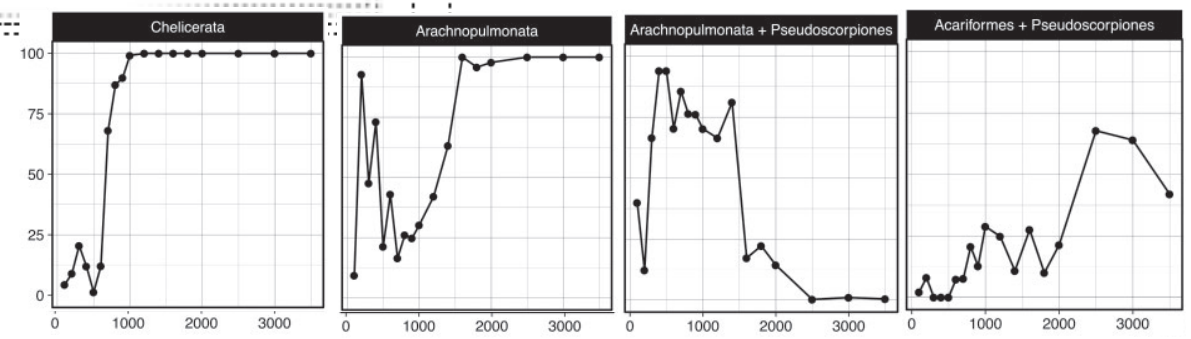


Sharma et al. 2014 Mol. Biol. Evol.

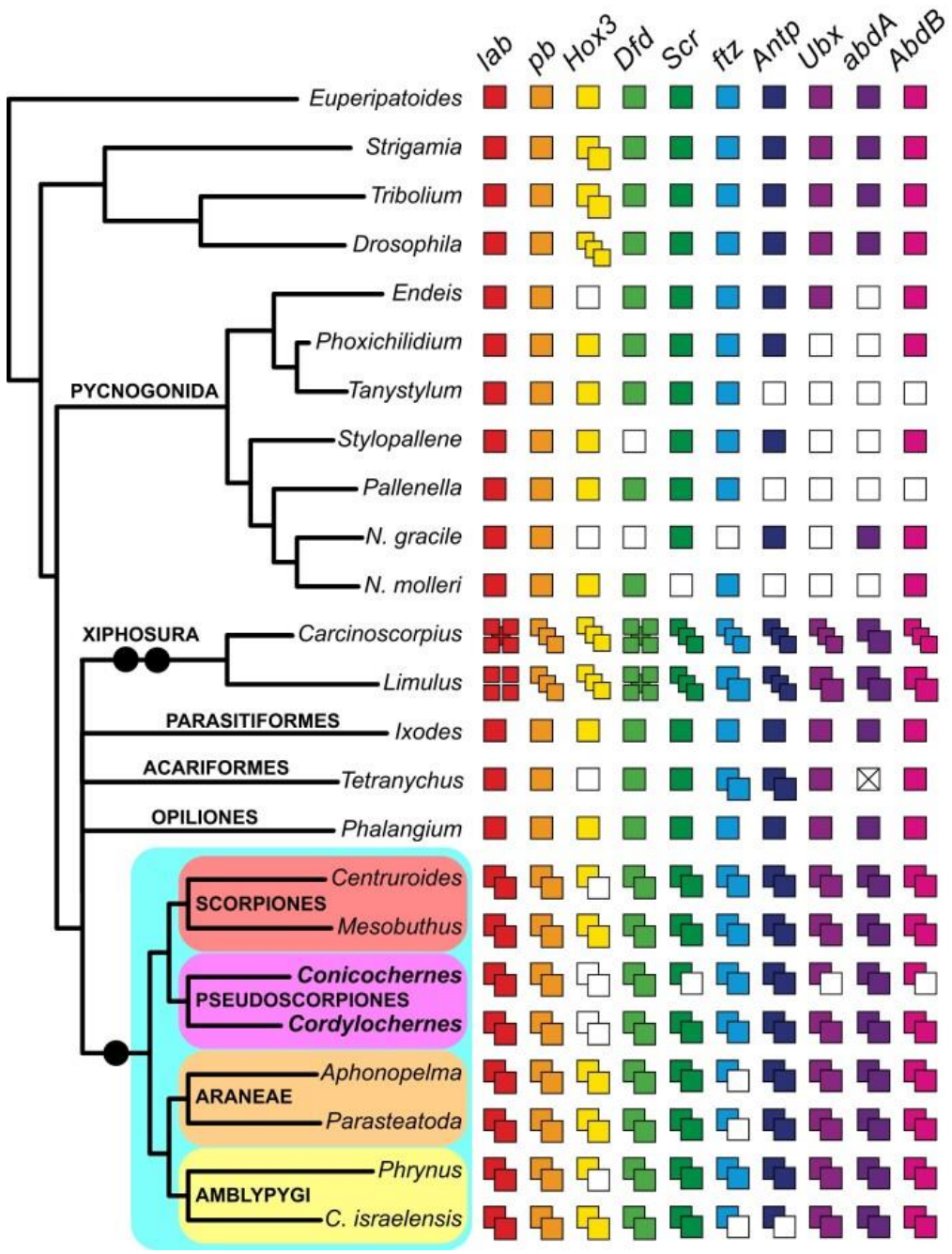


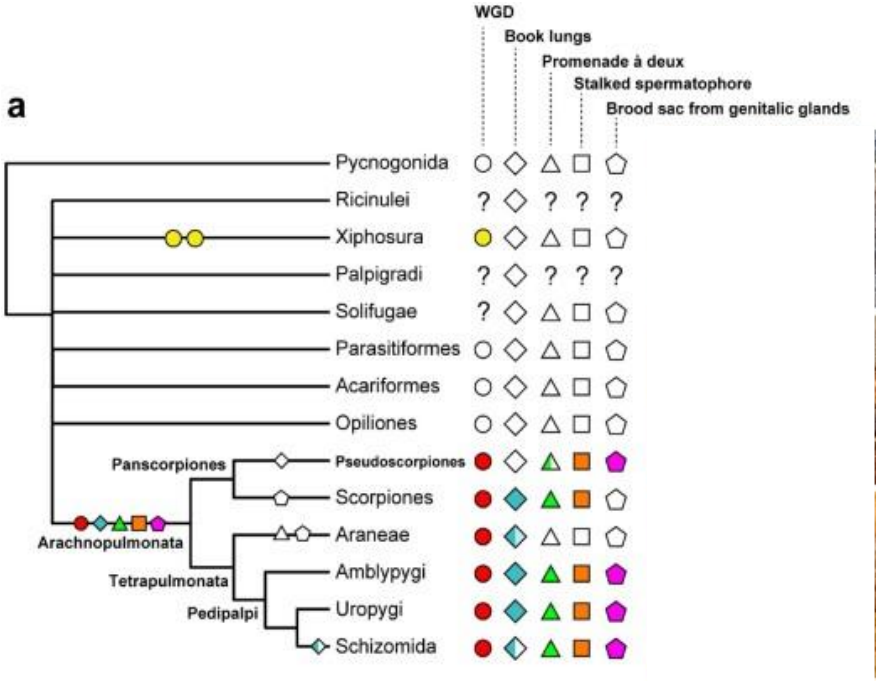


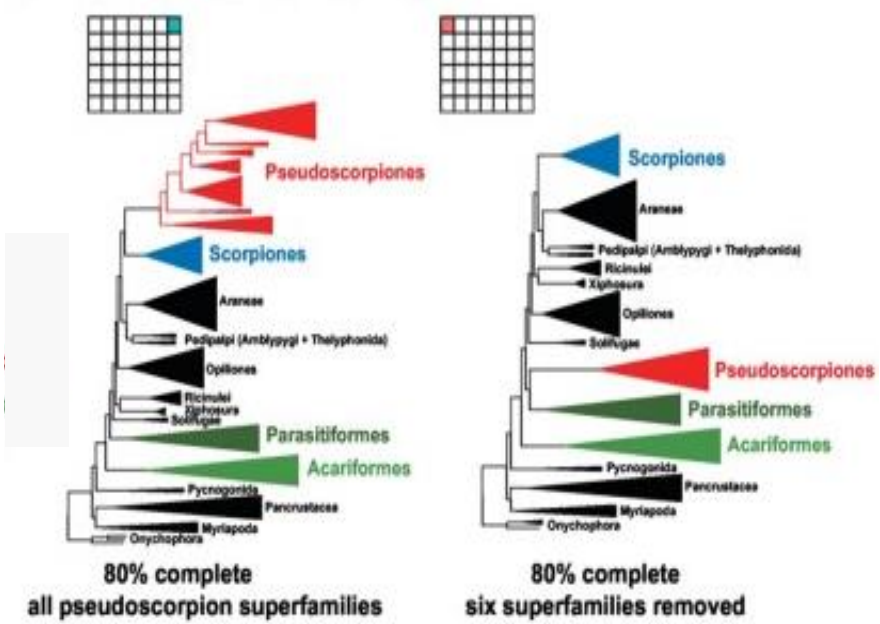
Lozano-Fernandez et al. 2019



Balesteros & Sharma 2019


lab
pb
Hox3
Dfd
Scr
ftz
Antp
Ubx
abdA
AbdB
Euperipatoides
Strigamia
Tribolium
Drosophila
Endeis
Phoxichilidium
Tanystylum
Stylopallene
Pallenella
N. gracile
N. molleri
Carcinoscorpius
Limulus
Ixodes
Tetranychus
Phalangium
Centruroides
Mesobuthus
Conicochernes
Cordylochernes
Aphonopelma
Parasteatoda
Phrynus
C. israelensis
PYCNOGONIDA
XIPHOSURA
PARASITIFORMES
ACARIFORMES
OPILIONES
SCORPIONES
PSEUDOSCORPIONES
ARANEAE
AMBLYPYGI

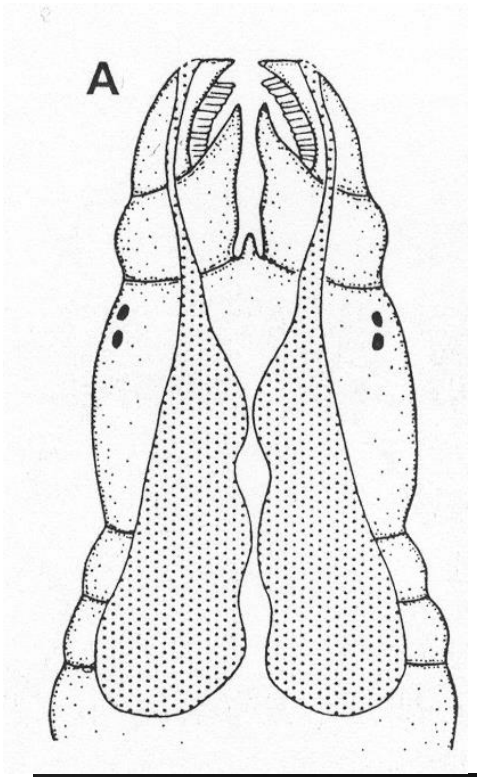

a
WGD
Book lungs
Promenade à deux
Stalked spermatophore
Brood sac from genitalic glands
Pycnogonida
Ricinulei
Xiphosura
Palpigradi
Solifugae
Parasitiformes
Acariformes
Opiliones
Panscorpiones
Pseudoscorpiones
Scorpiones
Arachnopulmonata
Araneae
Tetrapulmonata
Amblypygi
Pedipalpi
Uropygi
Schizomida

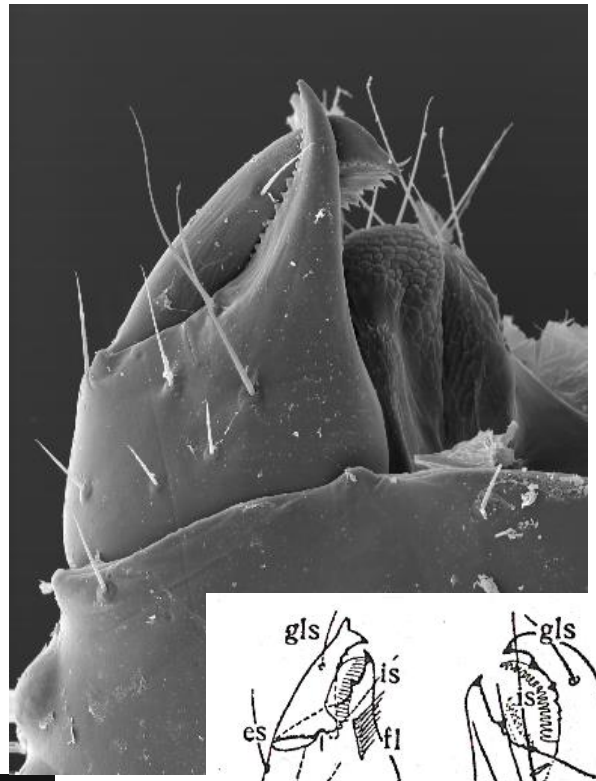

Pseudoscorpiones
Scorpiones
Araneae
Pedipalpi (Amblypygi + Thelyphonida)
Opiliones
Ricinulei
Xiphosura
Solifugae
Parasitiformes
Acariformes
Pycnogonida
Pancrustacea
Myriapoda
Onychophora
80% complete
all pseudoscorpion superfamilies
Scorpiones
Araneae
Pedipalpi (Amblypygi + Thelyphonida)
Ricinulei
Xiphosura
Opiliones
Solifugae
Pseudoscorpiones
Parasitiformes
Acariformes
Pycnogonida
Pancrustacea
Myriapoda
Onychophora
80% complete
six superfamilies removed

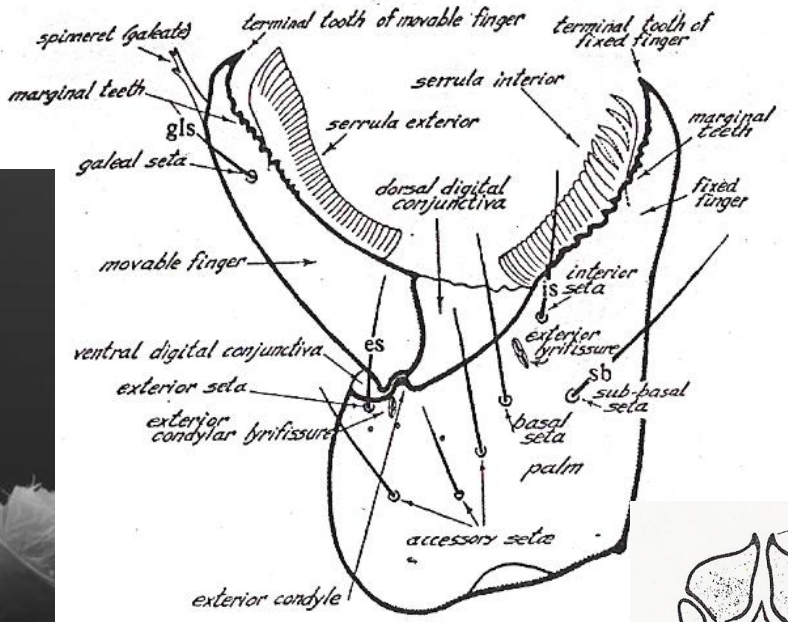
Charakteristics

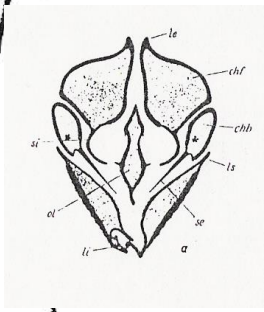
chelicerae – two-segmented, chelate

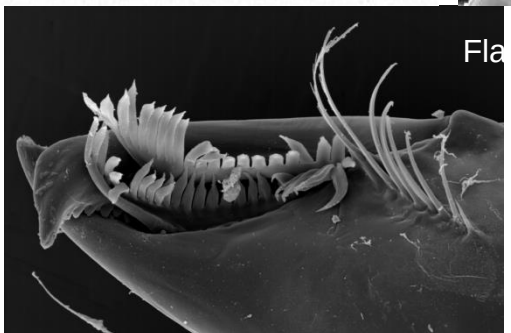
ventrolateral articulation

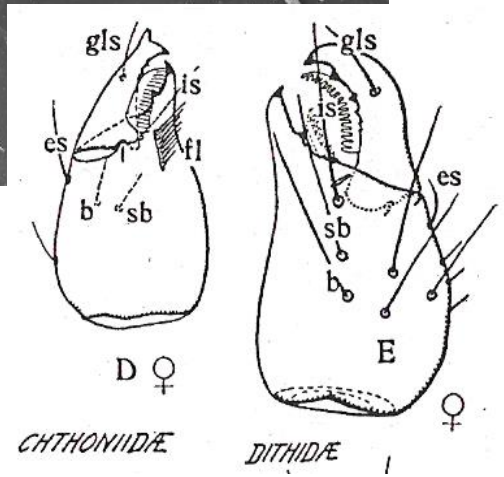


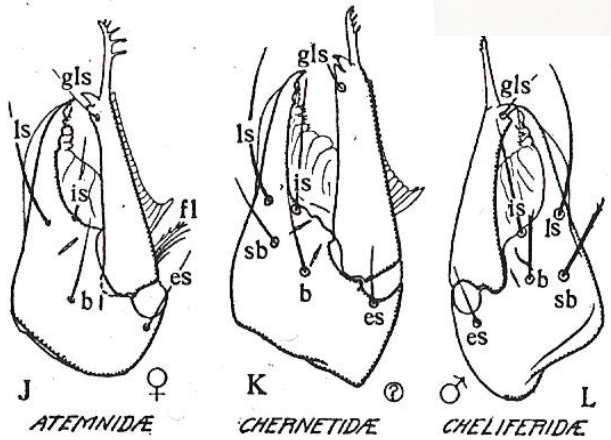








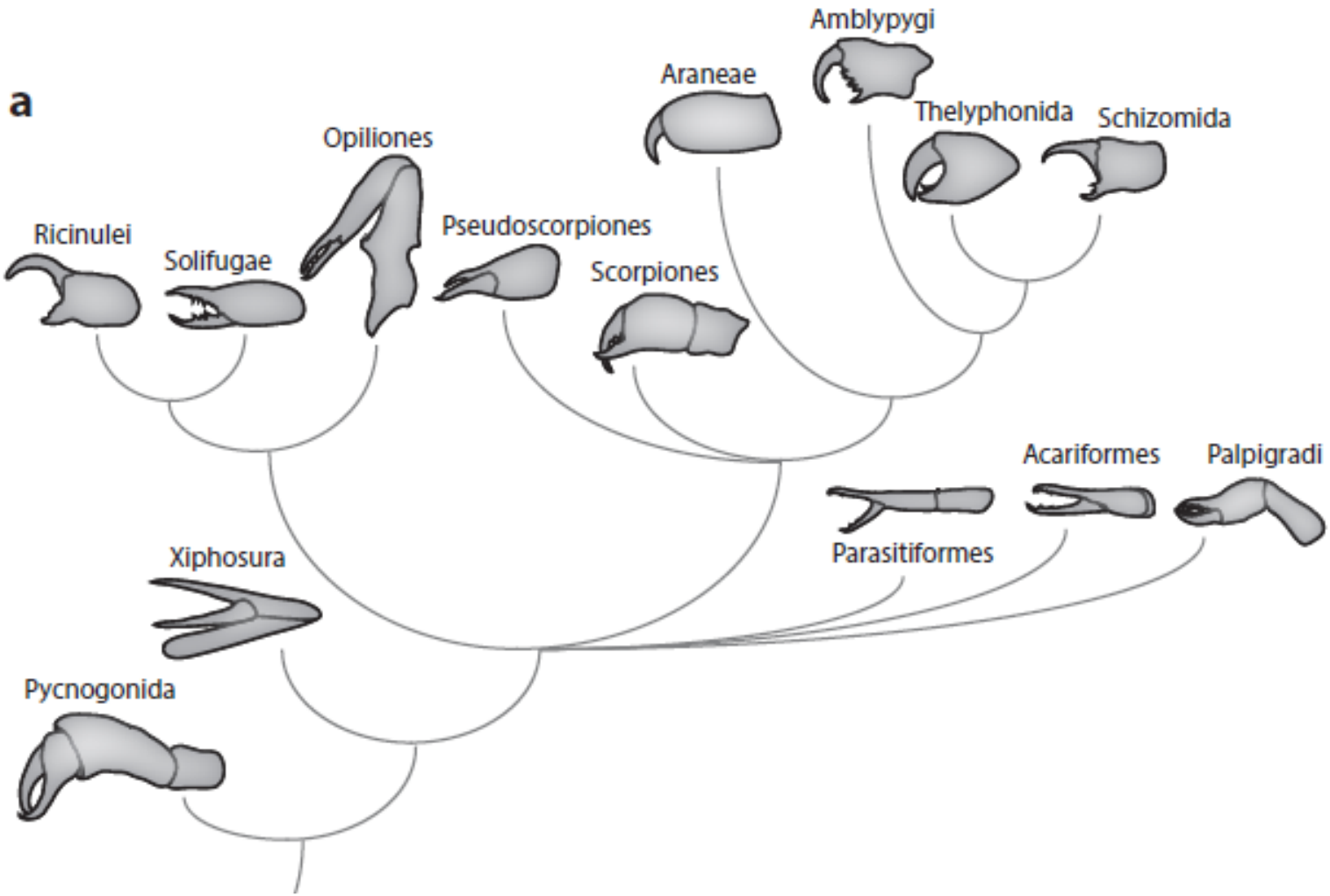




Charakteristics

chelicerae – two-segmented, chelate

ventrolateral articulation

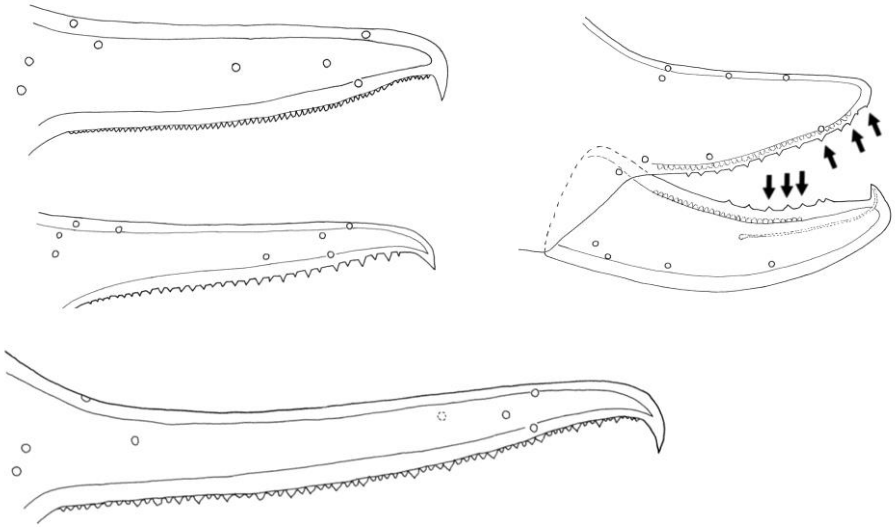


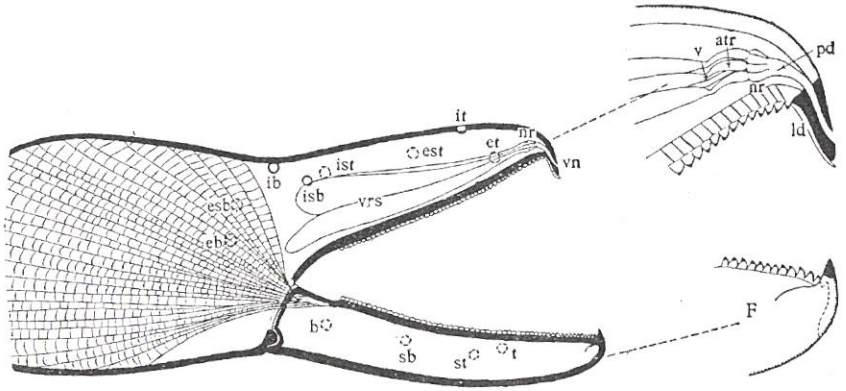
Giribet & Sharma 2015

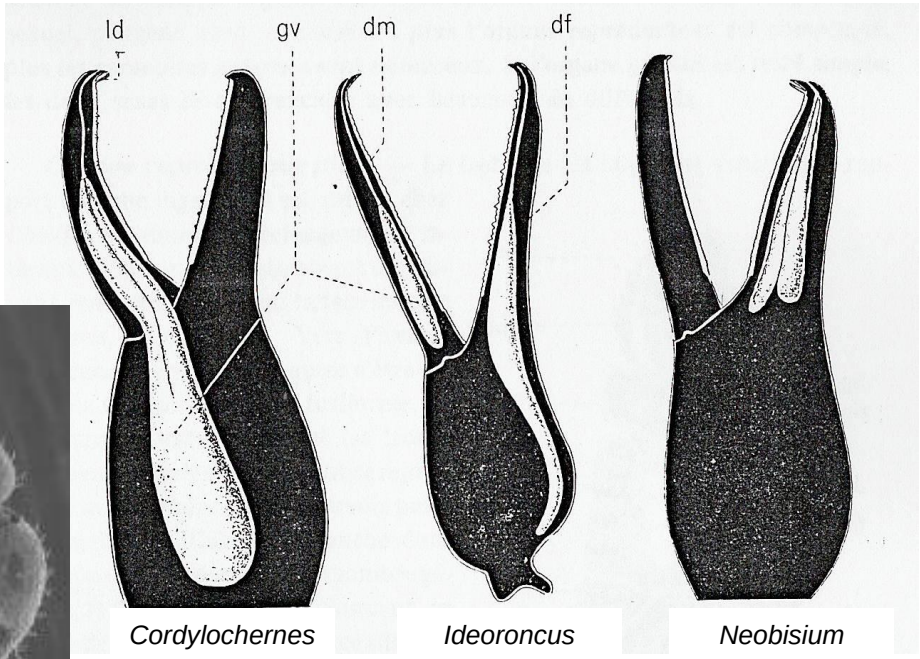
Charakteristics

pedipalps – with venom glands

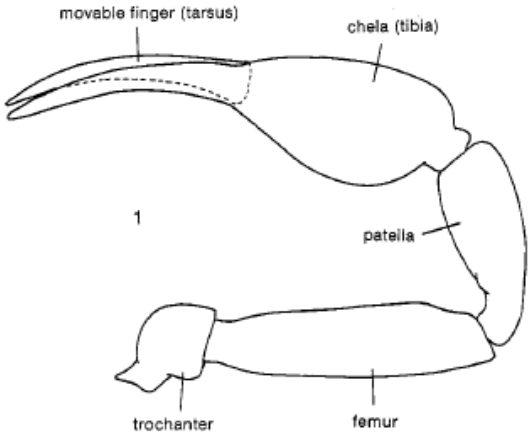
(without Heterosphyronida)

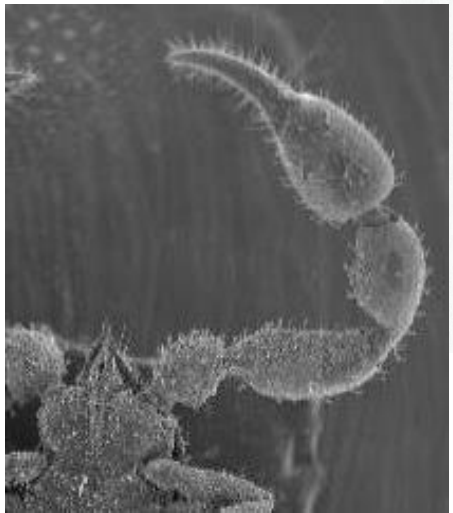




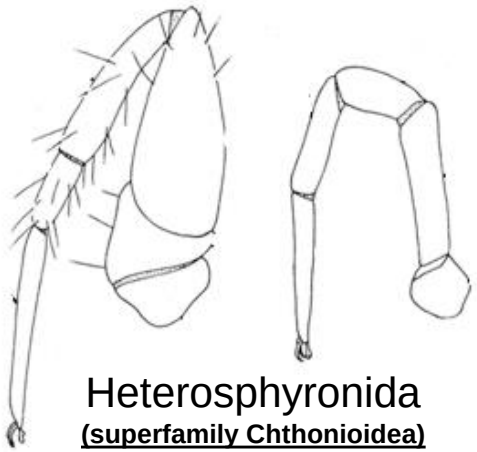


Cordylochernes *Ideoroncus* *Neobisium*

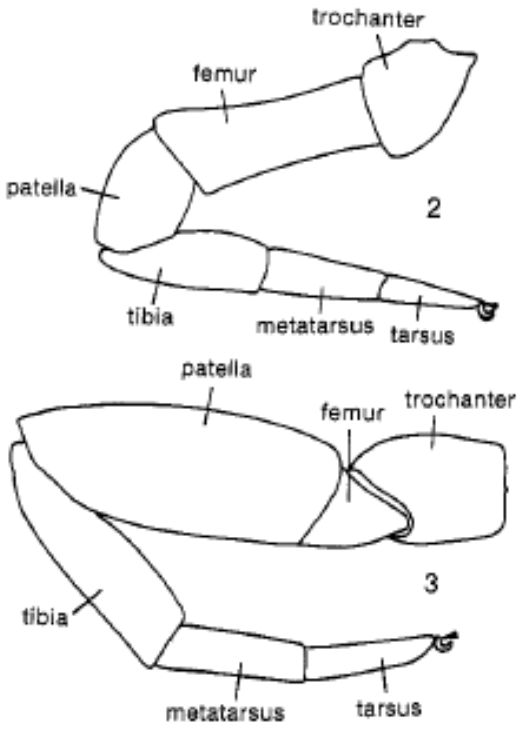


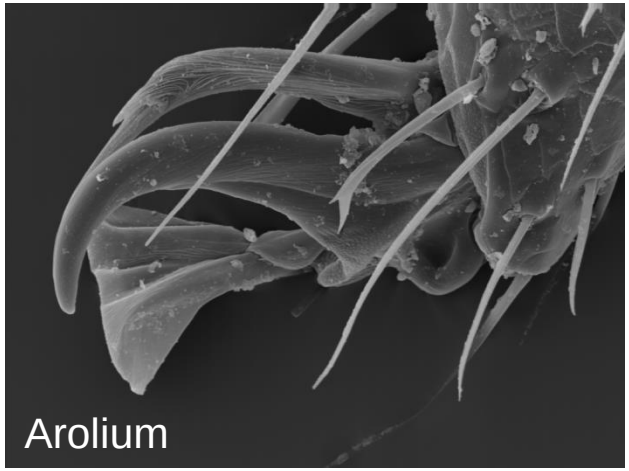


Charakteristics
legs



Heterosphyronida
(superfamily Chthonioidea)



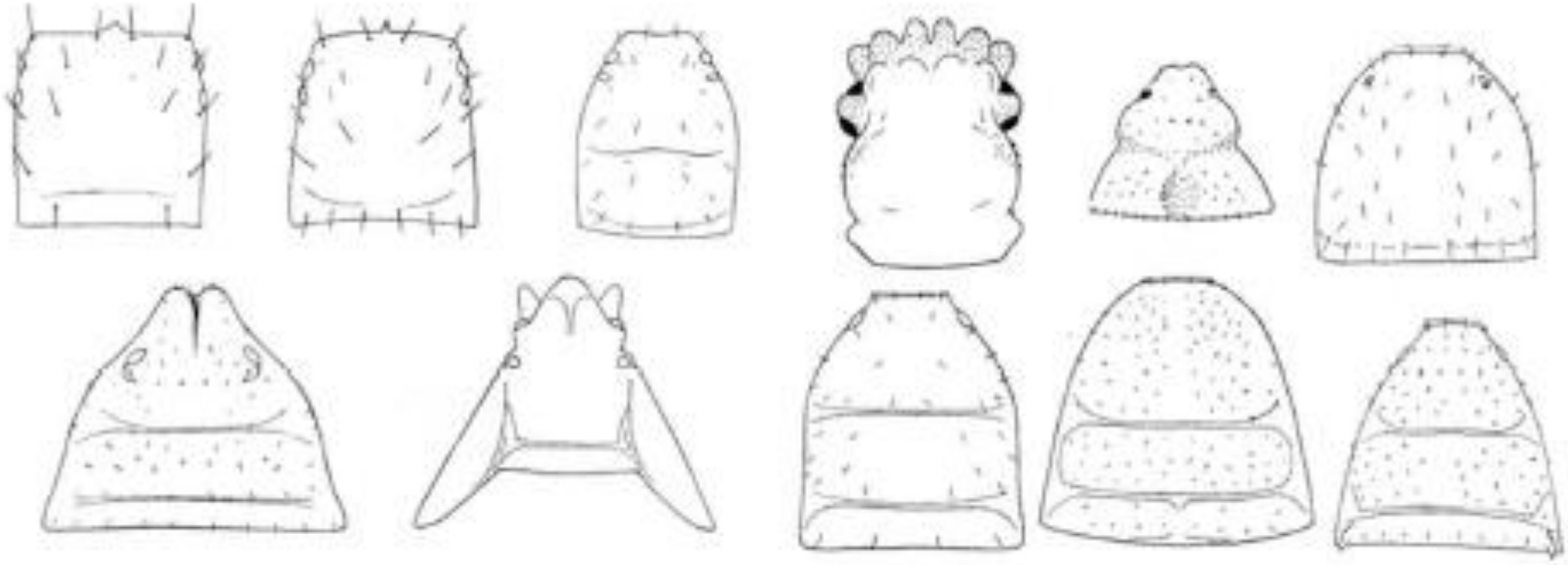


Diplosphyronida **(superfamily Neobisioidea a Garypoidea)**

Monosphyronida
(superfamily Cheliferoidea)

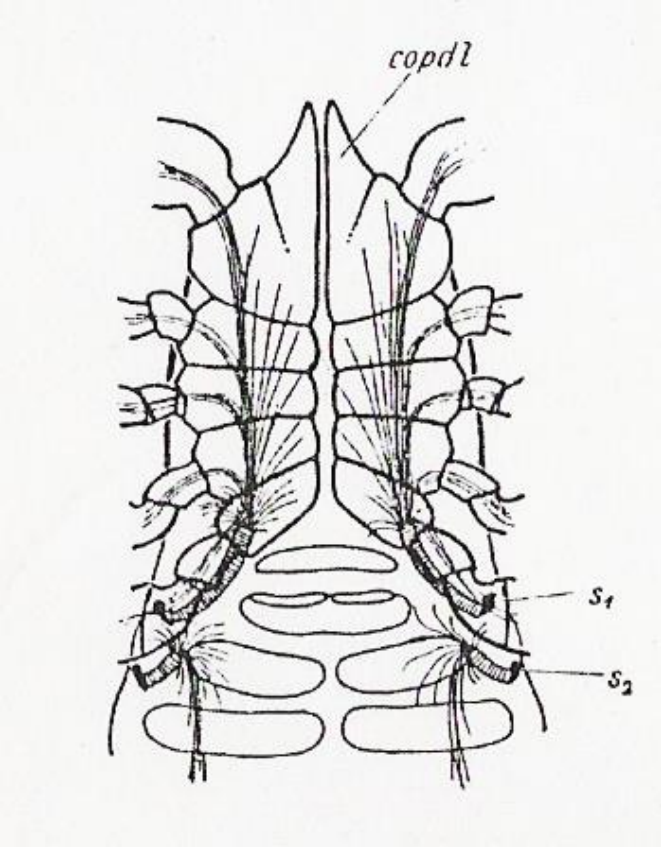
Charakteristics

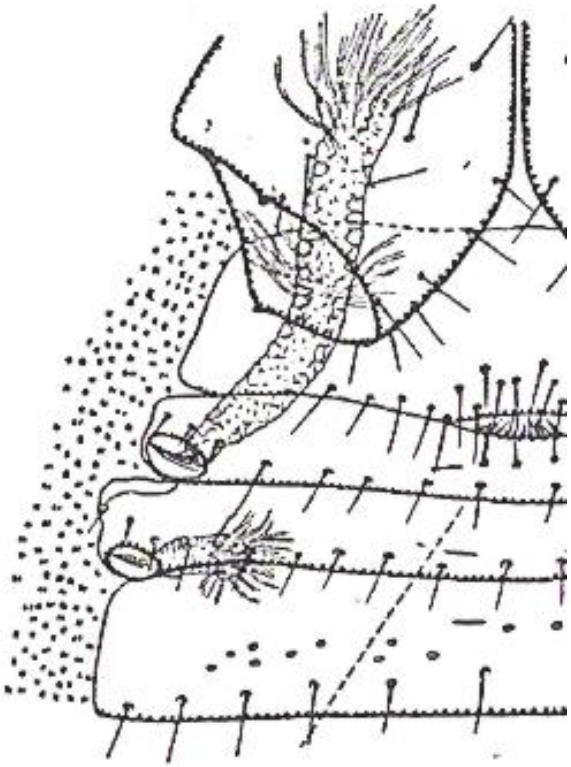
carapax



Charakteristics

trachee opening on 3. and 4. opisthosomal segment



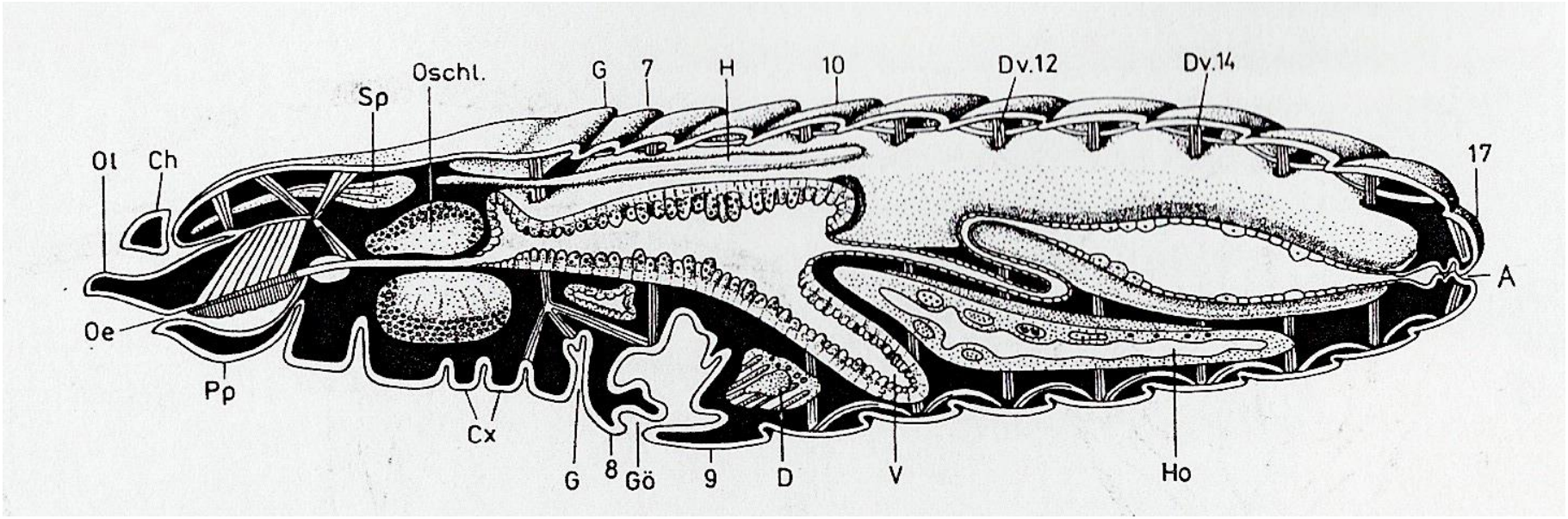


Charakteristics

Vascular system is opening (heart 4-2 pars of opening)

extrection: excretory cells in stomach

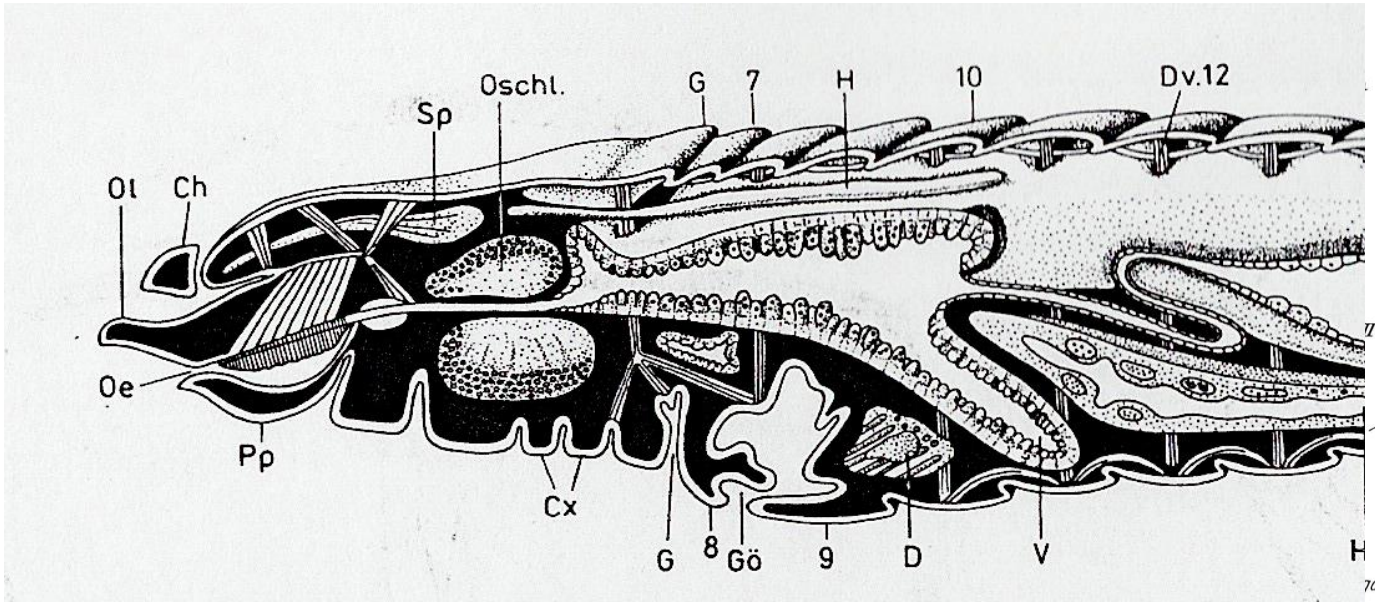
coxal glands

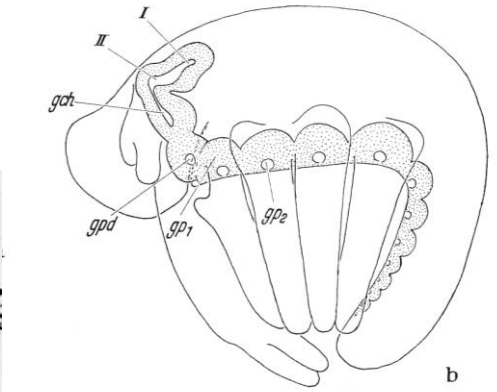


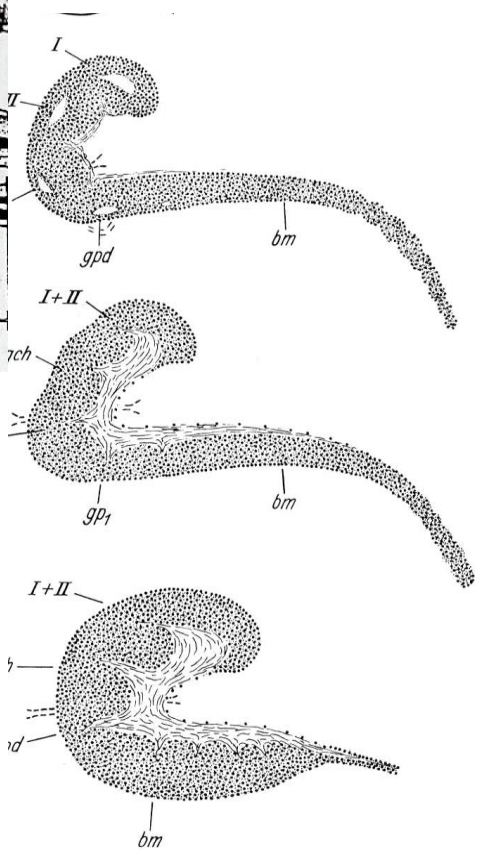
Charakteristics

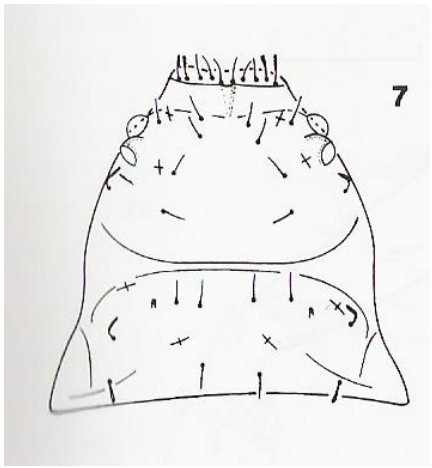
nervous system concentrated

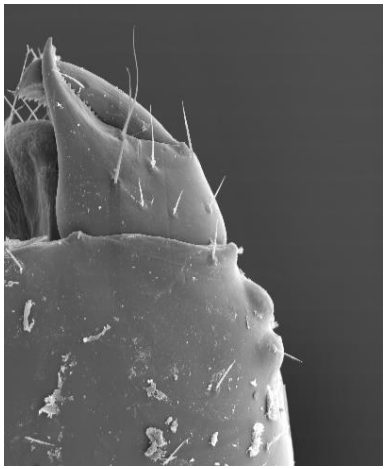
eyes 0-2 pairs





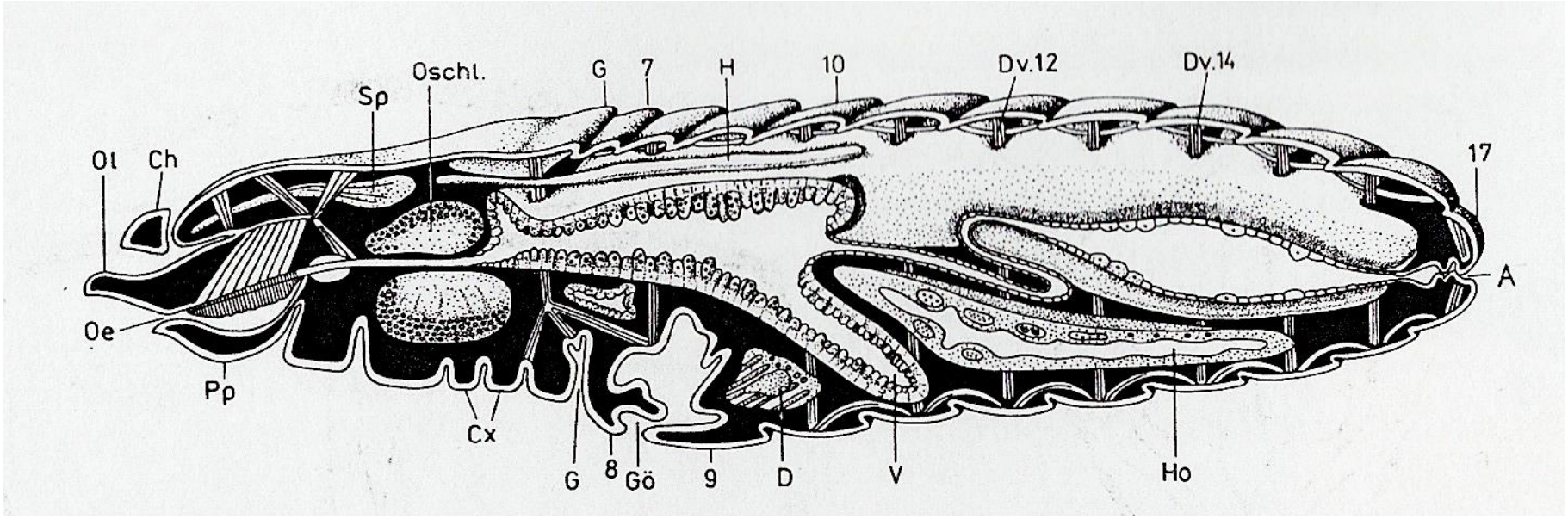


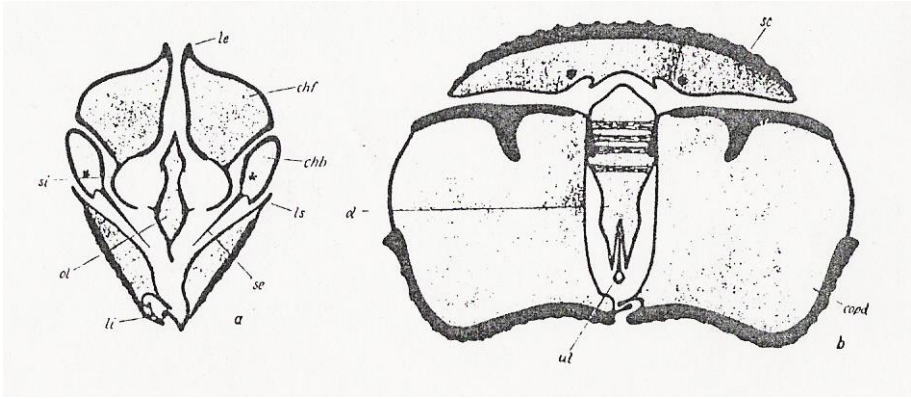


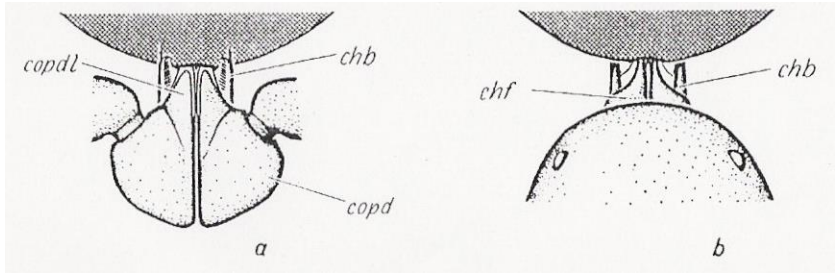


Charakteristics

Feeding, digestion

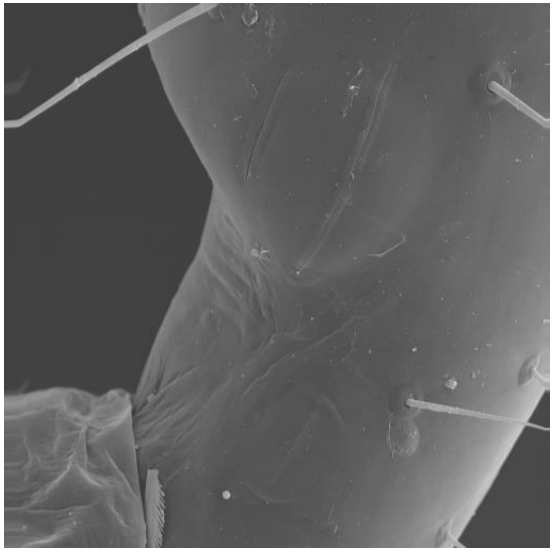


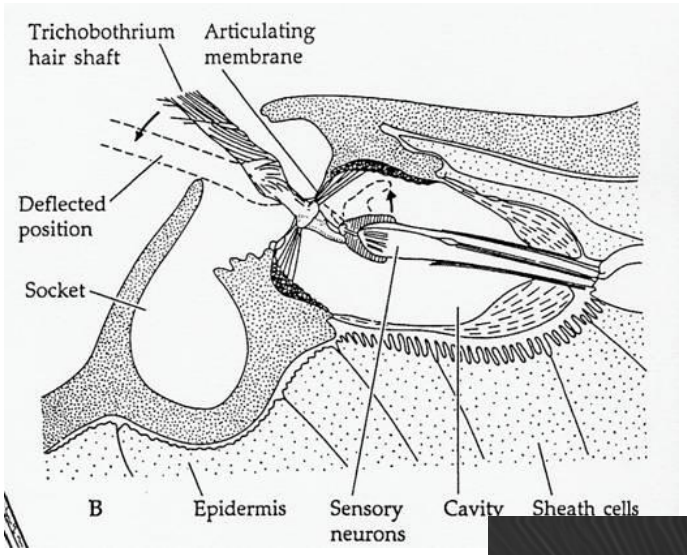


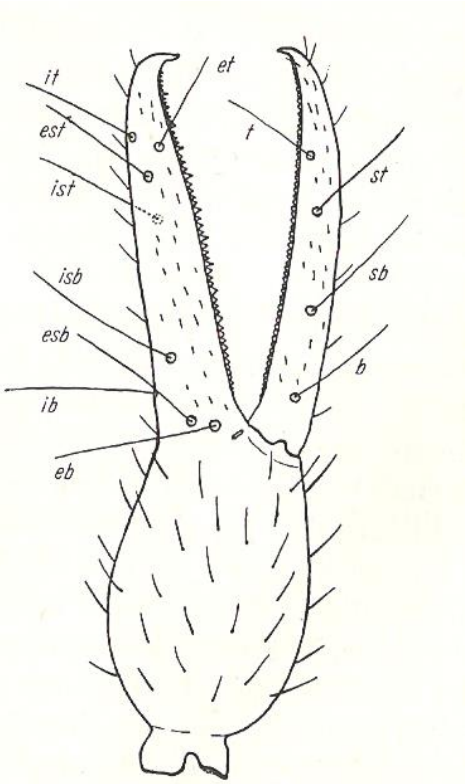


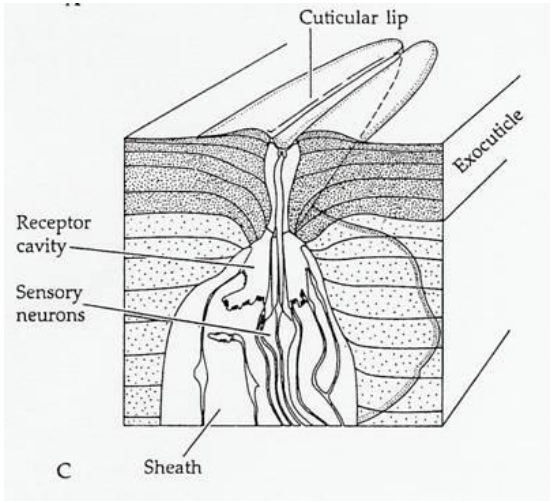
Charakteristics

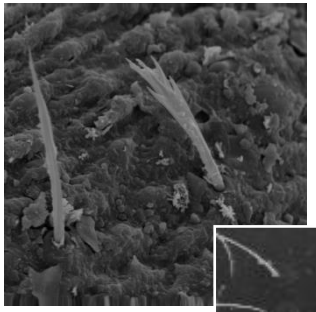
Cuticular sense organs

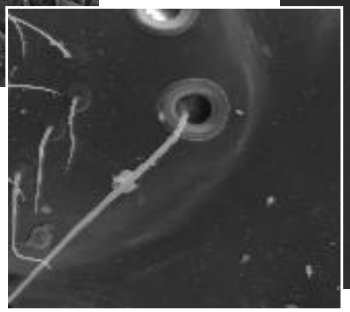


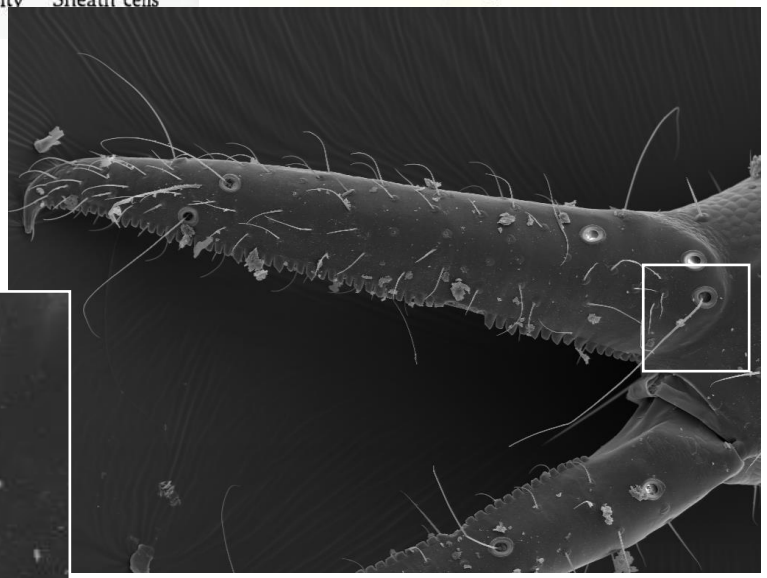






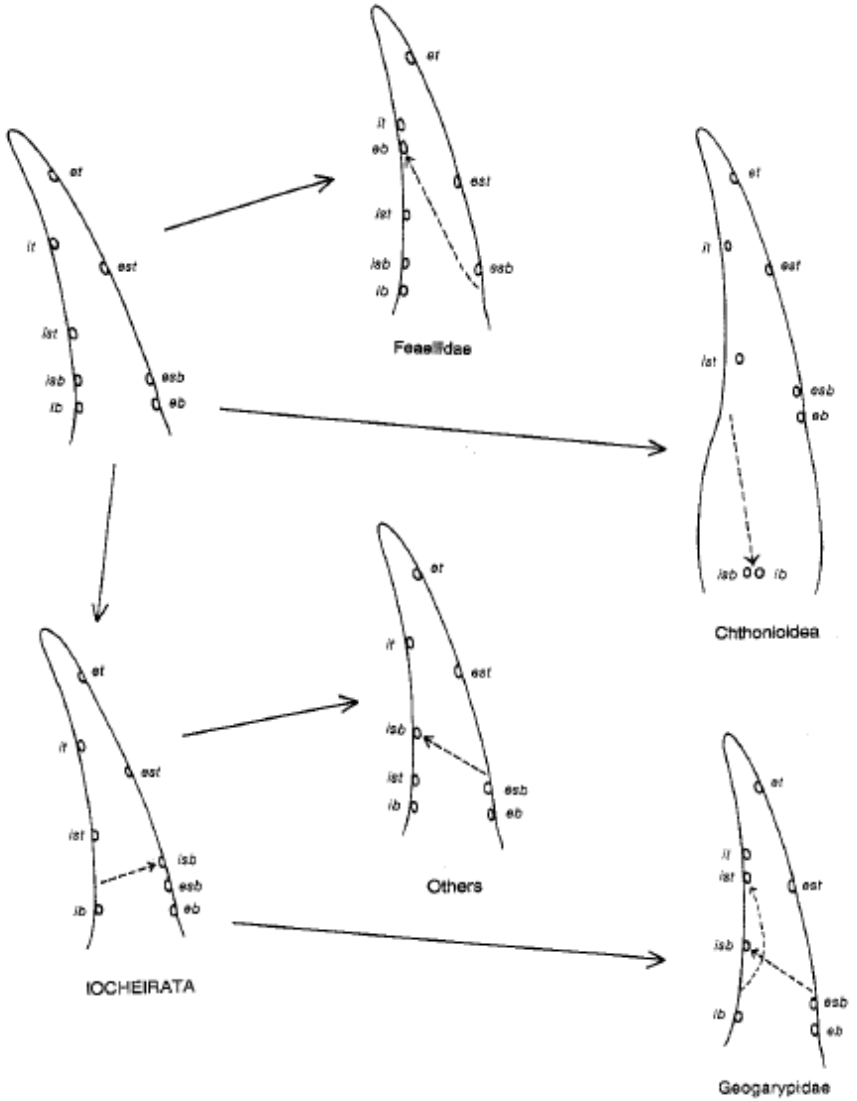


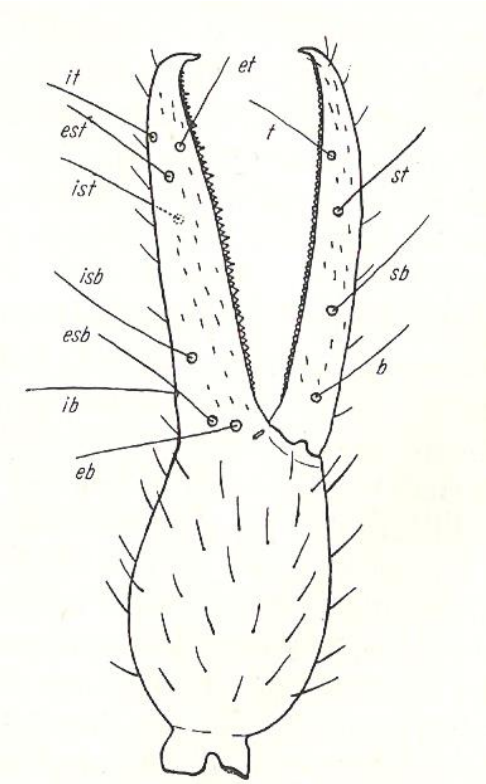


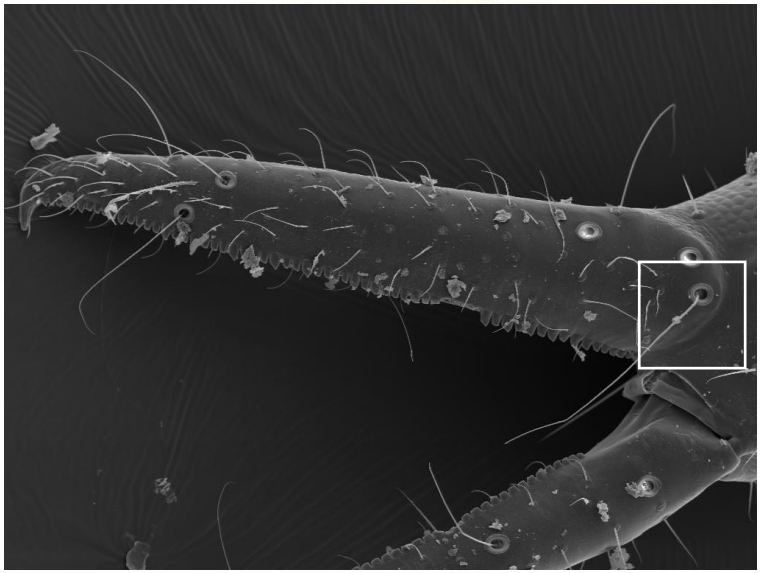


Charakteristics

Cuticular sense organs

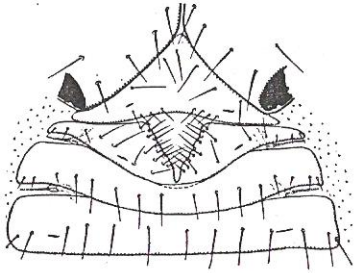


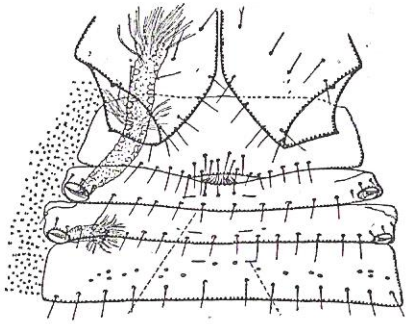


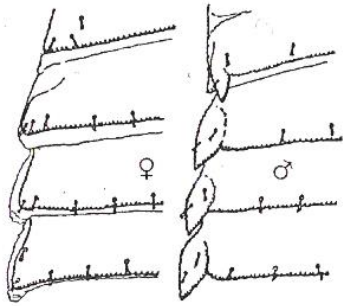


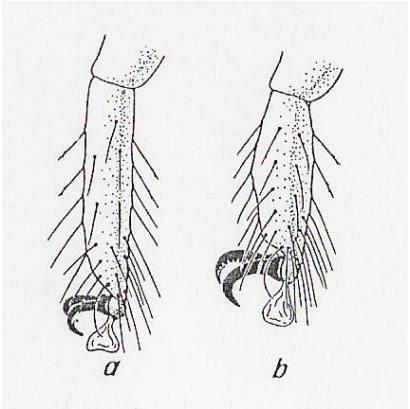
Reproduction

pseudoscorpions reproduce sexually

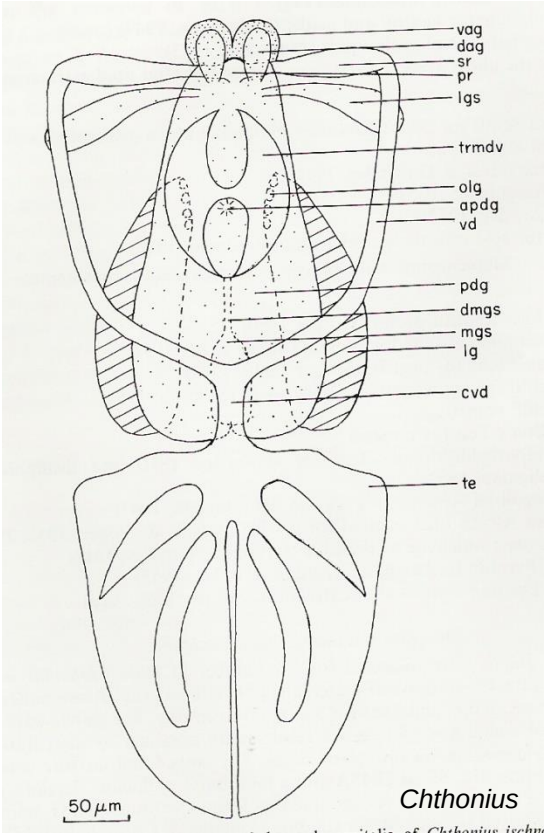




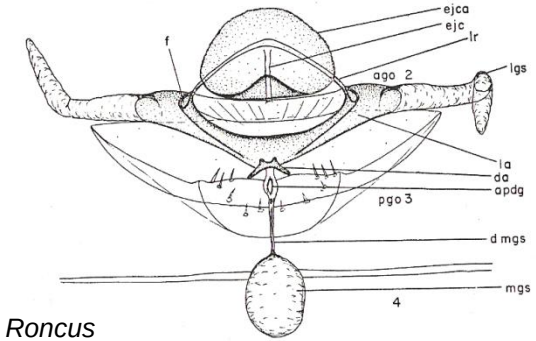




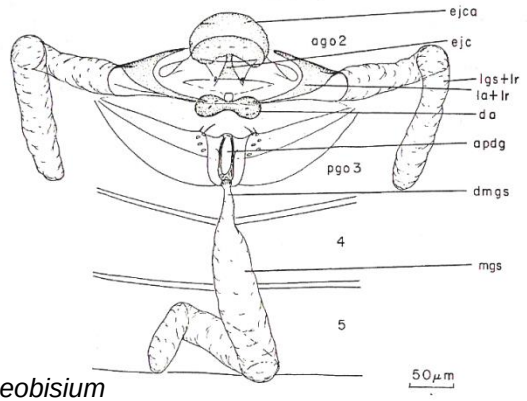
Reproduction



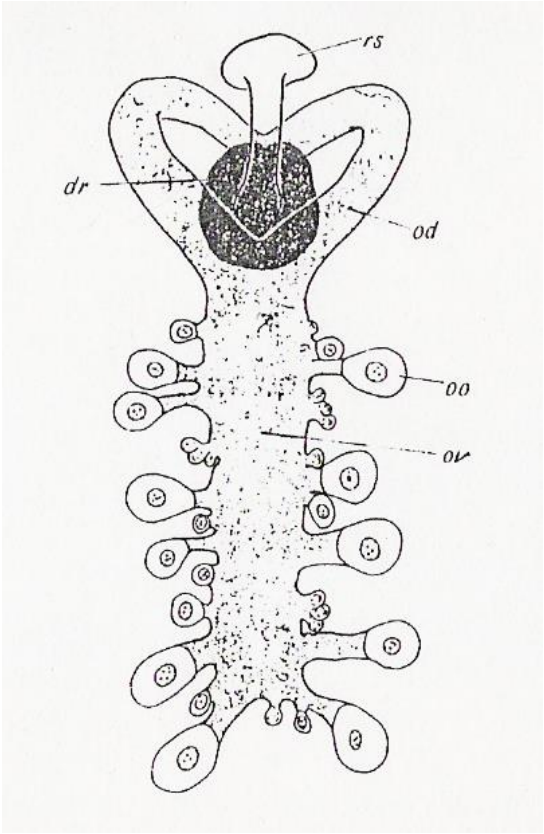
Chthonius

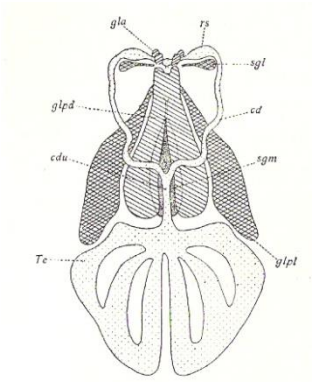


Roncus

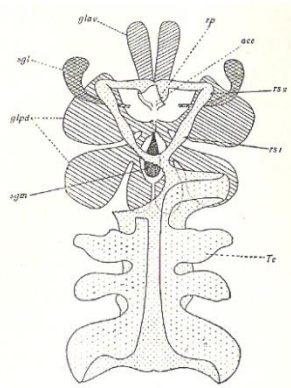


Neobisium

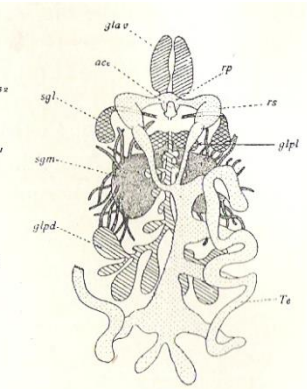




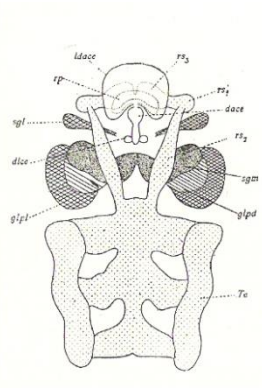
Chthonius



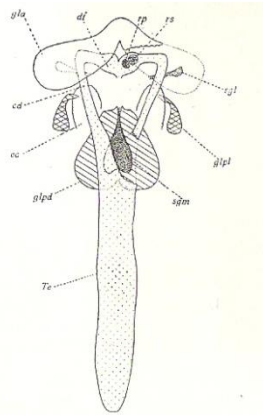
Neobisium



Garypus



Chernes



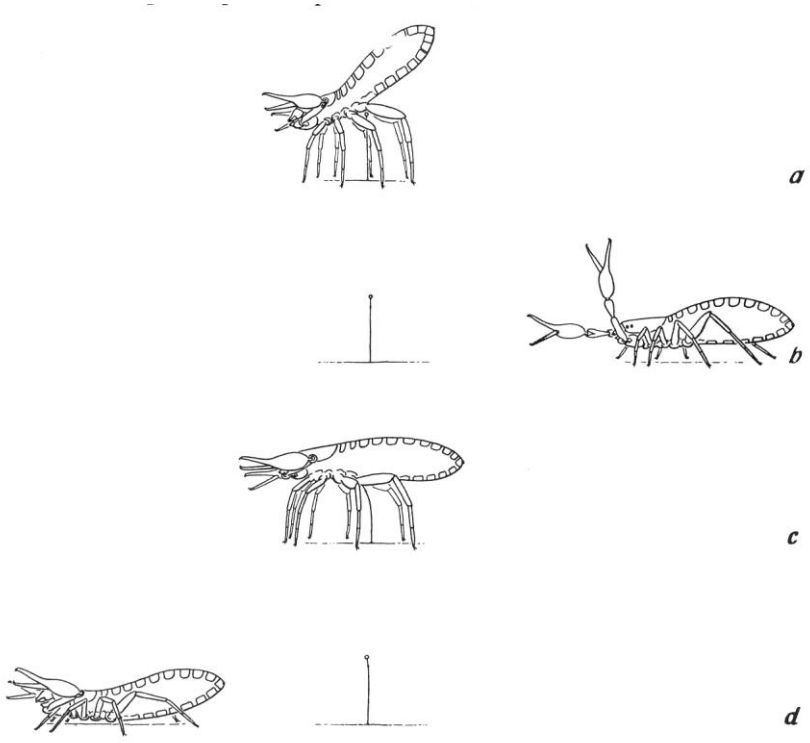
Chelifer

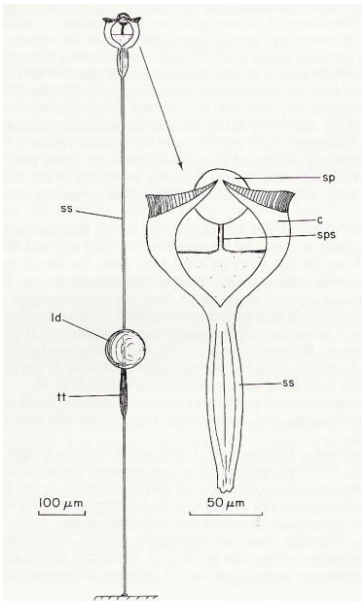
Reproduction

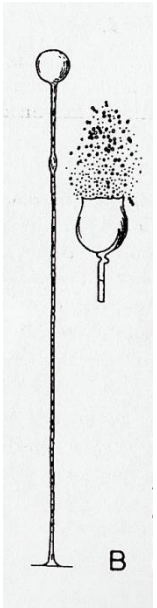
fertilization is internal but indirect

A) Spermatophors without females

Chthoniidae
Neobisiidae
Cheiridiidae
Olpiidae





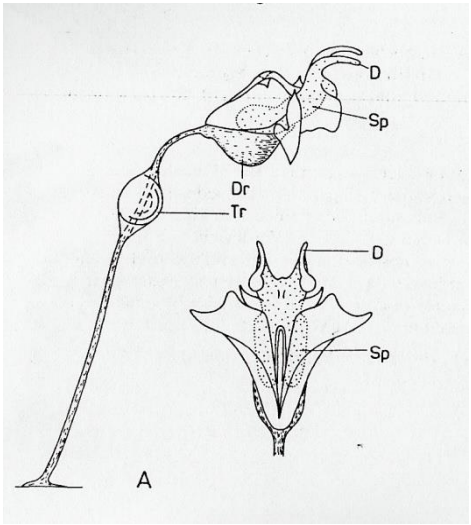


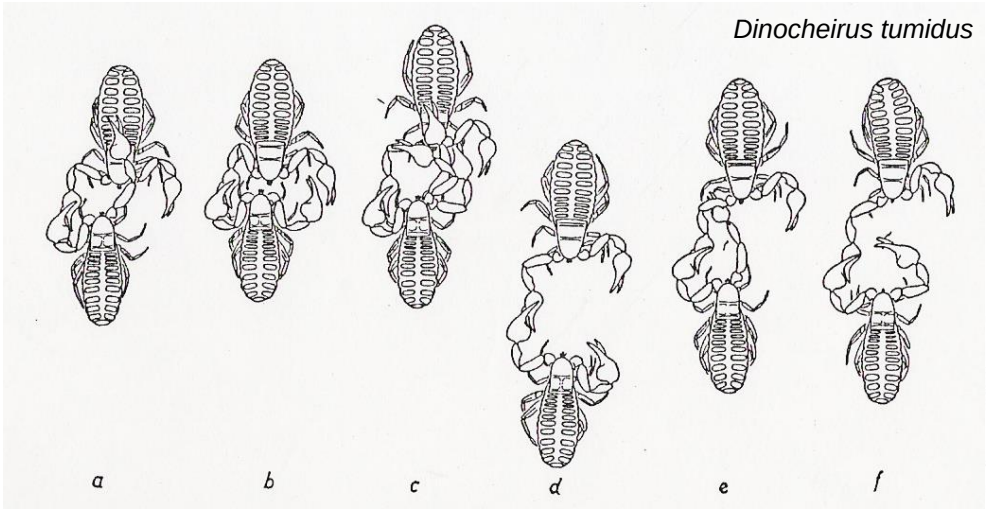
Reproduction

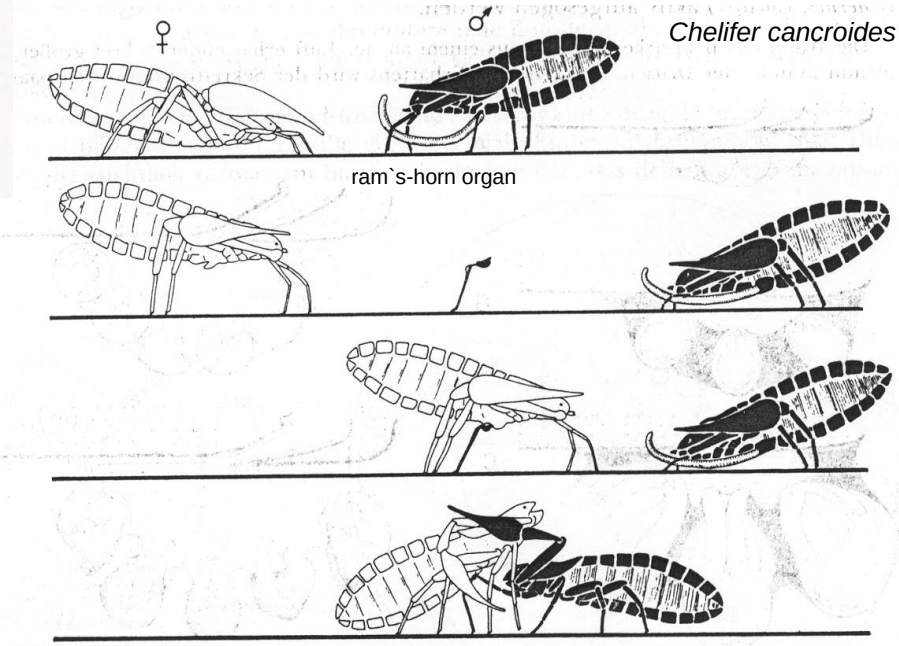
fertilization is internal but indirect

A) Spermatophors with females

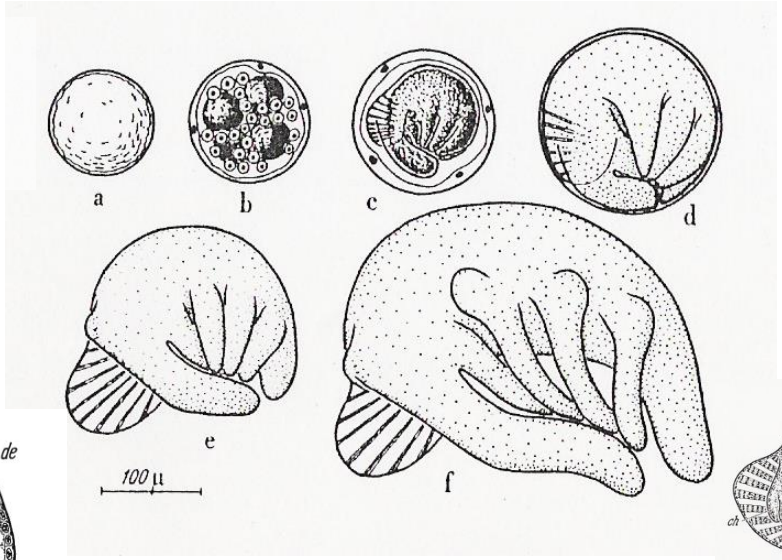
Atemnidae
Chernetidae
Cheliferidae

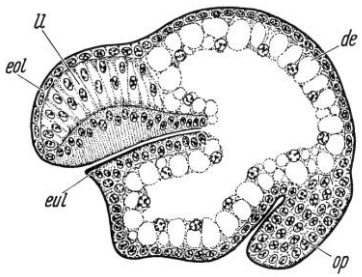


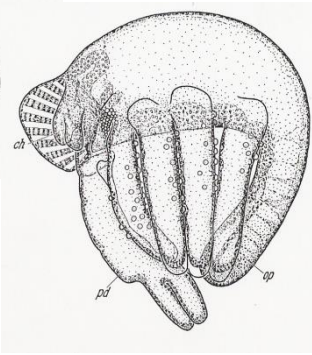


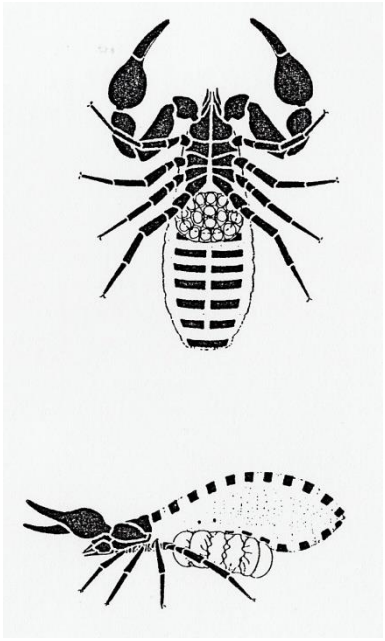


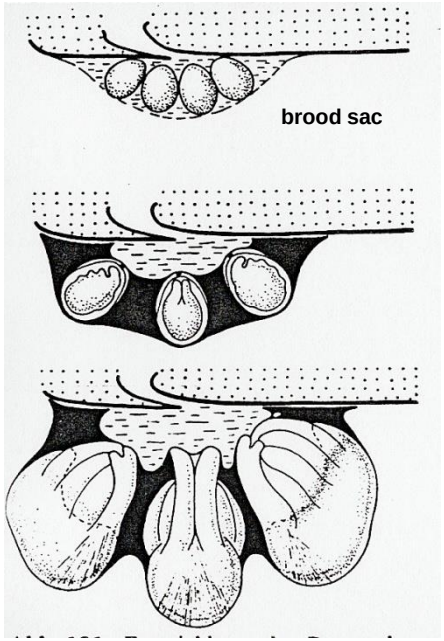
Reproduction

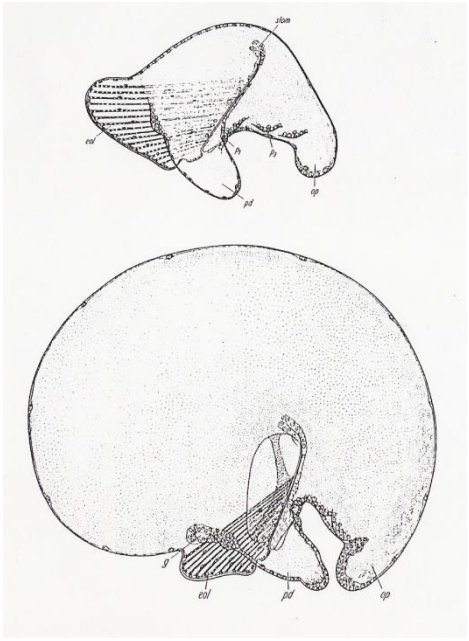












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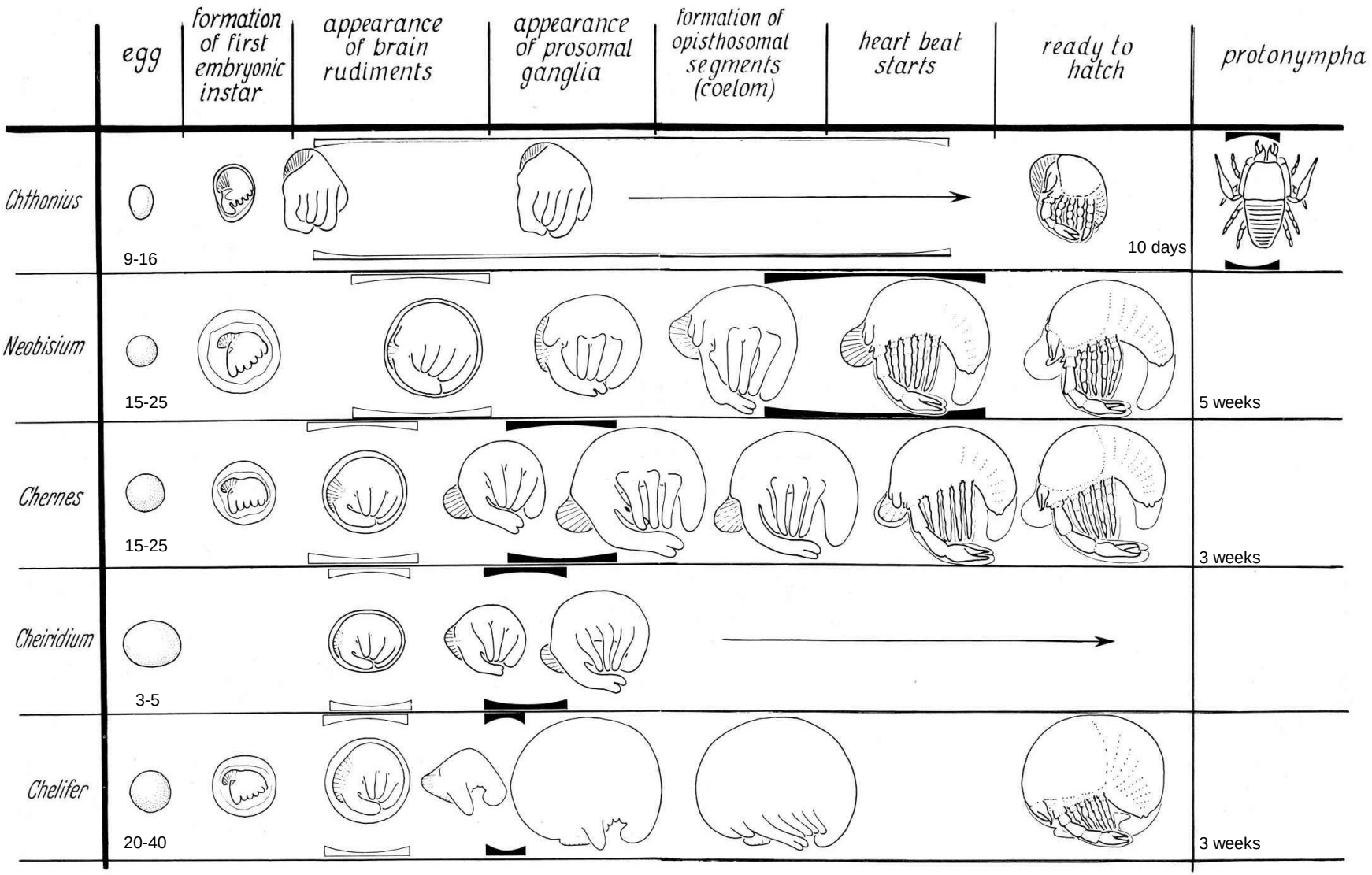
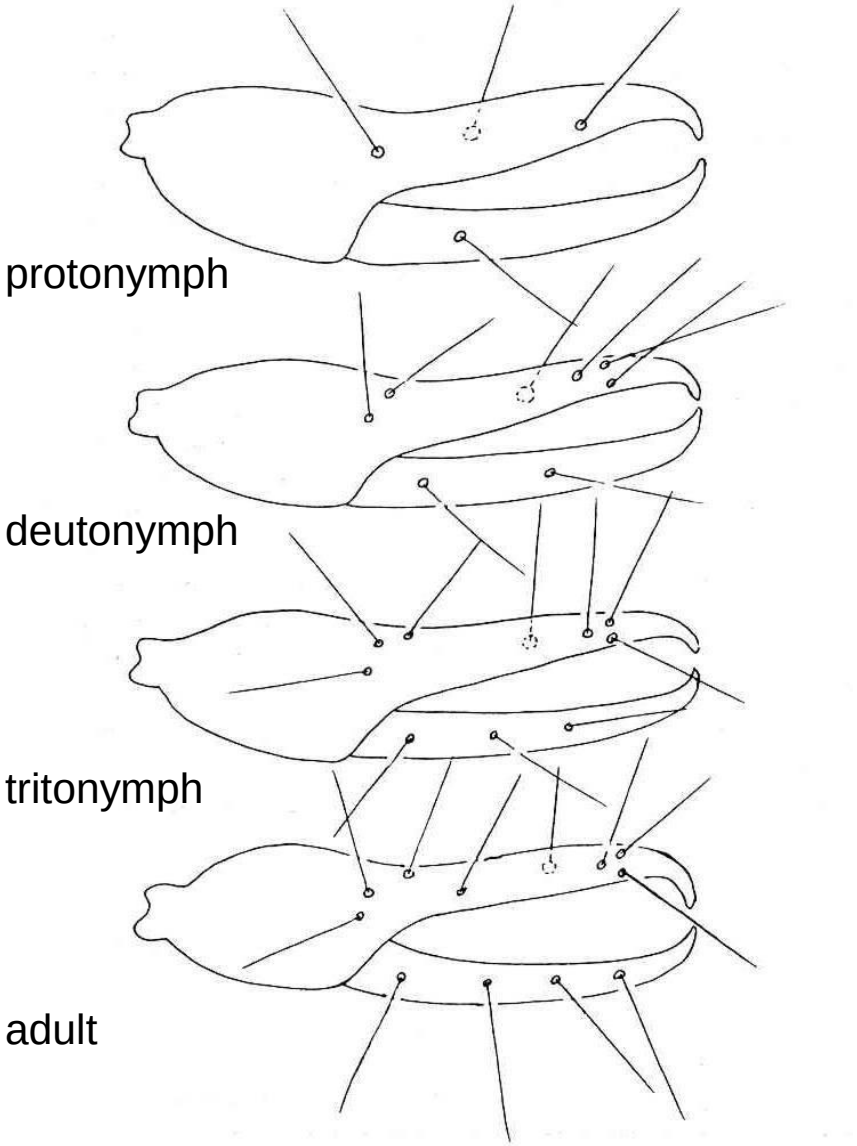


Life cycle

nymphs (3 instars)

1 mm

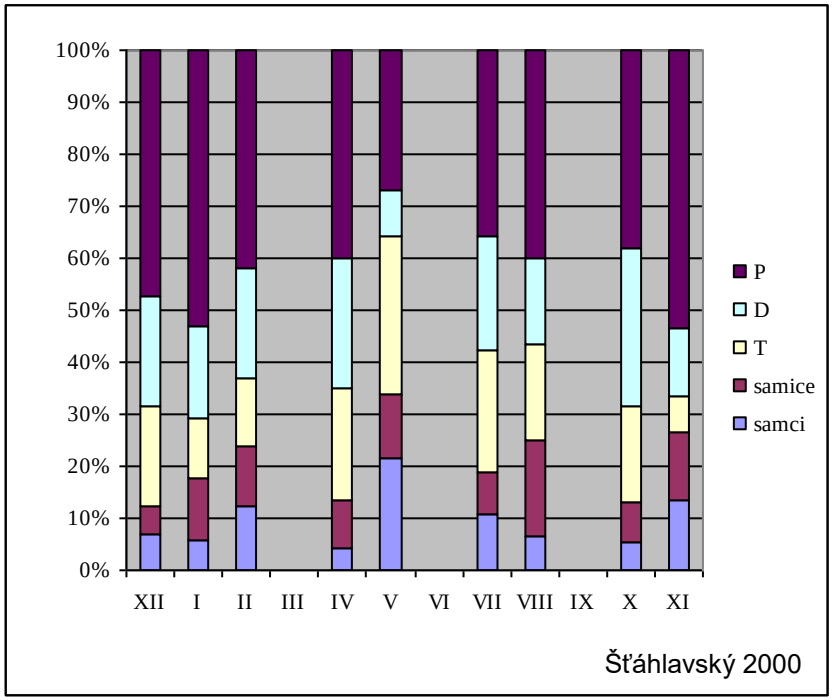


Life cycle

longevity 2 – 4 years

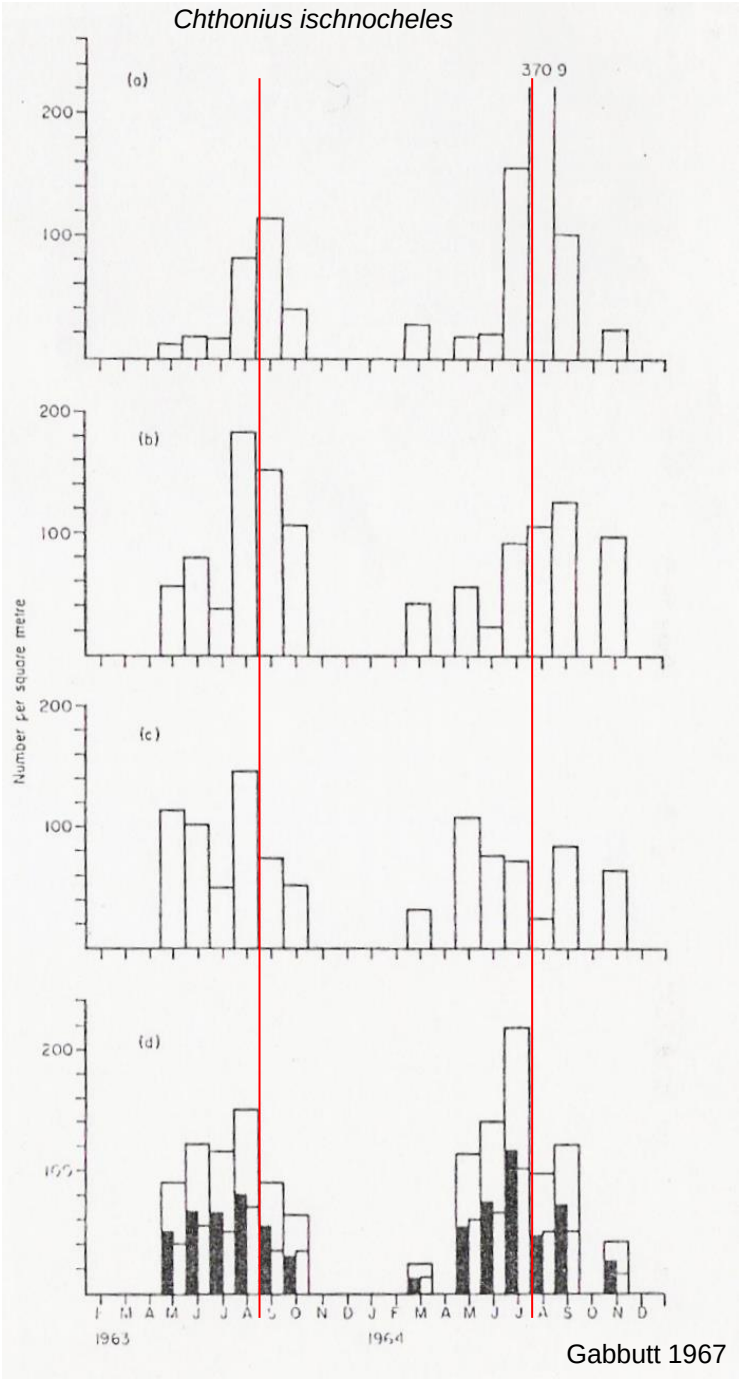
Abbundance up to 900 ex./m^2

Allochernes wideri



Šťáhlavský 2000

Chthonius ischnocheles



Gabbutt 1967

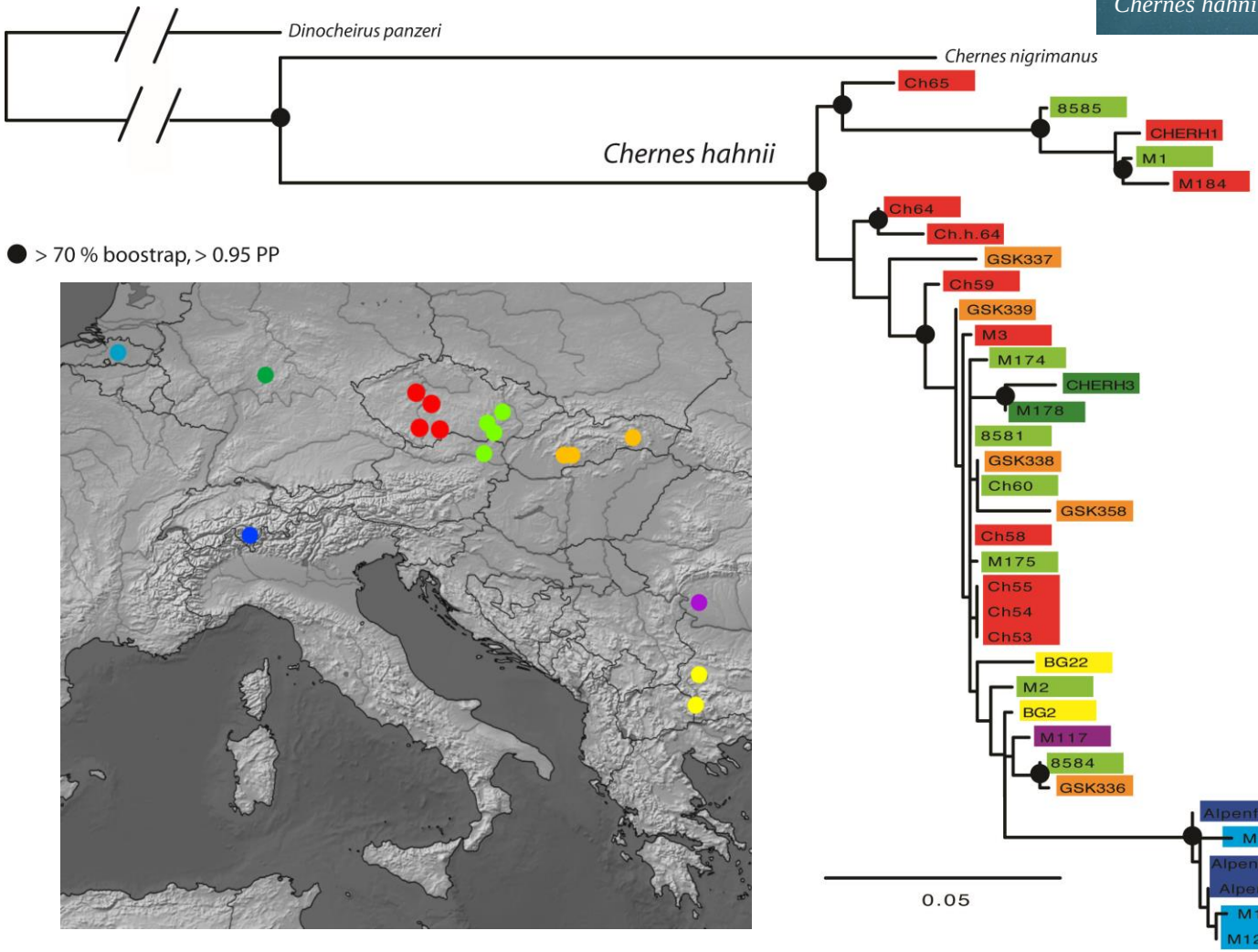
Phoresy

Tridenchthoniidae	1
Lechytiidae	3
Syarinidae	1
Neobisiidae	1
Larcidae	1
Sternophoridae	1
Cheiridiidae	3
Cheliferidae	9
Atemnidae	7
Withiidae	3
Chernetidae	39

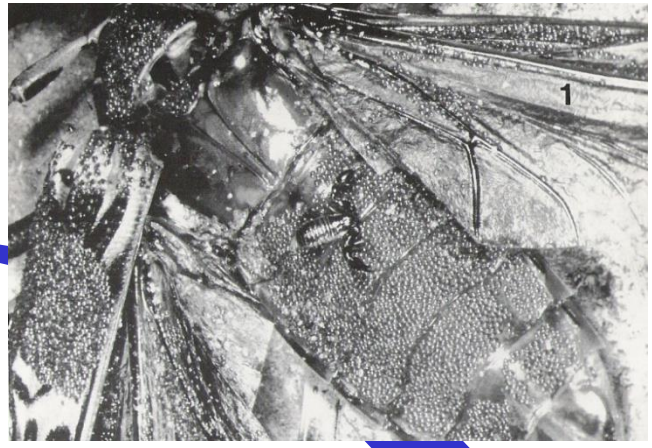
dispersal
x
predation

theory of origin

Garypinus electri (Baltic amber)



Opatová & Šťáhlavský 2008


1

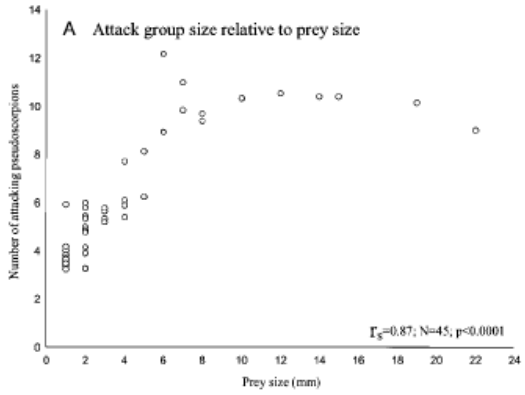
Sociality

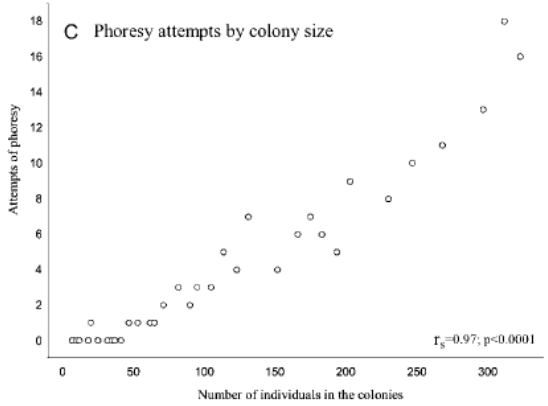
Del-Claro K. & Tizo-Pedroso E. 2009: Ecological and evolutionary pathways of social behavior in Pseudoscorpions (Arachnida: Pseudoscorpiones). Acta Ethologica 12: 13-22.

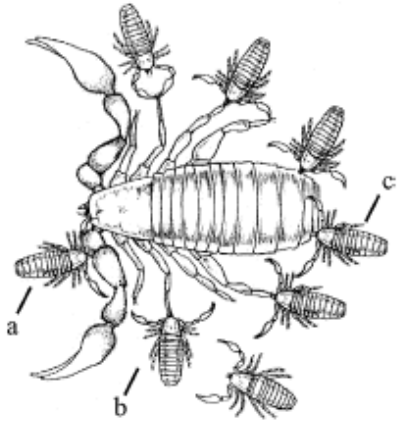
Paratemnoides nidificator

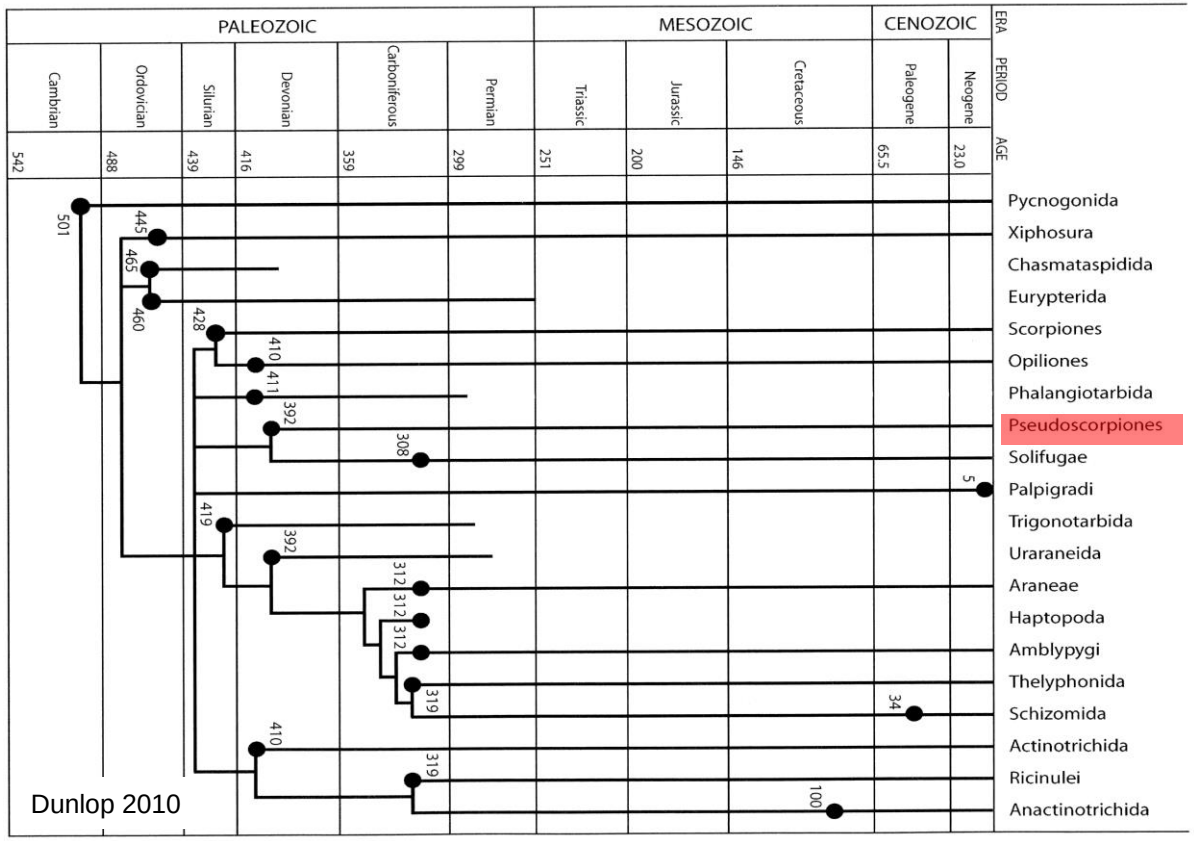
Table 2 Available knowledge about social behavior in Pseudoscorpions

Species	Family	Distribution[a]	Social level	Classification[b]	Author(s) and publication year
Paratemnoides nidificator	Atemnidae	Central and South America	Permanent and cooperative life form	Non-territorial permanent social	Hahn and Matthiesen (1993a, b); Tizo-Pedroso and Del-Claro (2005, 2007, 2008)
Paratemnoides elongatus	Atemnidae	Central and South America and south of	Permanent and cooperative life form	Non-territorial permanent social	Brach (1978); Zeh and Zeh (1990)

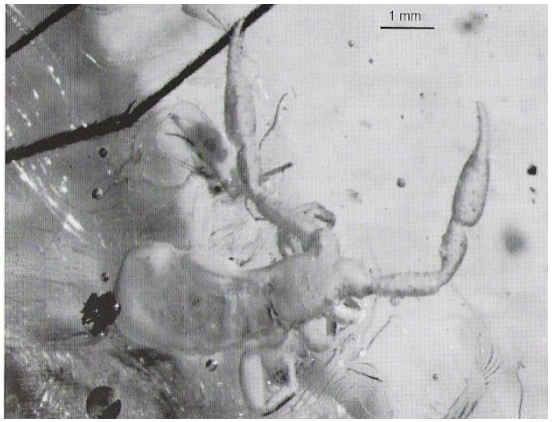




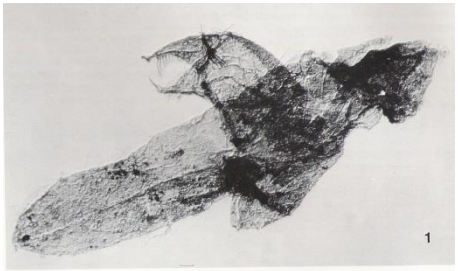


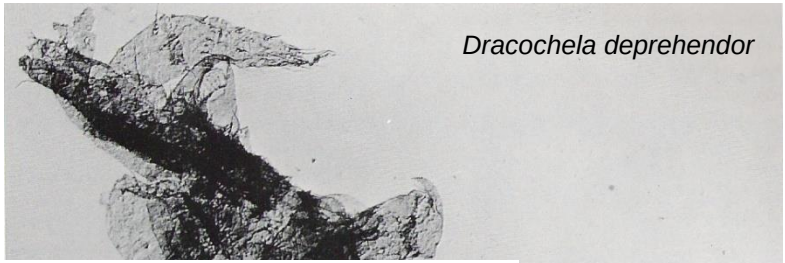


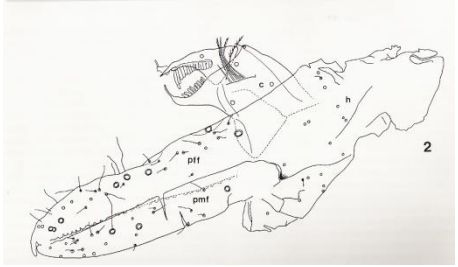
Dunlop 2010

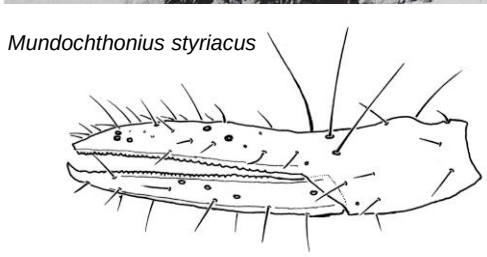


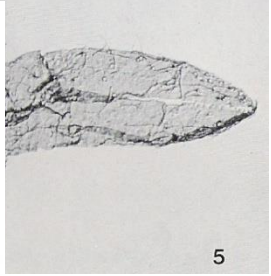
Garypinus electri Baltic amber
35-40 mil.

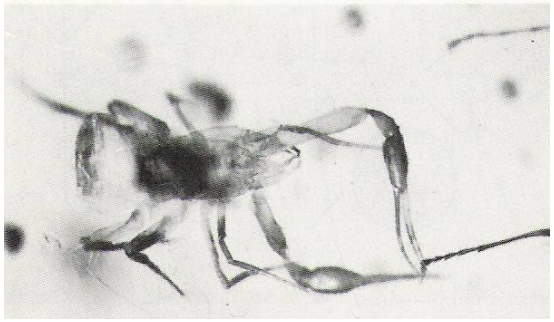




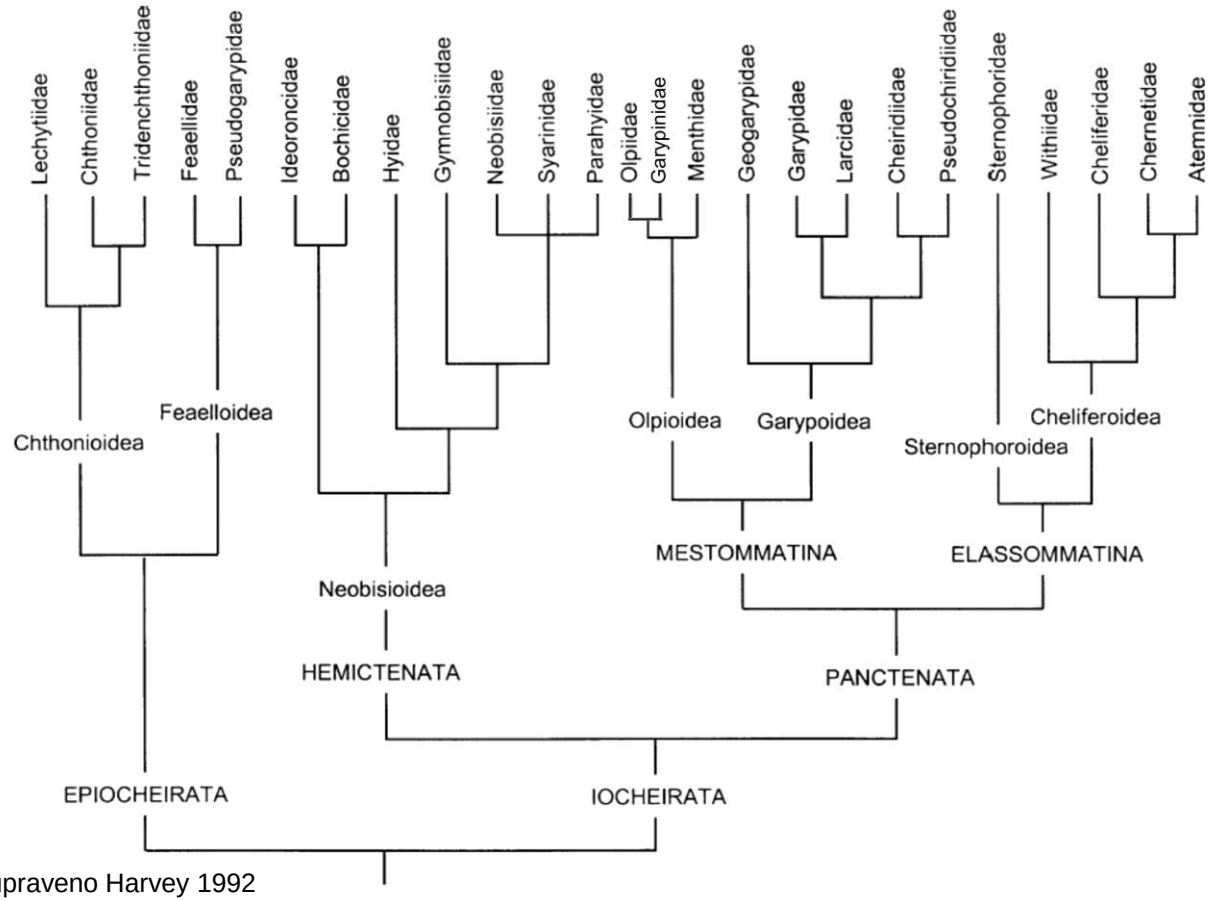








Pseudochthonius squamosus Dominican amber
30 mil.



upraveno Harvey 1992

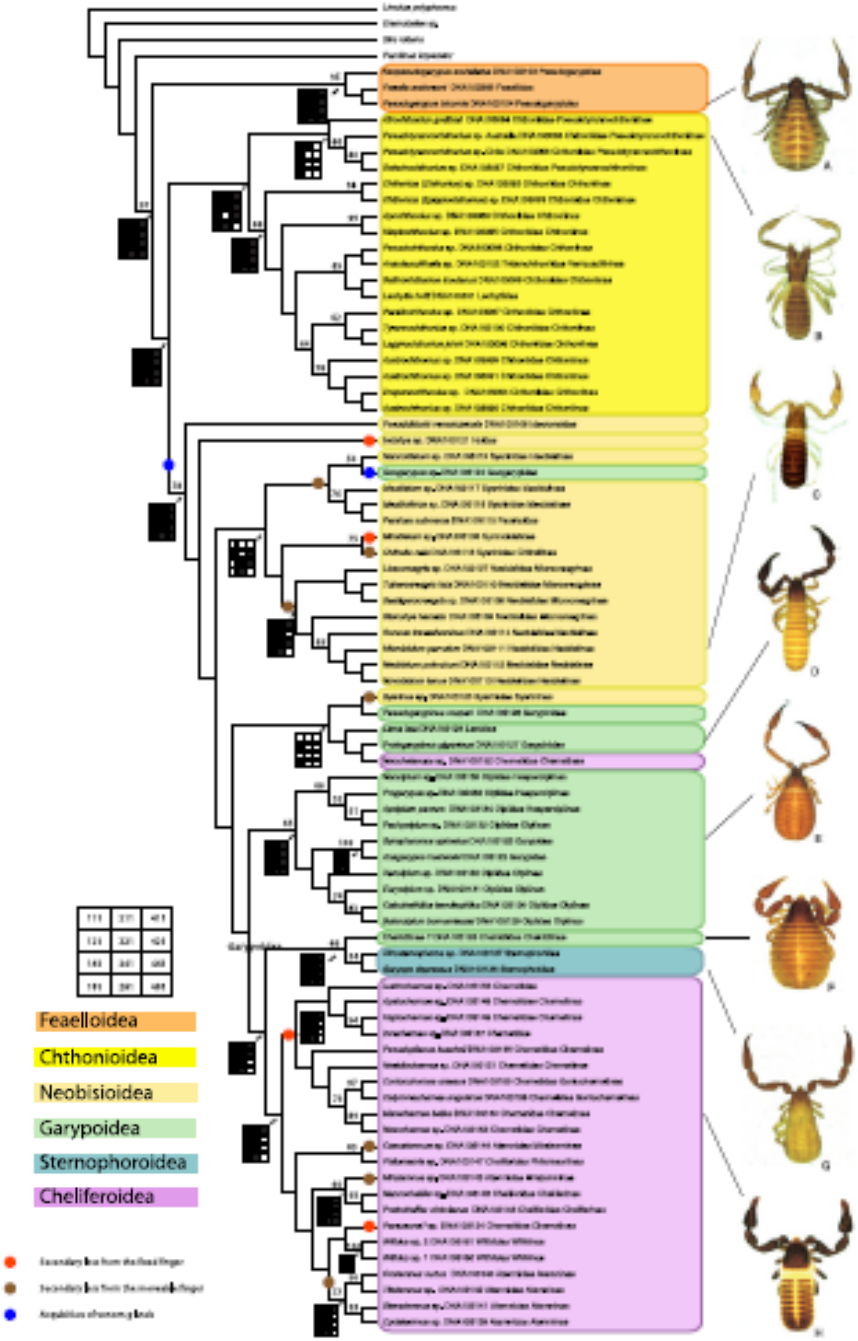


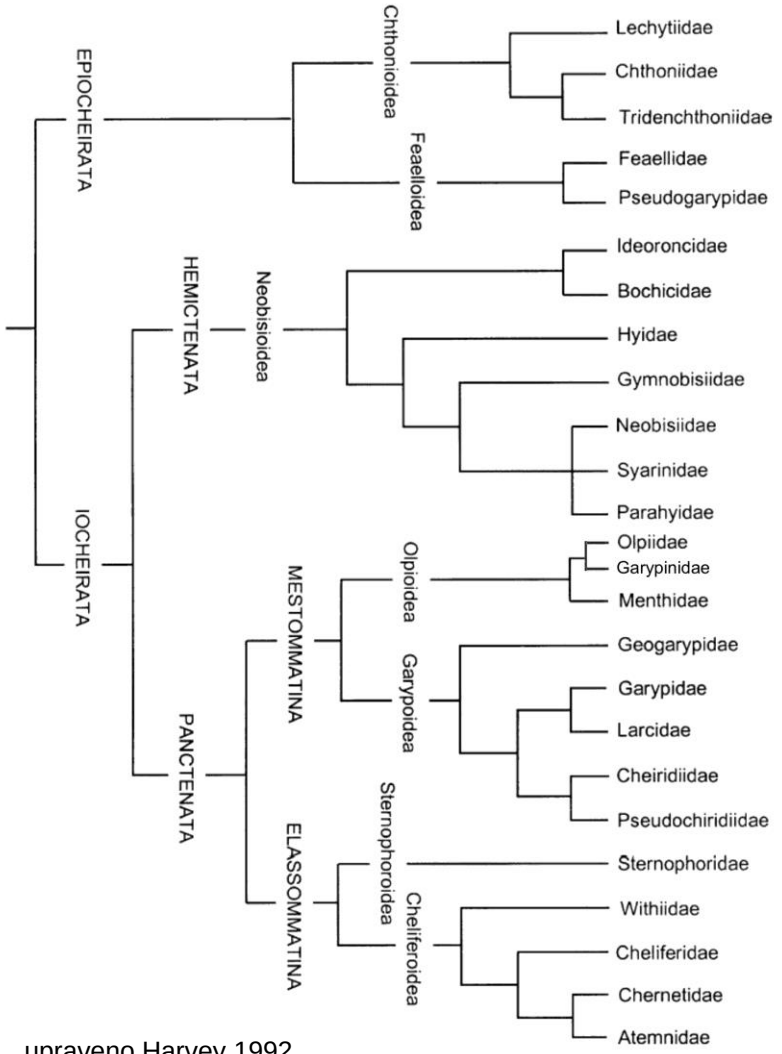








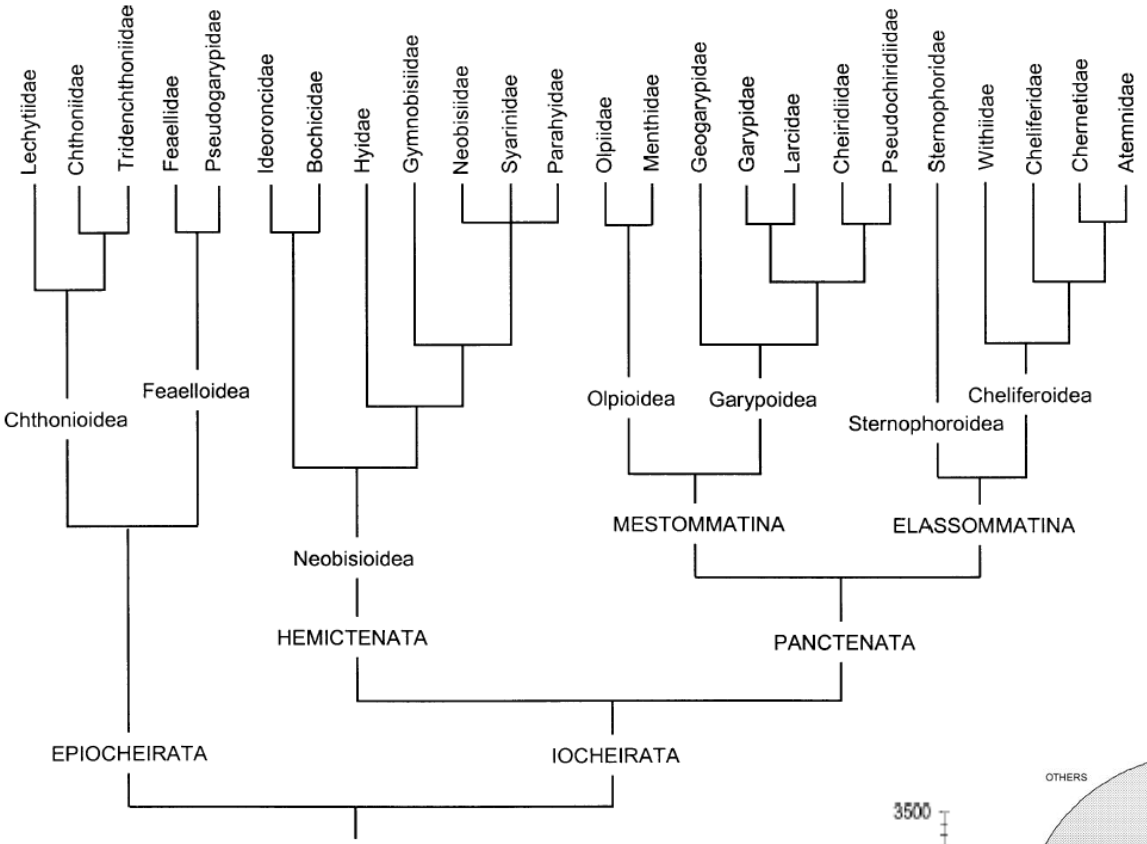




upraveno Harvey 1992

Murienne, J., Harvey, M. S. & Giribet, G. (2008) First molecular phylogeny of the major clades of Pseudoscorpiones (Arthropoda: Chelicerata). *Molecular Phylogenetics and Evolution*, 49, 170–184.

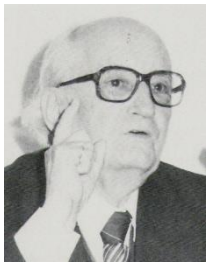
Dracochelidae †
Pseudotyrannochthoniidae
Chthoniidae
Pseudogarypidae
Feaellidae
Ideoroncidae
Hyidae
Bochicidae
Syarinidae
Parahyidae
Gymnobisiidae
Neobisiidae
Geogarypidae
Hesperolpiidae
Garypidae
Menthidae
Olpiidae
Garypinidae
Larcidae
Sternophoridae
Cheiridiidae
Pseudochiridiidae
Chernetidae
Cheliferidae
Atemnidae
Withiidae
DRACOCHELOIDEA
CHTHONIOIDEA
FEAELLOIDEA
NEOBISIOIDEA
GARYPOIDEA
GARYPINOIDEA
STERNOPHOROIDEA
CHEIRIDIOIDEA
CHELIFEROIDEA
This study
PALAEOSPHYRONIDA
HETEROSPHYRONIDA
HOMOSPHYRONIDA
ATOPOSPHYR-ONIDA
IOCHEIRATA
HEMICTENATA
PANCTENATA
EMI-
EMICTENODACTYLI
PANCTENODACTYLI
HEMI-
HEMICTENODACTYLI
PANCTENODACTYLI
PAN-
HETERO-SPHYR-ONIDA
HOMOSPHYRONIDA
MONO-
DIPLOSPHYRONIDA
MONOSPHYRONIDA
CHTHO-NOINEA
NEOBISIINEA
CHELIFERINEA
Balzan 1892
With 1906
Chamberlin 1931
Beier 1932
Harvey 1992
EPIOCHIERATA
IOCHEIRATA
HEMICTENATA
PANCTENATA
MESTOMMATINA
ELASSOMMATINA



Beier M.

Chamberlin J.C.

Heurtault J.



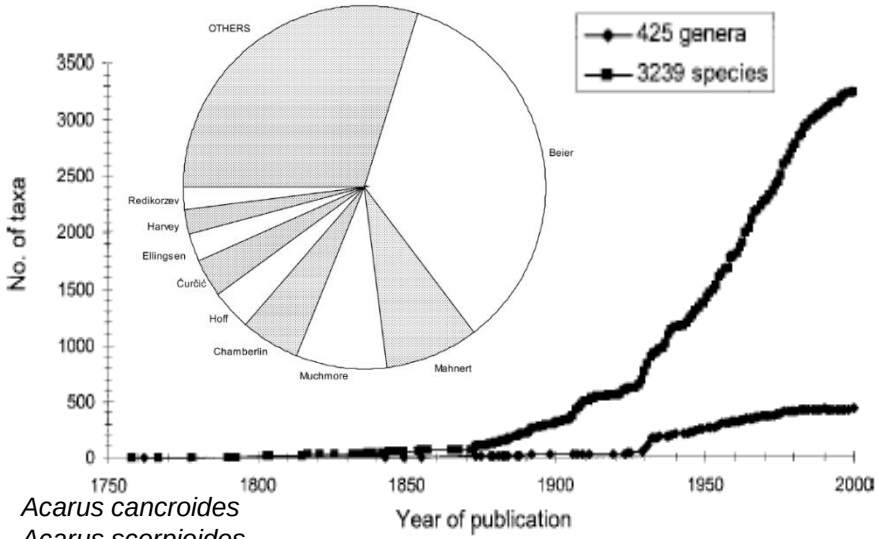
Vachon M.

Weygoldt P.

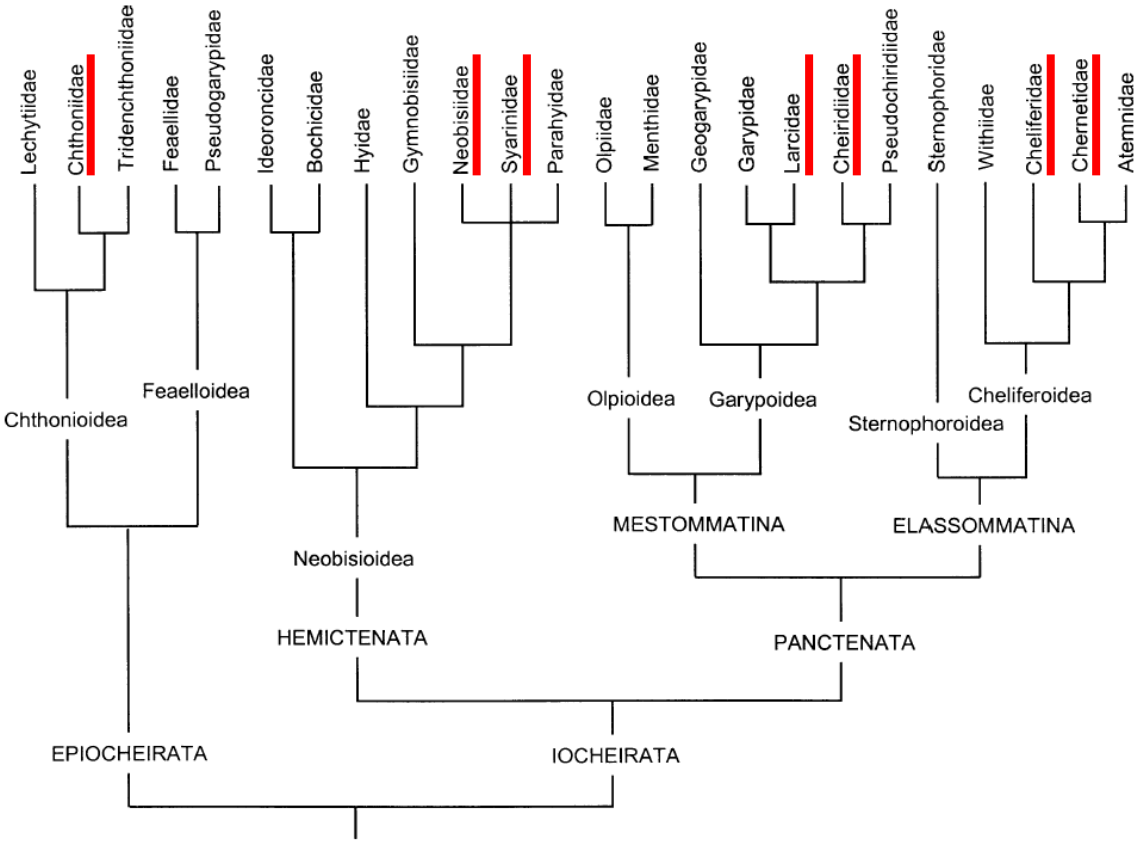
Mahnert V.

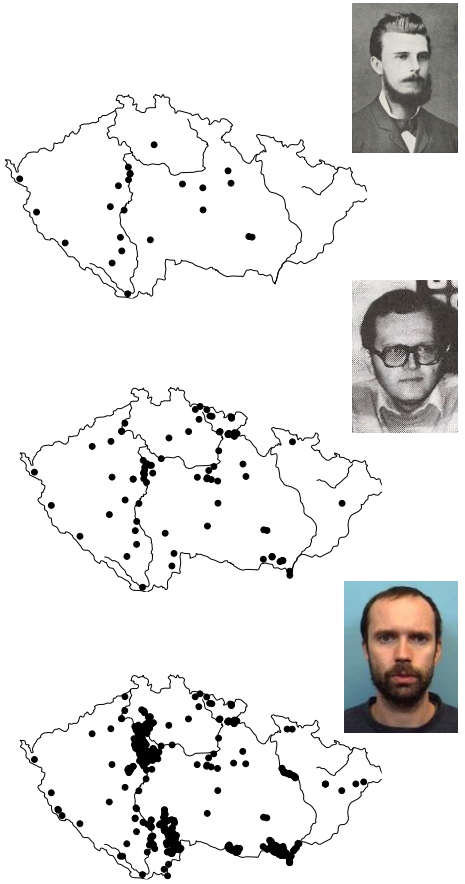
Judson M.

Harvey M.S.

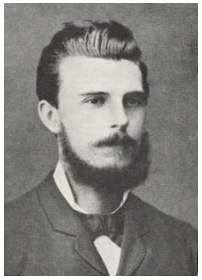


Acarus cancroides
Acarus scorpioides





Červená et al. 2020 *Arthropoda Selecta 29(2):* 219–228



Stecker A.

Verner P.H.

Ducháč V.

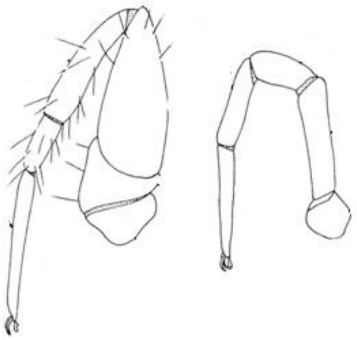
Families	Countries								
	AT	CH	CZ	DE	HU	PL	SI	SK	Σ
Chthoniidae	18/3	18/4	10/3	15/4	13/3	6/3	11/3	14/3	34/4
Geogarypidae	1/1	0/0	0/0	0/0	0/0	0/0	0/0	0/0	1/1
Neobisiidae	24/3	17/3	8/3	12/3	18/3	12/3	19/2	17/3	48/3
Syarinidae	1/1	3/1	1/1	1/1	0/0	0/0	0/0	0/0	4/2
Larcidae	1/1	0/0	1/1	1/1	1/1	1/1	0/0	1/1	1/1
Cheiridiidae	2/2	2/2	2/2	2/2	1/1	2/2	0/0	1/1	2/2
Atemnidae	1/1	1/1	0/0	0/0	2/2	0/0	0/0	2/2	2/2
Cheliferidae	5/5	6/6	3/3	3/3	3/3	3/3	0/0	7/5	9/6
Chernetidae	15/7	15/7	13/7	15/8	13/6	14/7	3/2	14/7	22/8
Withiidae	2/1	2/1	0/0	1/1	2/1	0/0	0/0	1/1	2/1
Species/genera total	70/25	64/25	38/20	50/23	53/20	38/19	33/7	57/23	125/30

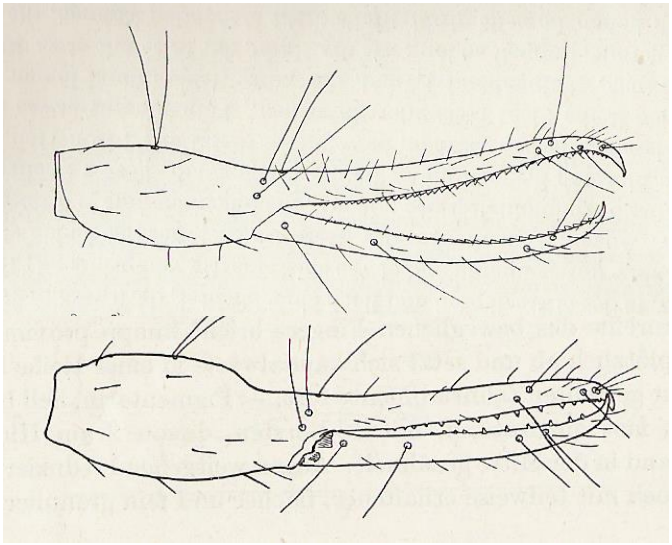
Abbreviations: AT — Austria, CH — Switzerland, CZ — the Czech Republic, DE — Germany, HU — Hungary, PL — Poland, SI — Slovenia, SK — Slovakia, Σ — number of species/genera for all considered countries.

čel.: **Chthoniidae** (631/9)

1122
carapax broader in front part
chelicerae large
pedipalps without venom glands
tergites undivided
simple spermatophors
ČR 3 genera:

Mundochthonius
Chthonius
Ephippiochthonius





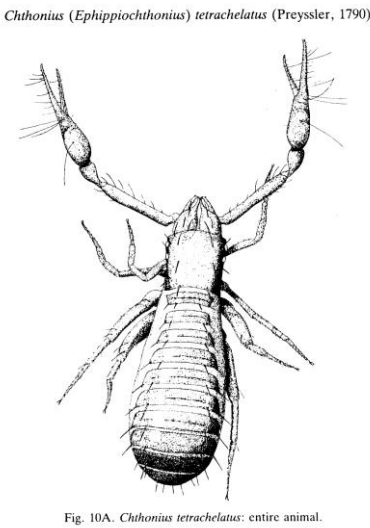


Fig. 10A. *Chthonius tetrachelatus*: entire animal.

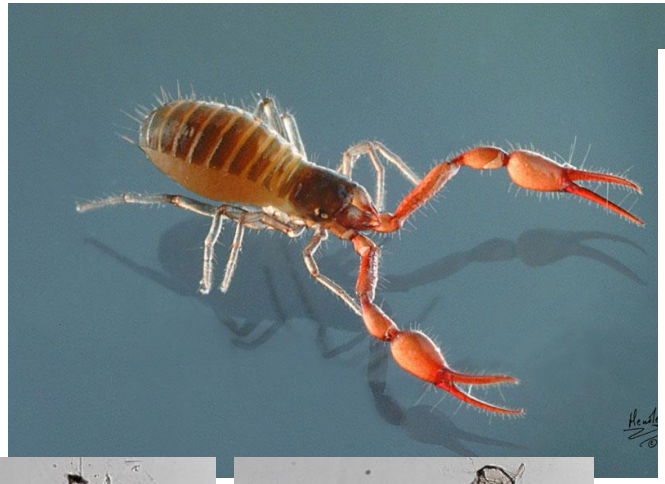
Preyssler, J. D. (1790): Verzeichniss Böhmischer Insekten. Prag 1-57.

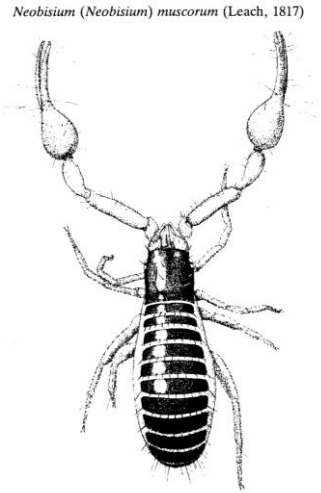
E. tetrachelatus

čel.: **Neobisiidae** (548/8)

2222
carapax of the same breadth
chelicerae large
tergites undivided
ČR 3 genera:

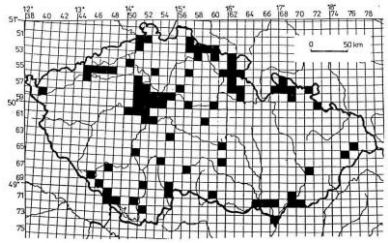
Neobisium
Roncus
Microbisium

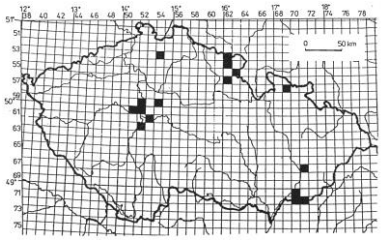


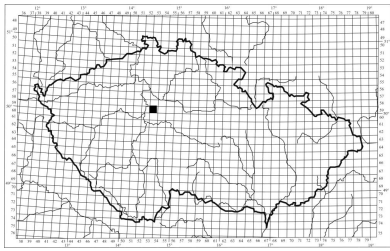


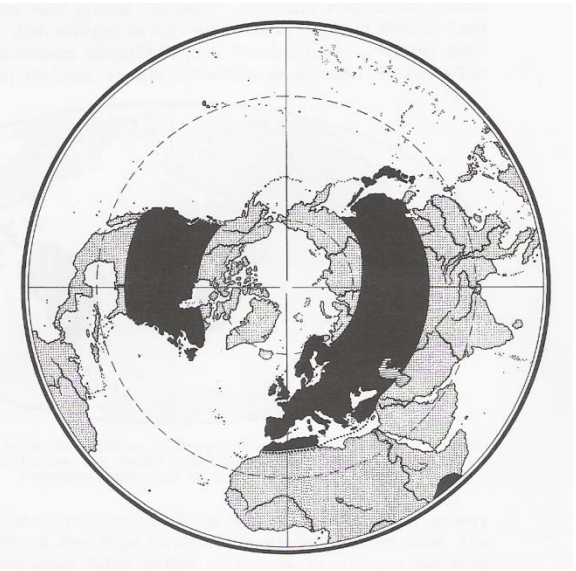
Neobisium (*Neobisium*) *muscorum* (Leach, 1817)

Fig. 17A. *Neobisium muscorum:* entire animal.





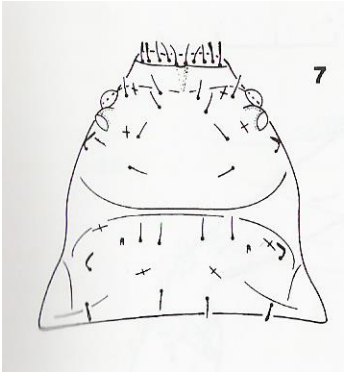


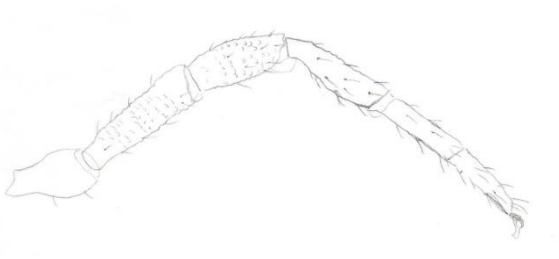


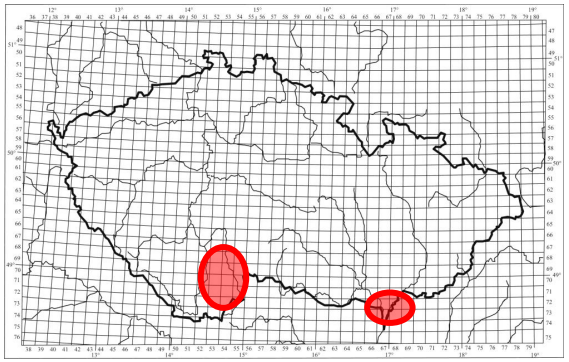
čel.: **Larcidae** (15/1)

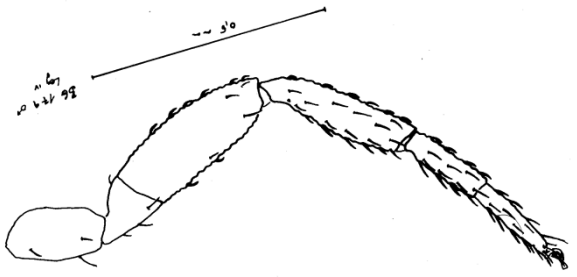
2222
2 pairs of eyes
chelicerae small
Tergites divided

ČR: *Larca lata*





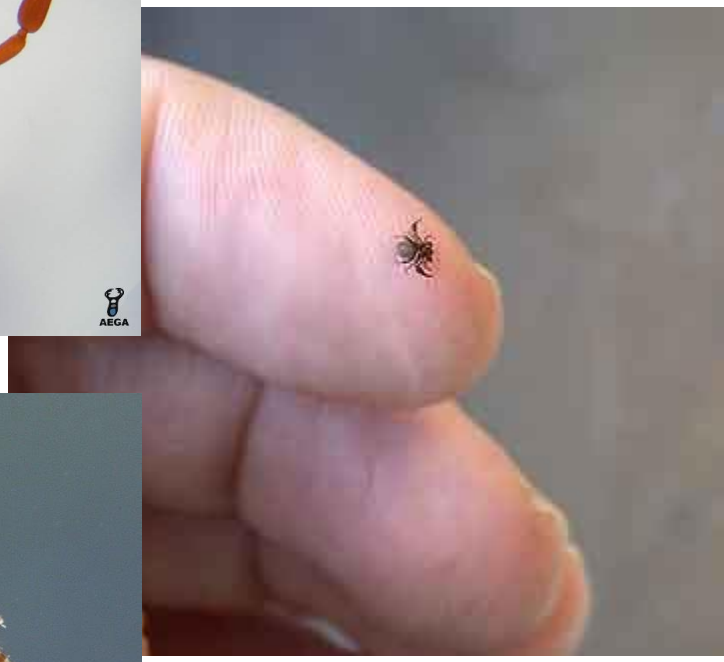


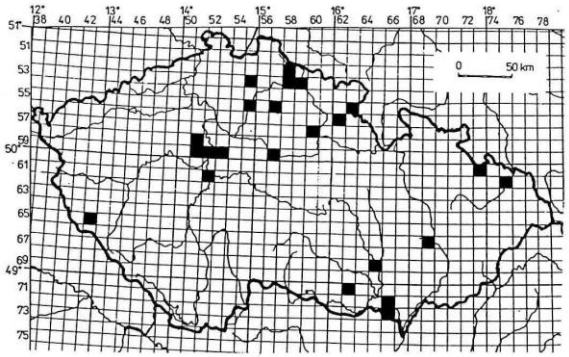


čel.: **Cheliferidae** (275/3)

1111
chelicerae small
Tergites divided

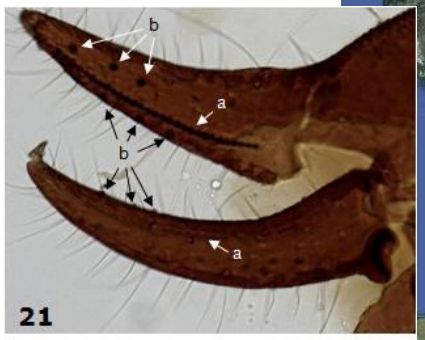
ČR: *Chelifer cancroides*
Mesochelifer ressli
Dactylochelifer latreillei



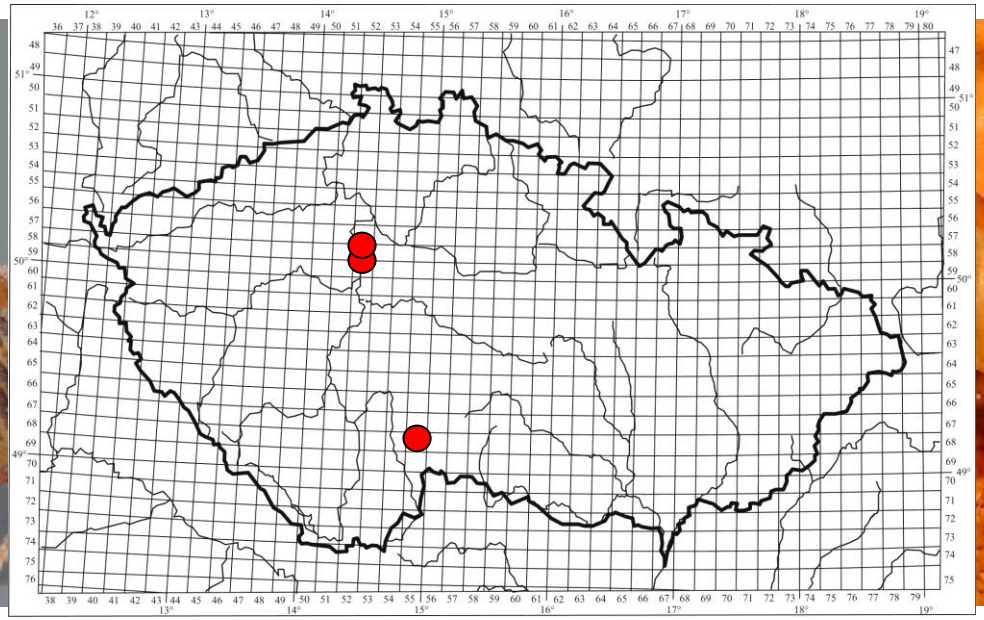


čel.: **Chernetidae** (652/13)

1111
Chelicerae small
Tergites divided
phoresy
Chernetidae – *Lamprochernes nodosus* (phoresy)
Chernes hahnii
Dendrochernes cyrneus
Anthrenochernes stellae



Chernes hahnii

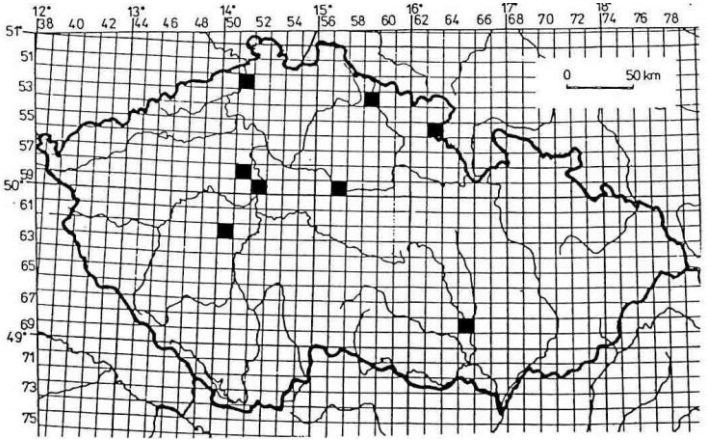


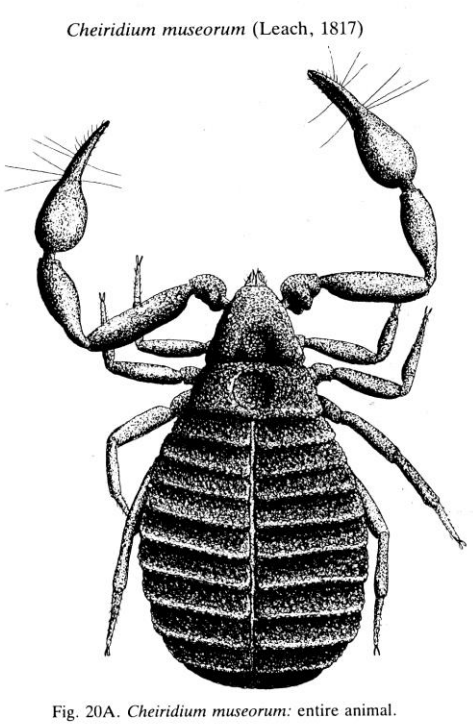
čel.: **Cheiridiidae** (71/2)

1111
Chelicerae small
Tergites divided
Body size small

ČR:

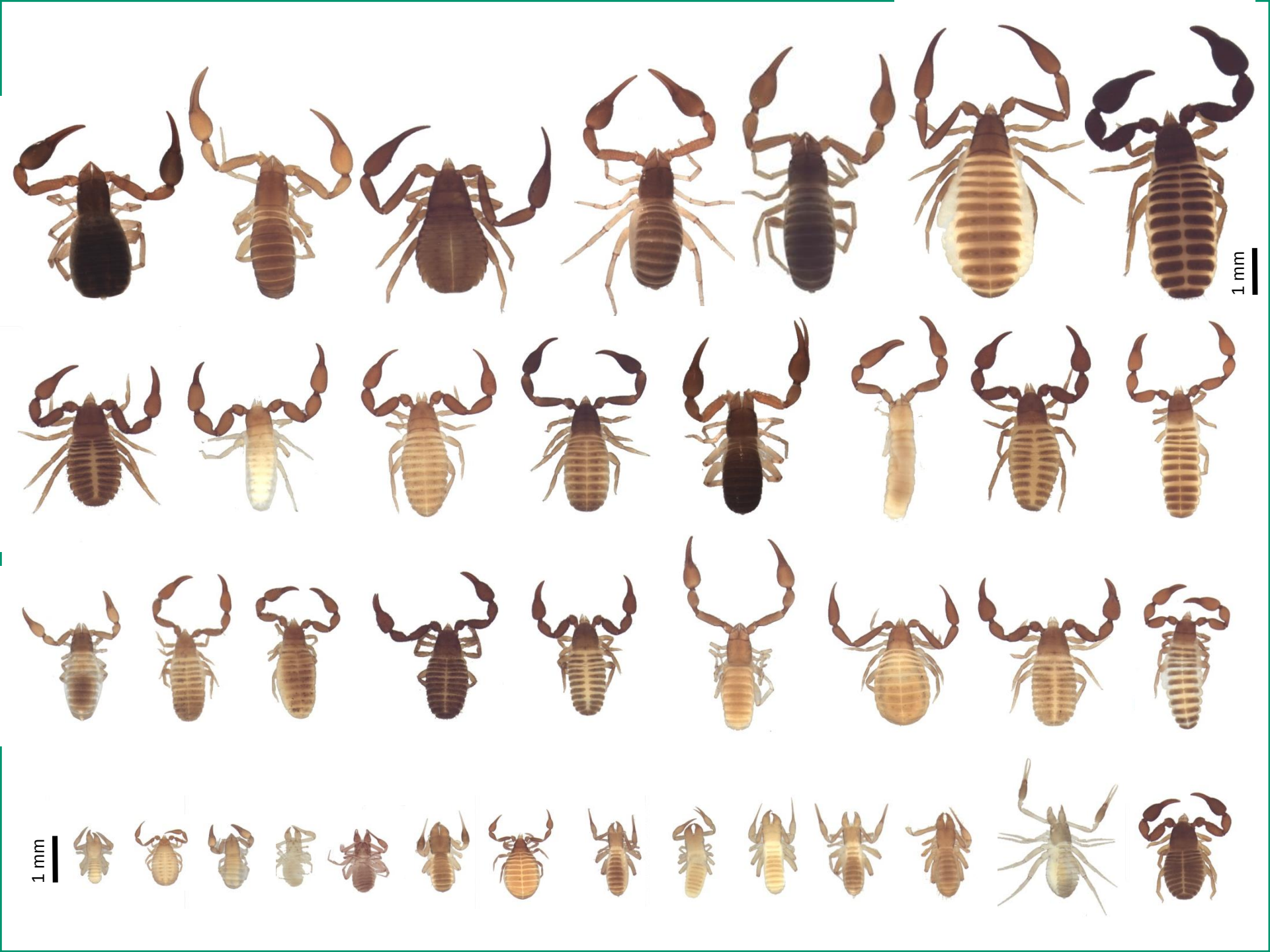
Cheiridium museorum
Apocheiridium ferum





Cheiridium museorum (Leach, 1817)

Fig. 20A. *Cheiridium museorum:* entire animal.

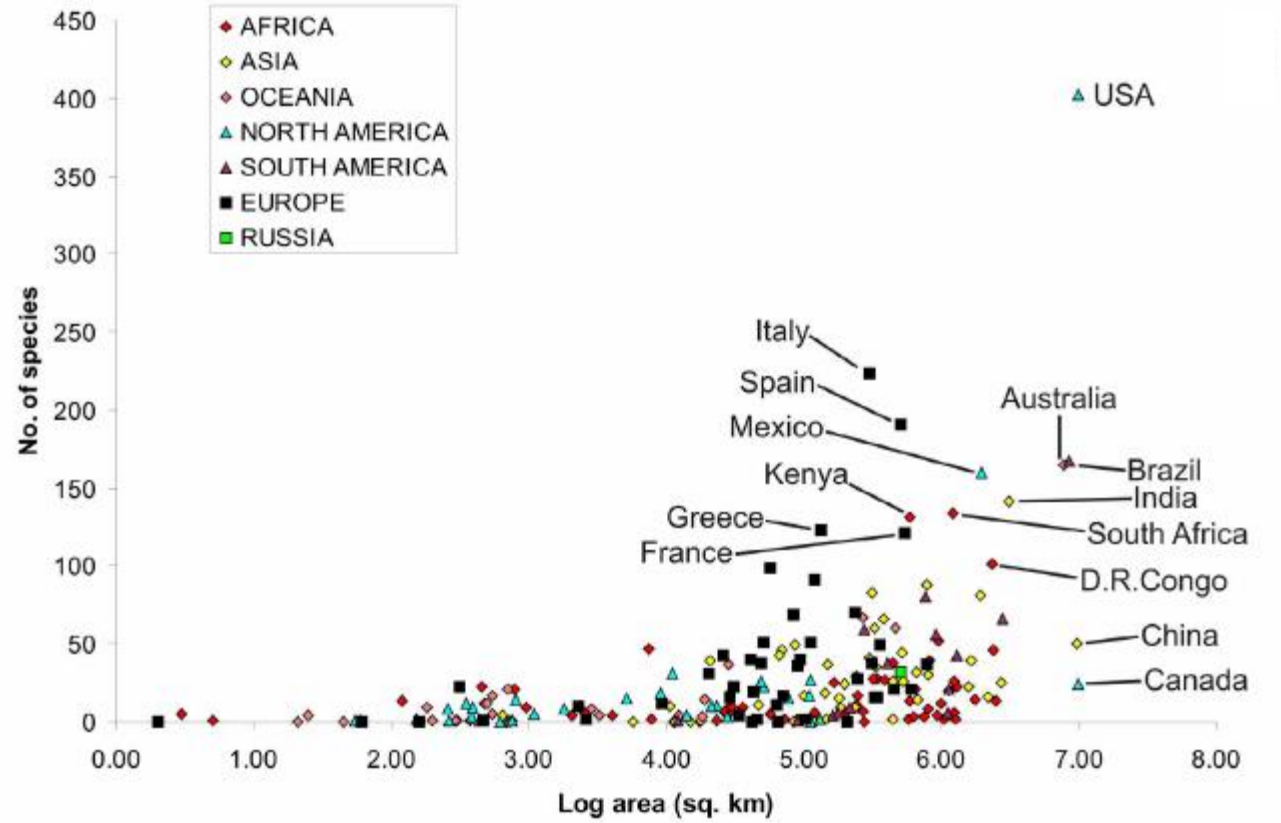

1 mm
1 mm

under bark

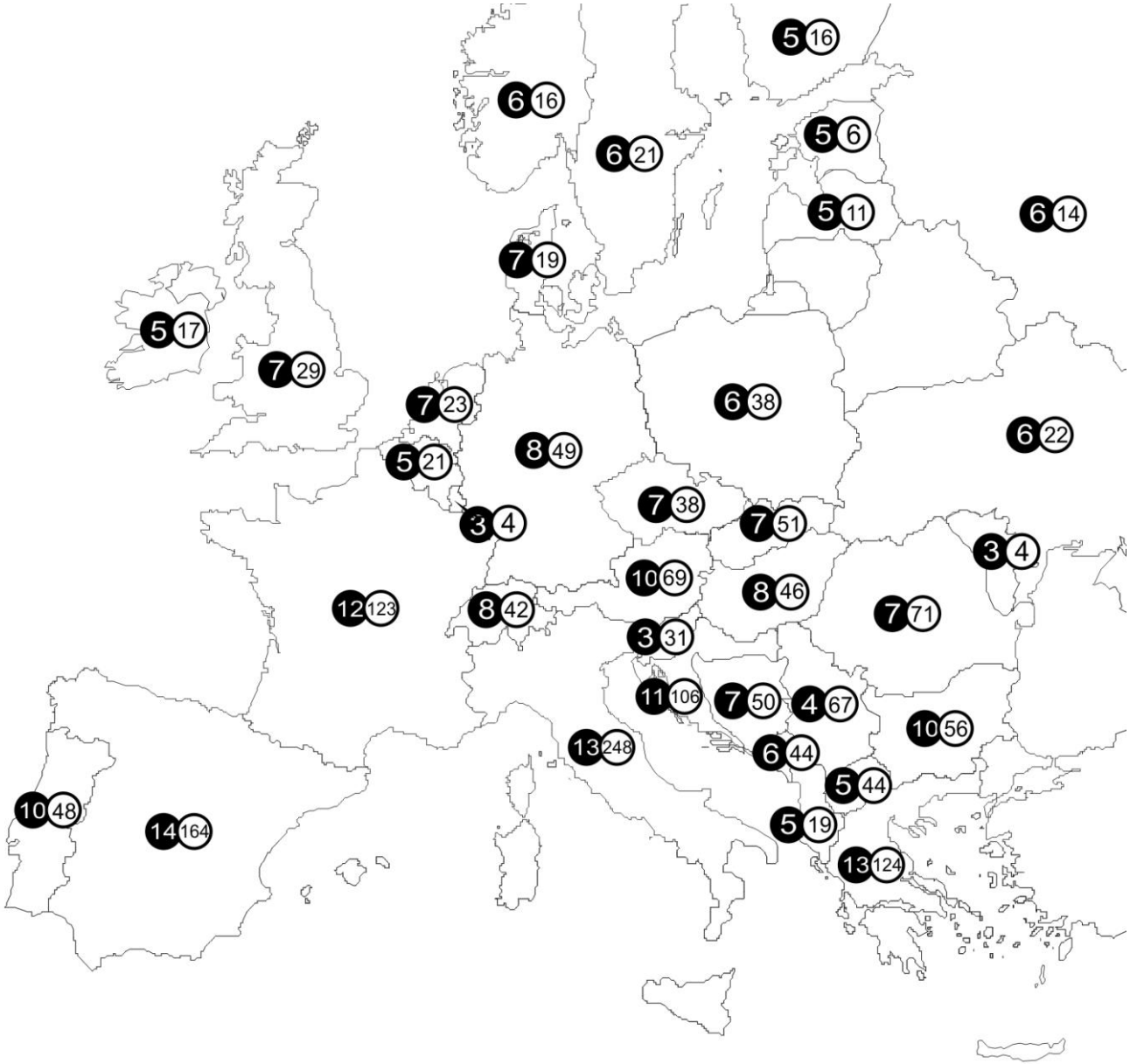
hollow trees

Leaf litter, soil

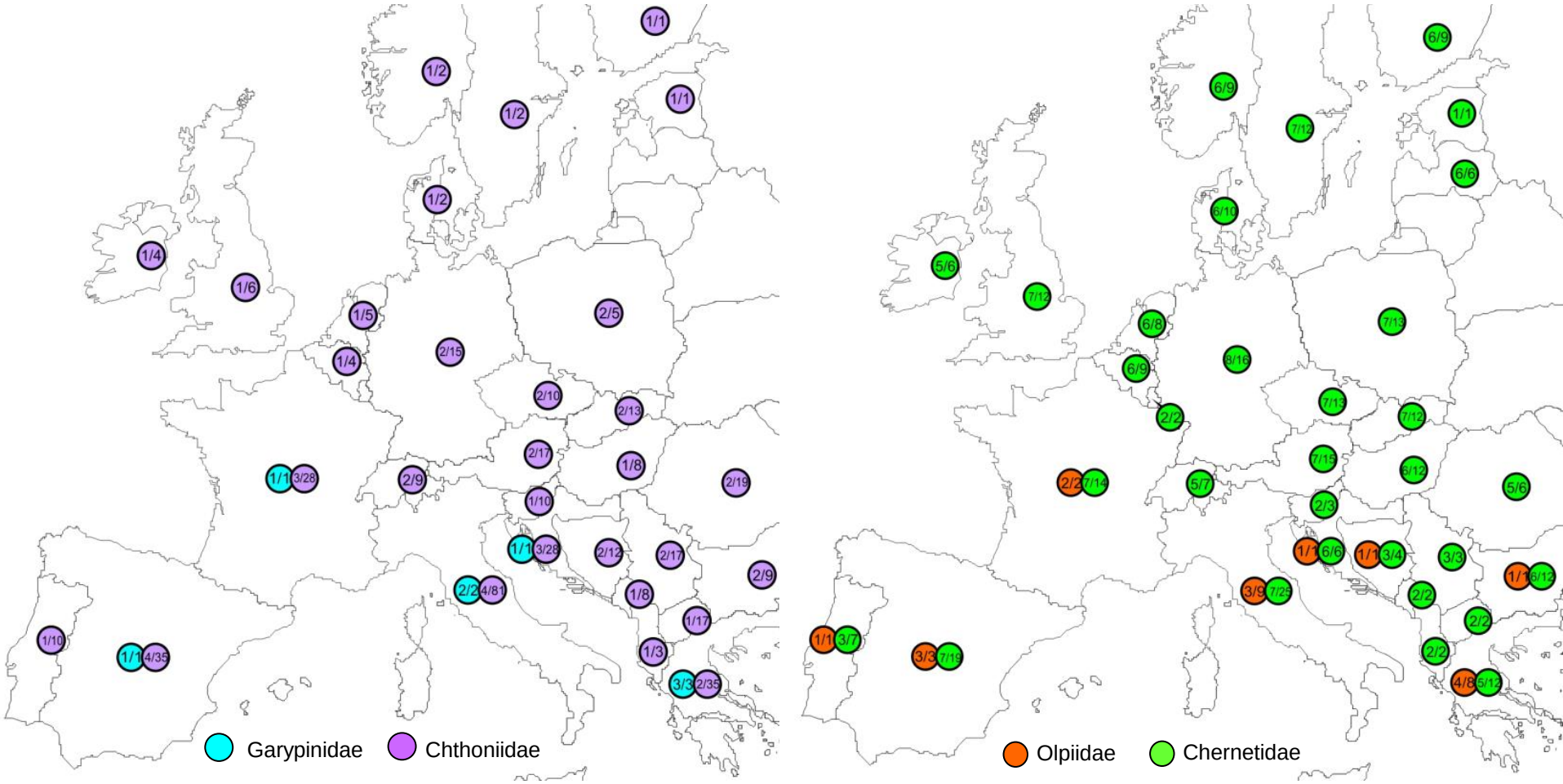
caves



Region	No. of species	Area (km^2)
AFRICA	559	30,343,578
ASIA	476	45,036,492
EUROPE	760	9,908,599
NORTH AMERICA	583	24,680,331
OCEANIA	367	8,504,256
SOUTH AMERICA	405	17,815,420



Kotrbová 2012

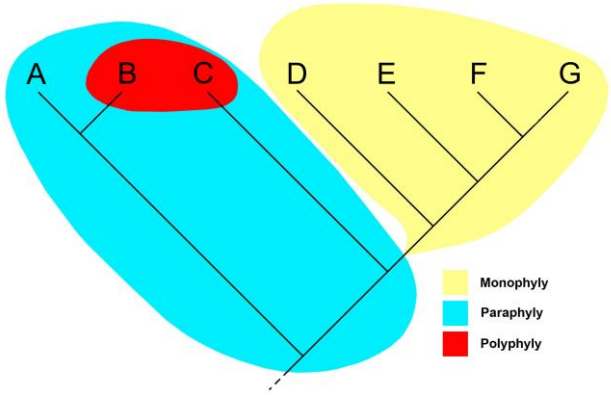


Kotrbová 2012

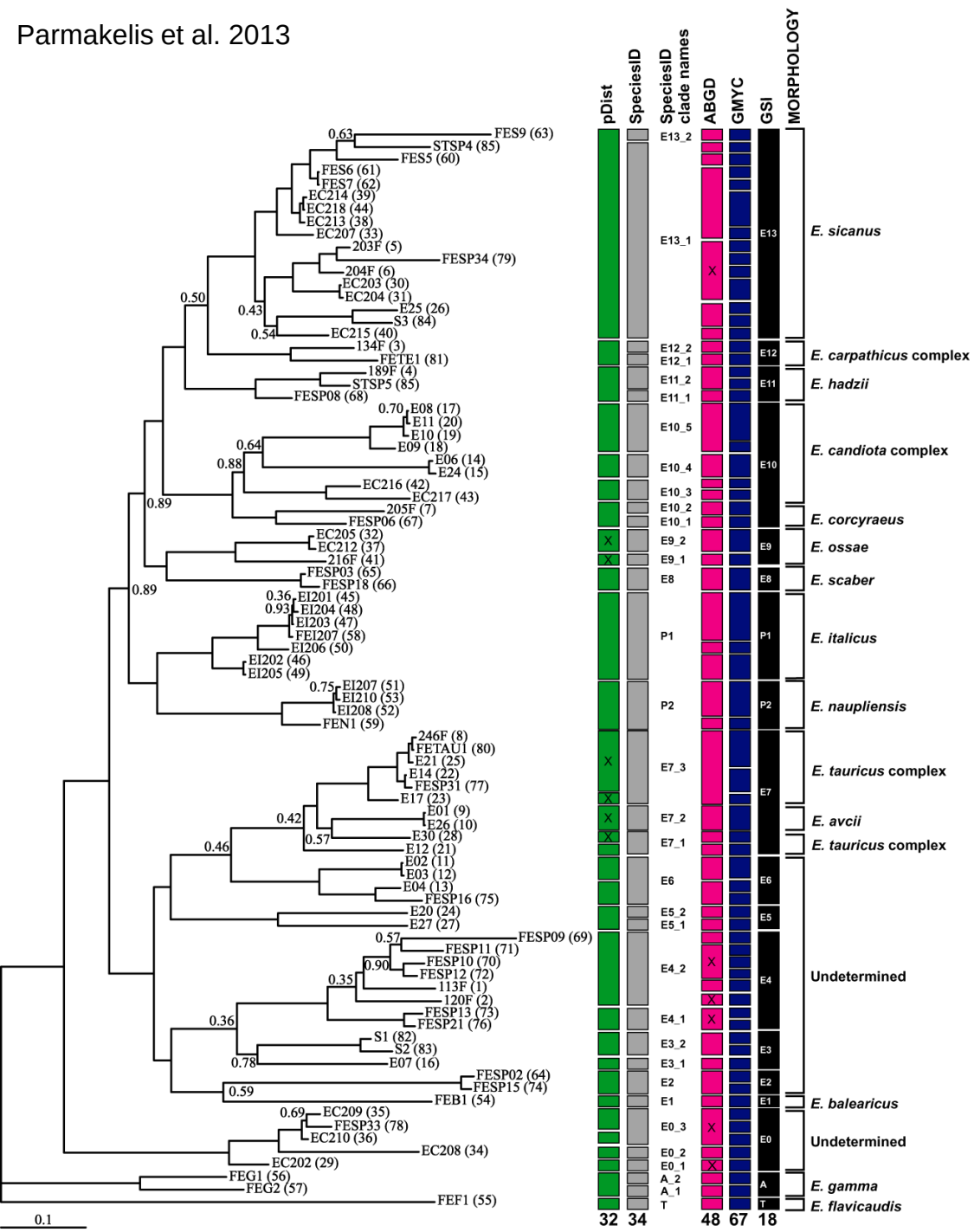
Definition of species

Biological species concept (reproductive or isolation concept)	groups of actually or potentially interbreeding natural populations, which are reproductively isolated from other such groups (Mayr 1942)
Mate-recognition species	a group of sexually reproducing organisms that recognize one another as potential mates
Evolutionary species	an entity composed of organisms which maintains its identity from other such entities through time and over space, and which has its own independent evolutionary fate and historical tendencies (Simpson 1951)
Typological species (morphospecies)	a group of organisms in which individuals conform to certain fixed properties (a type)

problems – variability, cryptic species, monophyly



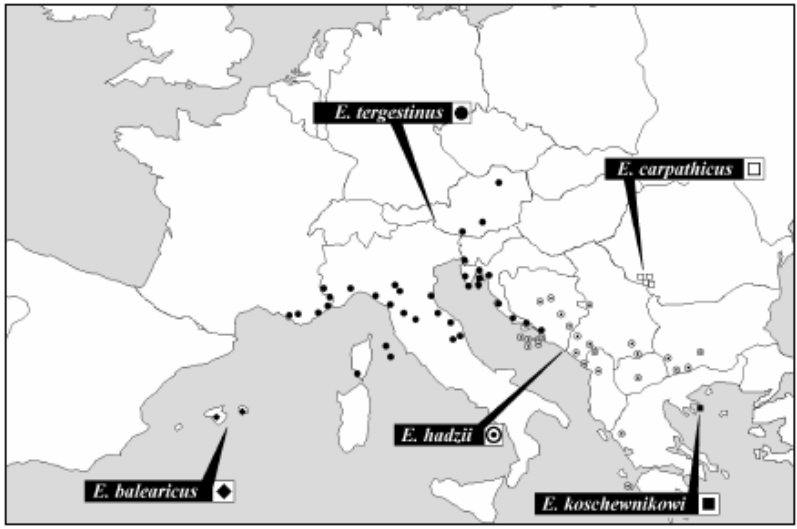
Parmakelis et al. 2013



Euscorpius

Kovařík 1998 → Rein 2021

1 genus/5 species **3 genera/90 species**



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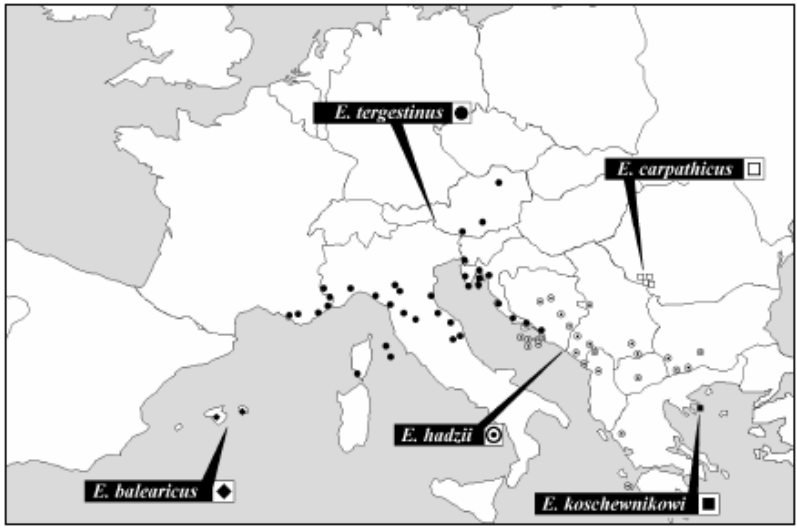
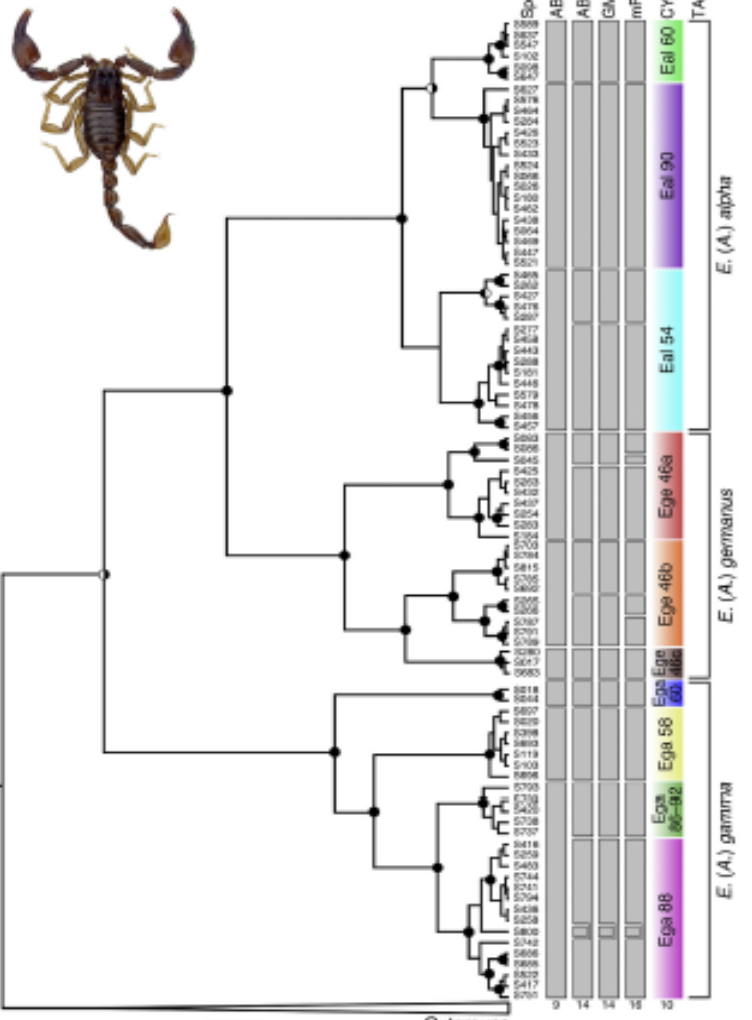
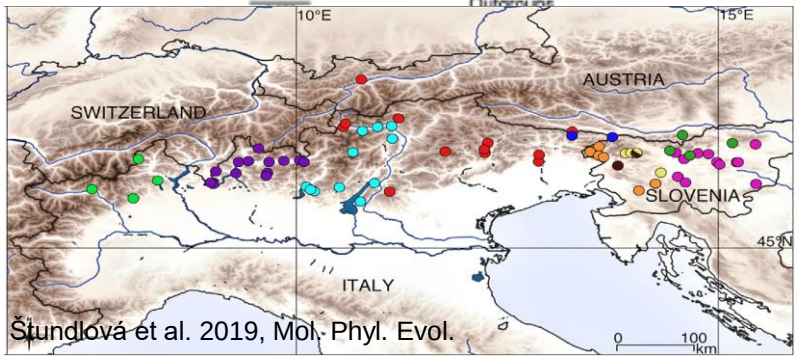
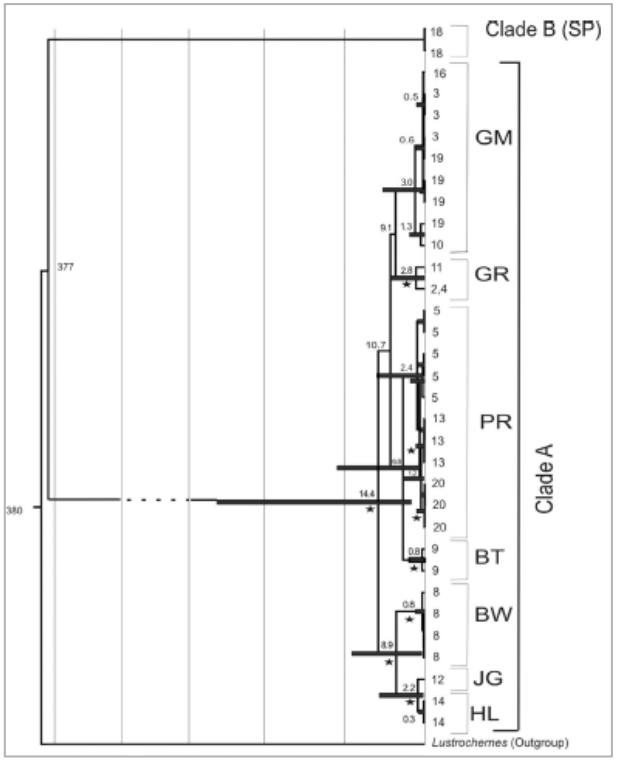




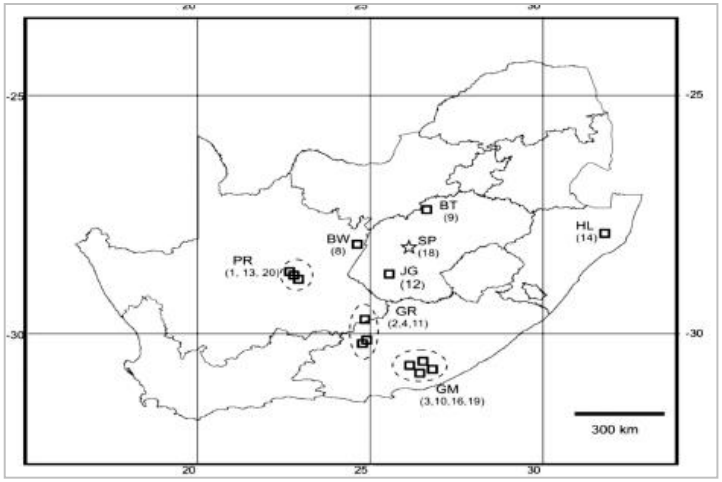


Stundlová et al. 2019, Mol. Phyl. Evol.

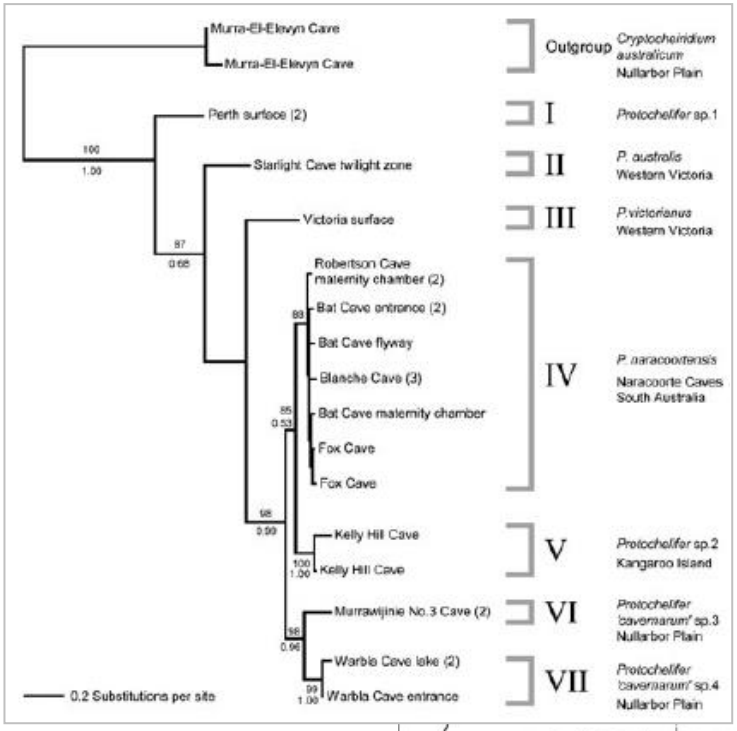
Horus



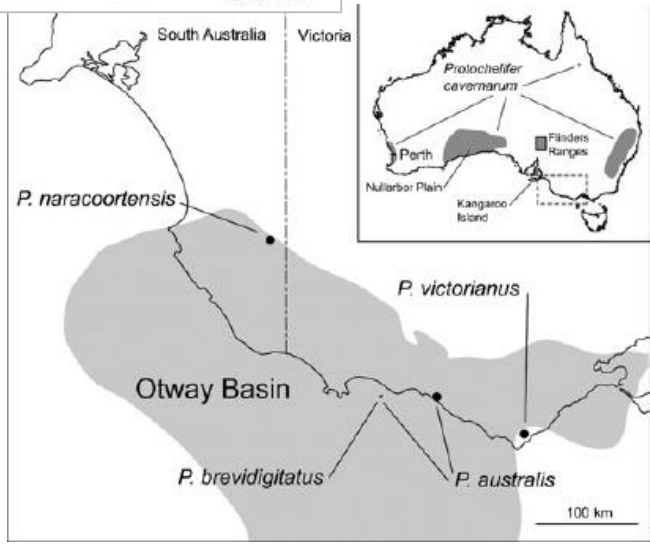
van Haarden et al. 2013



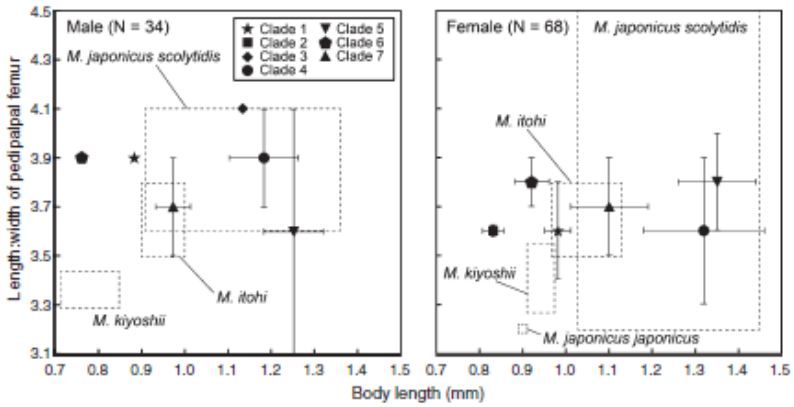
Protochelifer



Moulds el al. 2007

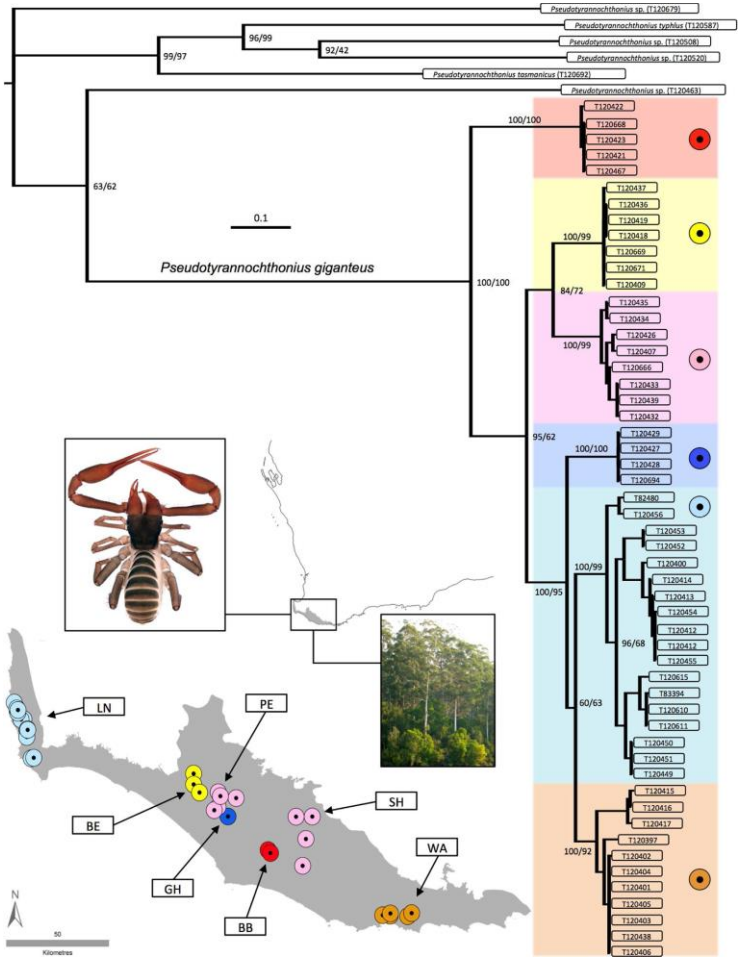


Mundochthonius



Ohira et al. 2018

Pseudotyrannochthonius



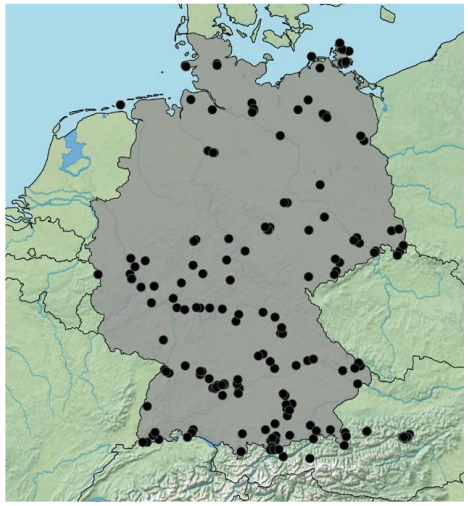
Harms 2018

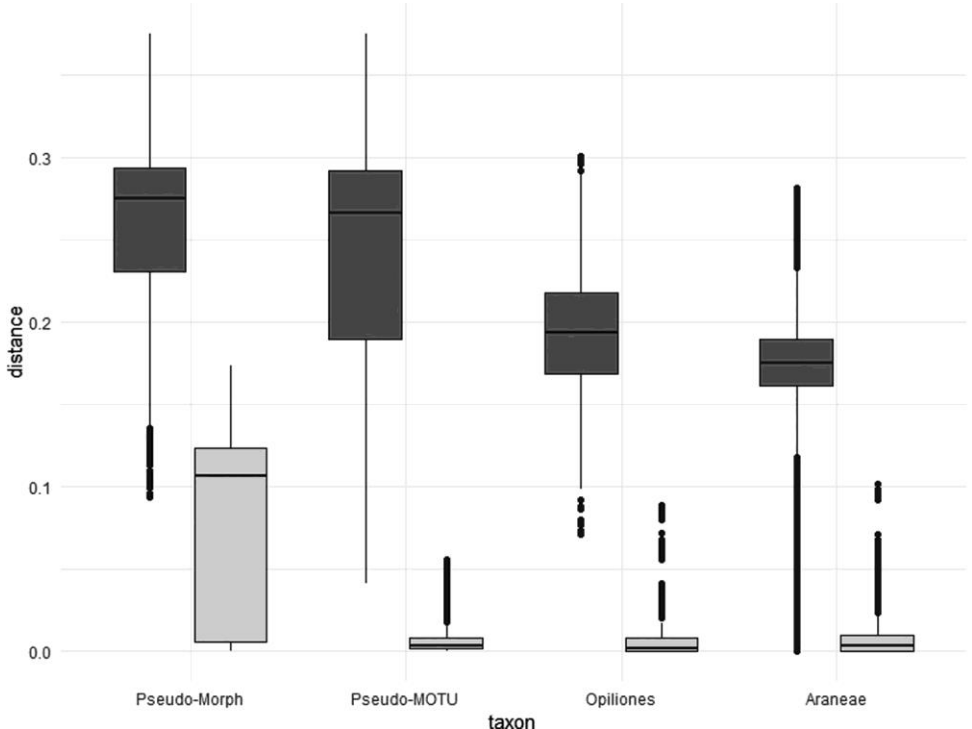
F

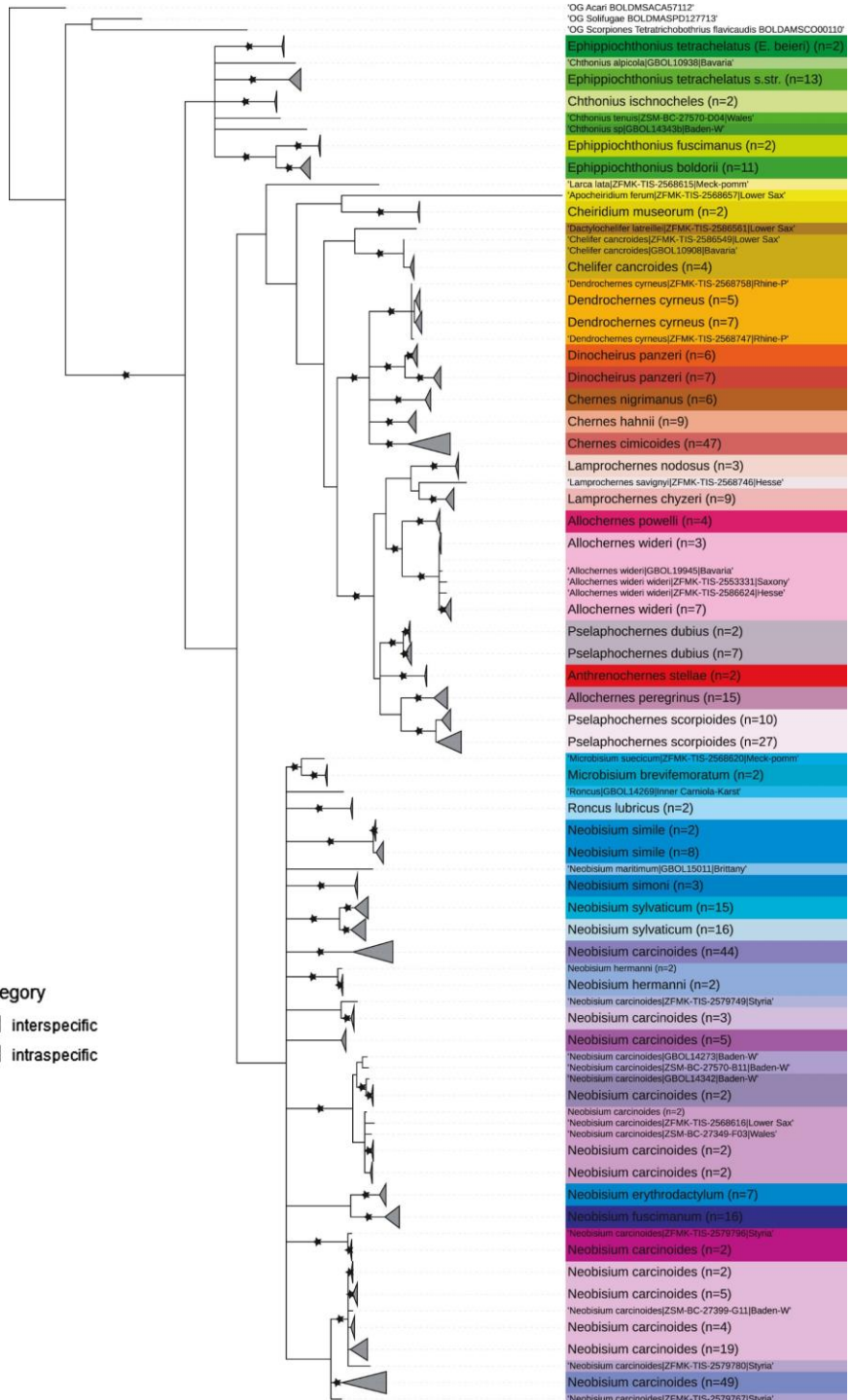
E

„The German Barcode of Life campaign reveals high levels of undocumented diversity in European false scorpions“

Muster et al. 2021, *Ecol. Evol.*, doi: 10.1002/ece3.8088





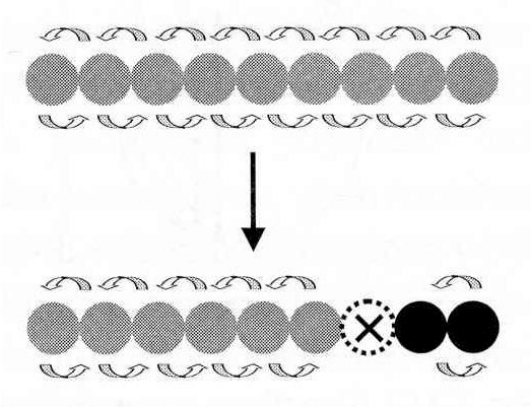


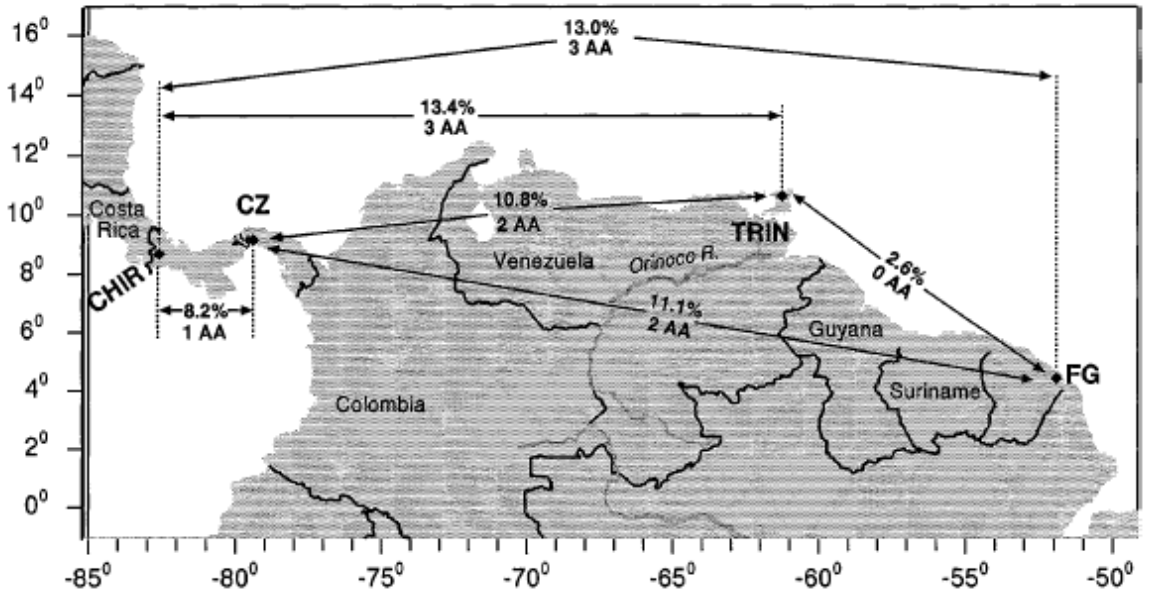
fast speciation

- extinction

  Gene flow only between neighbouring populations. Extinction of some population cause very fast genetic separation.

Cordylochernes scorpioides





Wilcox et al. 1997

fast speciation

- Polyploidization or hybridization – frequently in plants

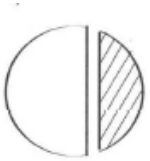
Chernetidae

Atemnidae

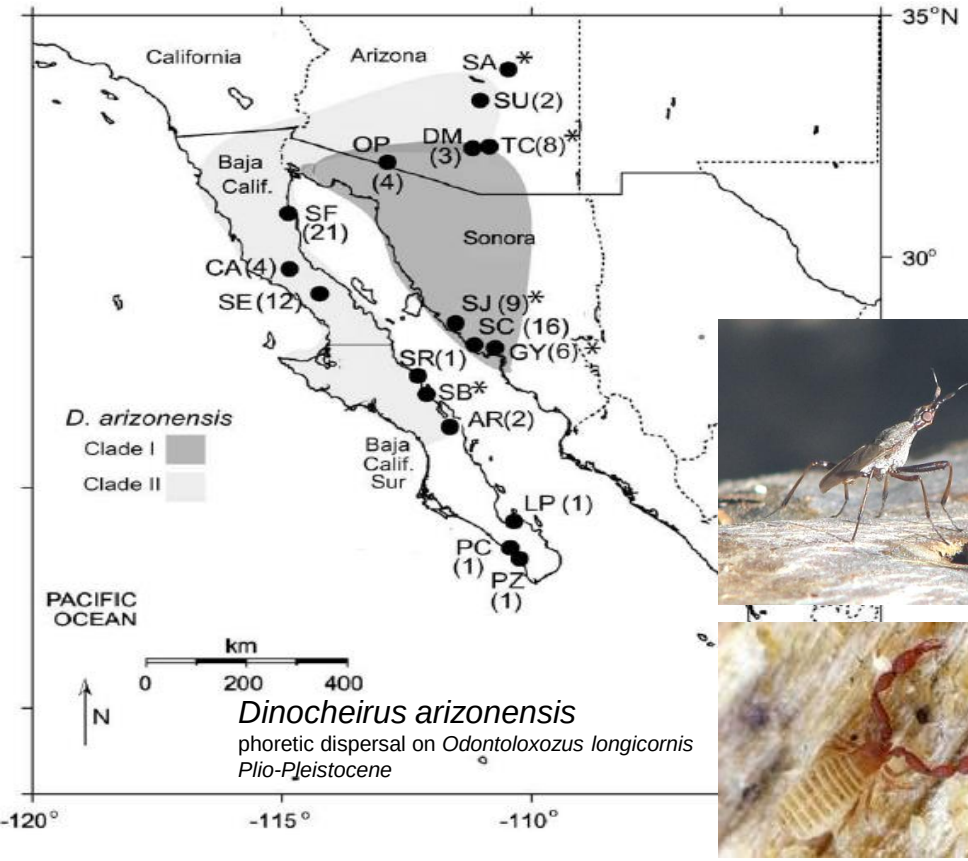
Chernes hahnii 2n=49

Diplotemnus insolitus 2n=122

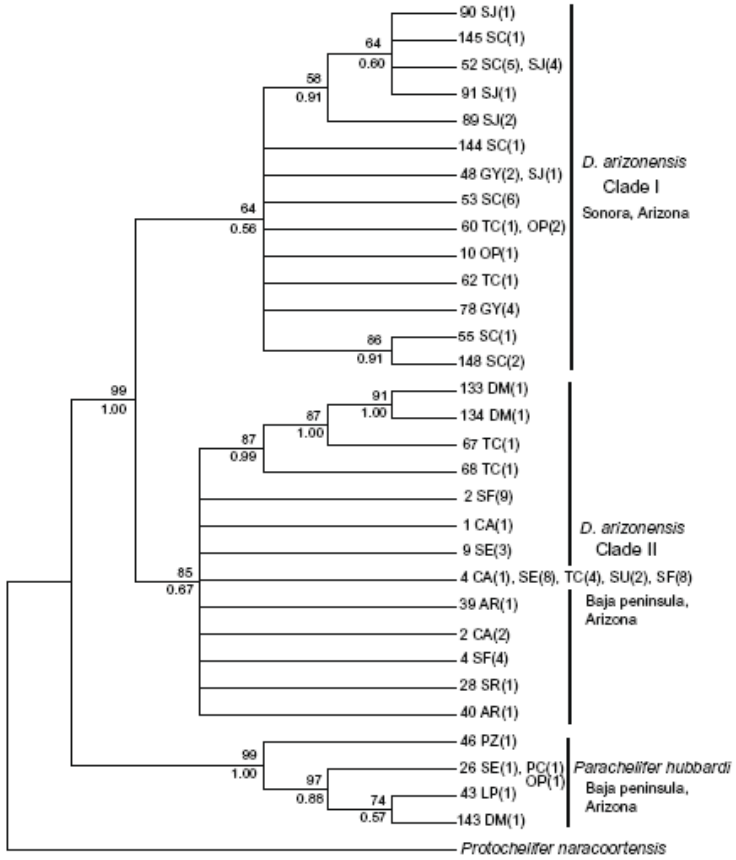
gradual speciation - allopatric population splits into two geographically isolated populations



vicariant new populations of similar size

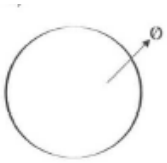


Dinocheirus arizonensis
phoretic dispersal on *Odontoloxozus longicornis*
Plio-Pleistocene



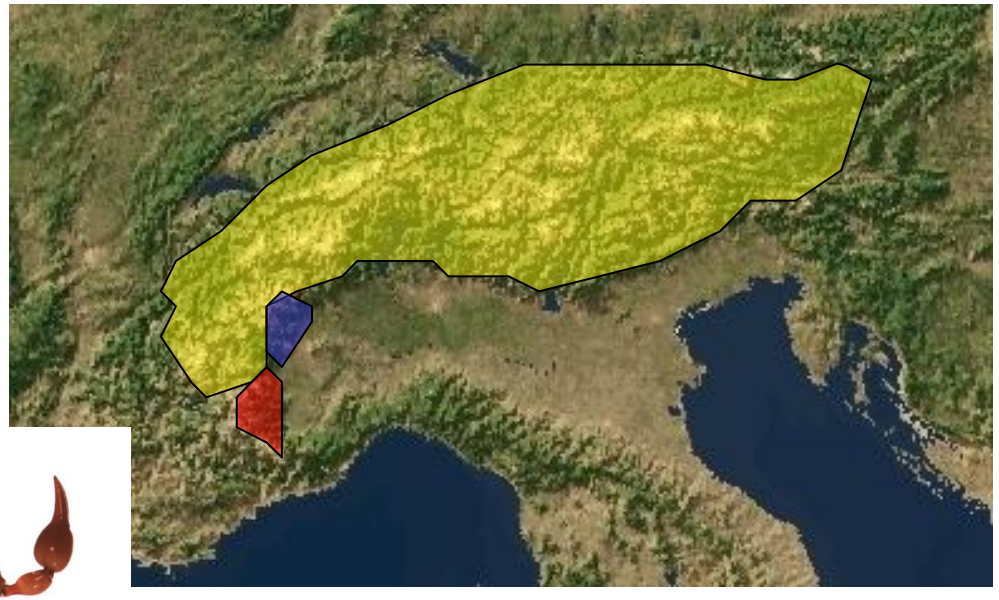
Pfeiler E, Bitler B.G., Castrezana S., Matzkin L.M. & Markow T.A. 2009: Genetic diversification and demographic history of the cactophilic pseudoscorpion Dinocheirus arizonensis from the Sonoran Desert. Molecular Phylogenetics and Evolution, 52: 133-141.

gradual speciation - allopatric population splits into two geographically isolated populations



peripatric separation of only small subpopulation

Roncus alpinus



Roncus binaghii

Roncus tuberculatus

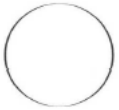
gradual speciation - sympatric formation of two or more descendant species from a single ancestral species all occupying the same geographic location

Chernes hahnii

under the bark

leaf litter

Chernes similis



Neobisium ruffoi

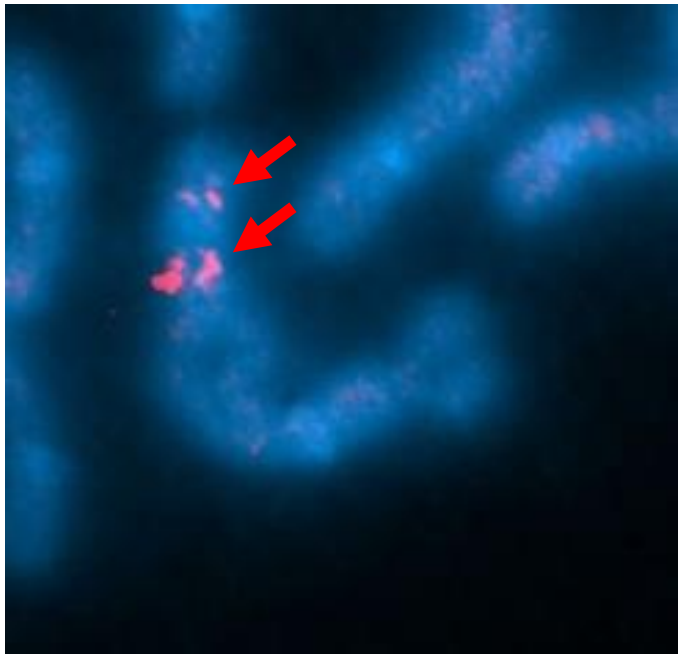
Neobisium dolomiticum

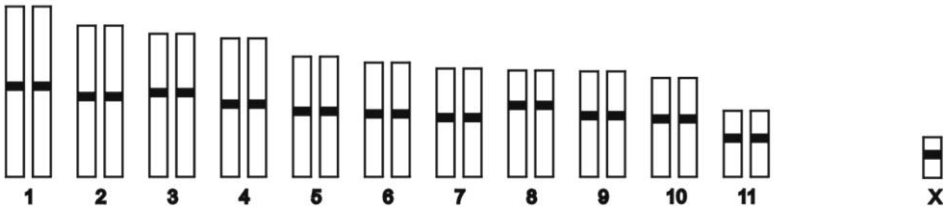
- parapatric between alopatric and sympatric speciation – gene flow still occurs

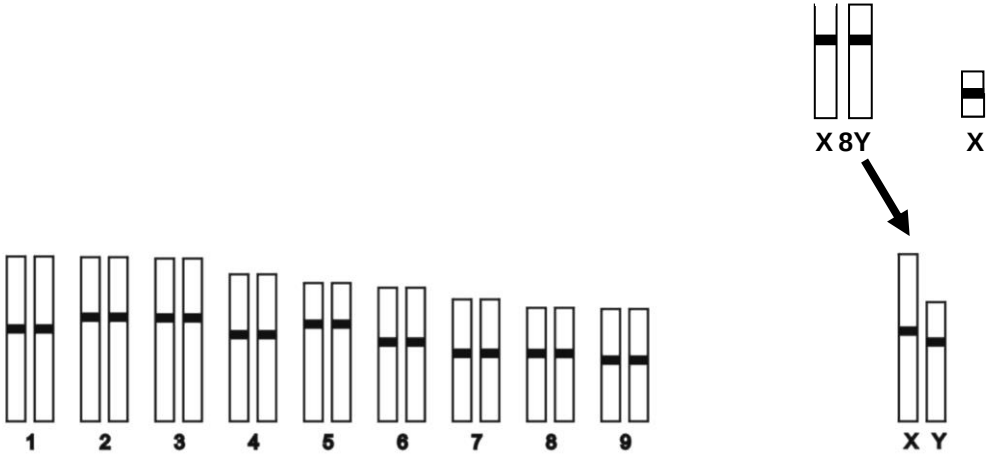
Chromosomal speciation

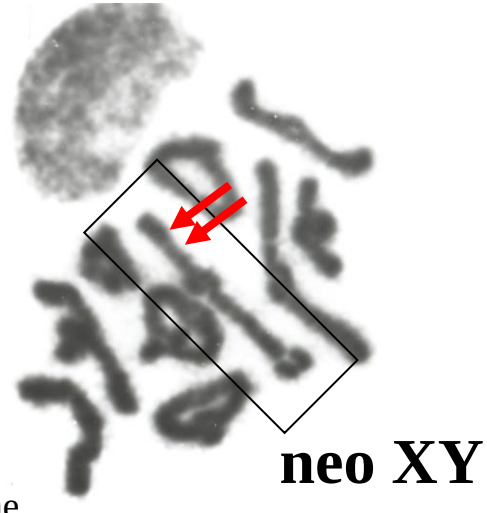
Majority of closely related species differ in karyotypes
(app. 90-98% speciation change karyotypes)
Is it consequence or cause of speciation?

"hybrid-sterility models" predicted that the recombination among rearranged chromosomes in heterokaryotypic hybrids generate unbalanced gametes and thus reduce fertility.



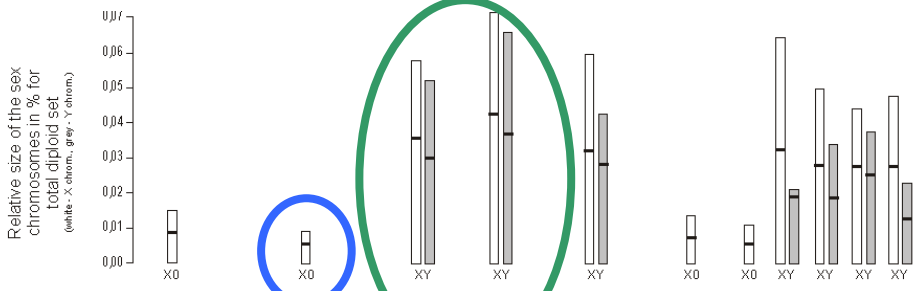






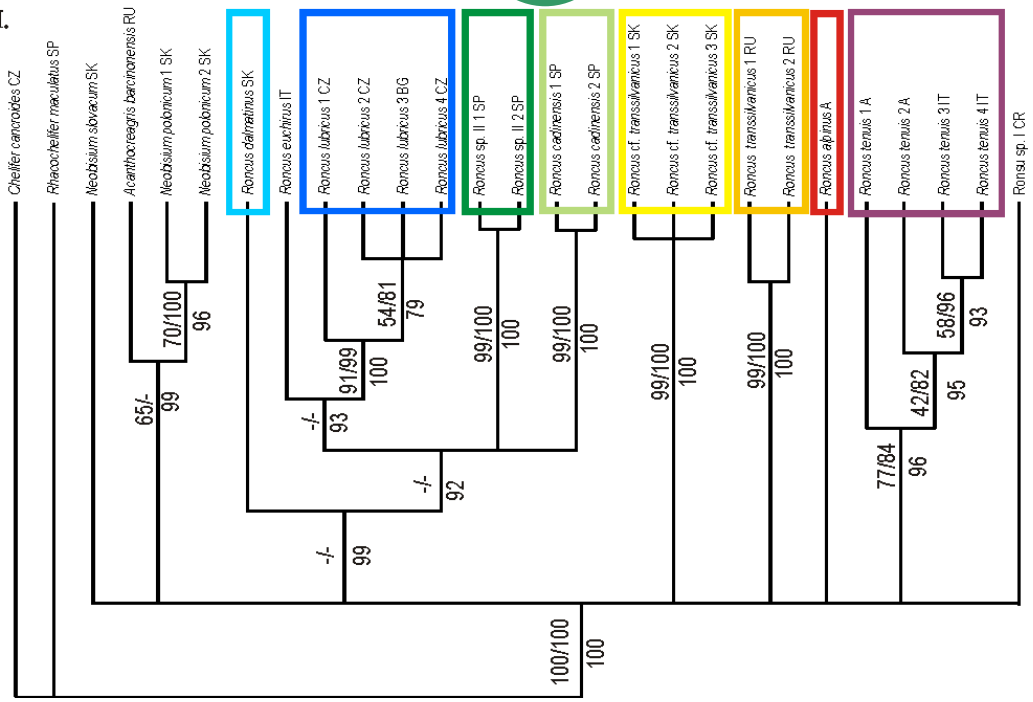
Diplotene

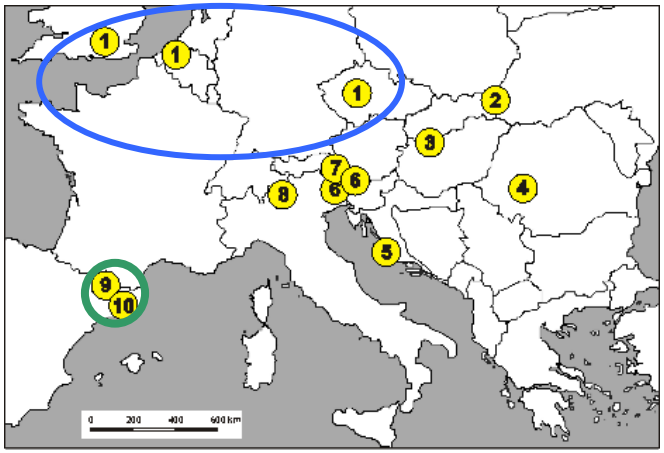
I.

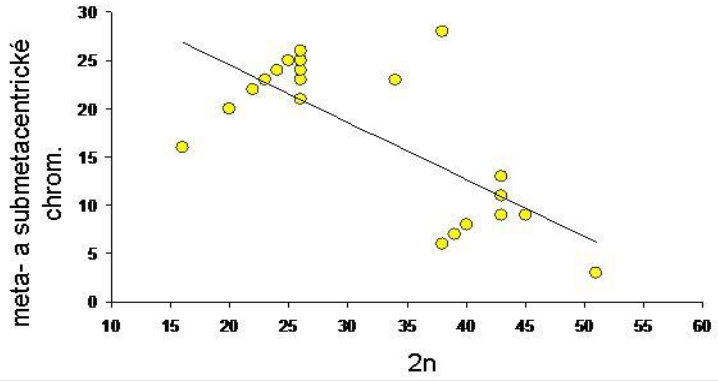


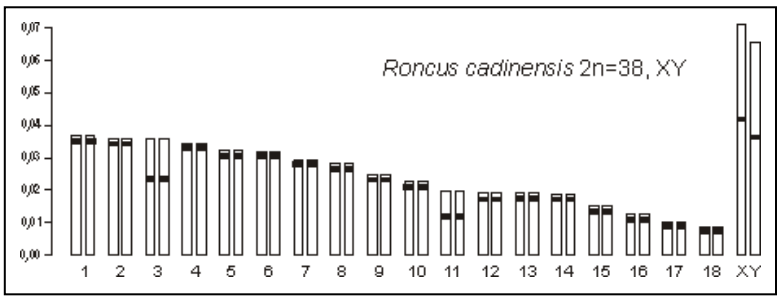
II. Diploid number: 23 ? 45 16 38 20 43 43 26 ?

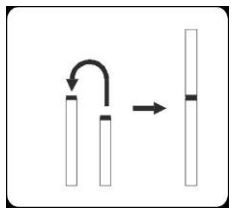
III.

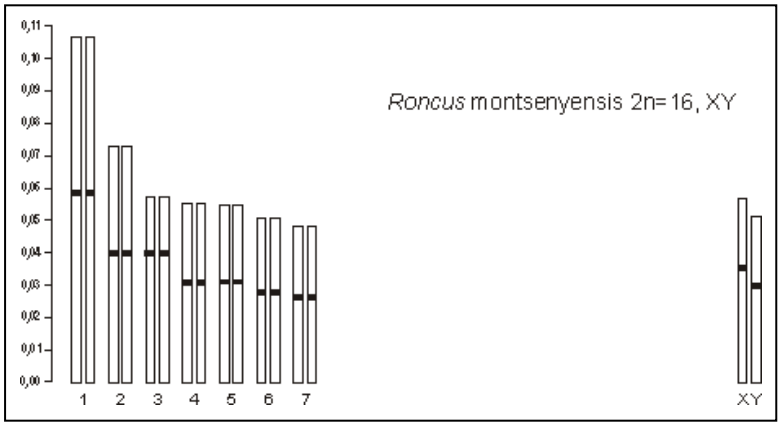




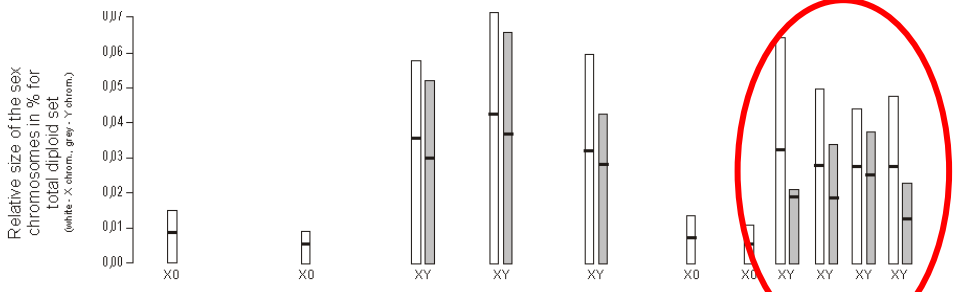






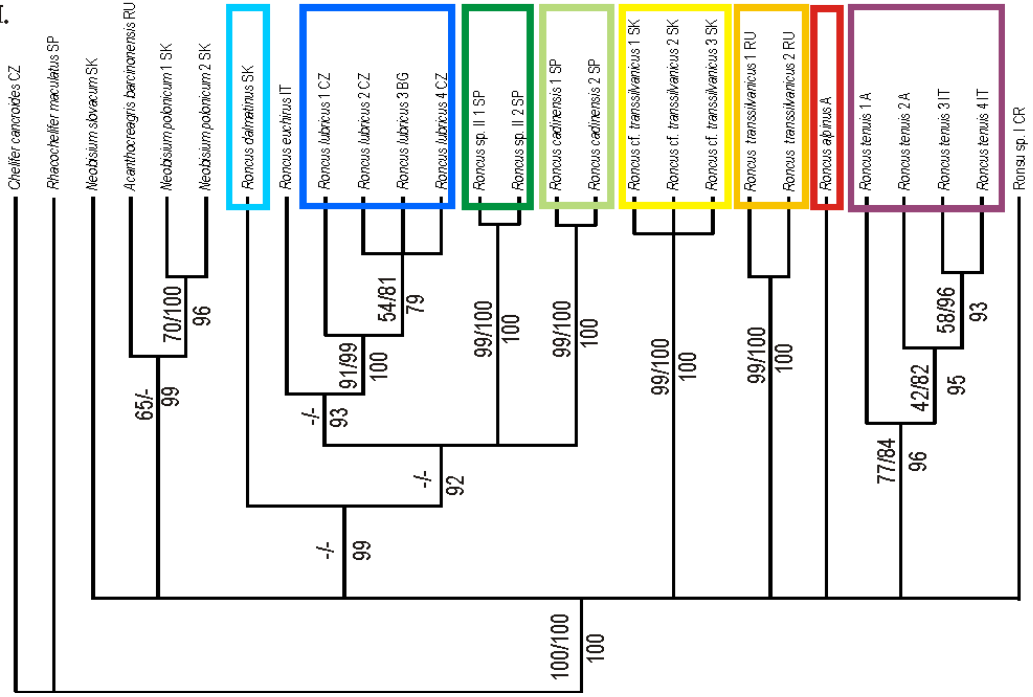


I.



II. Diploid number: 23 ? 45 16 38 20 43 43 26 ?

III.



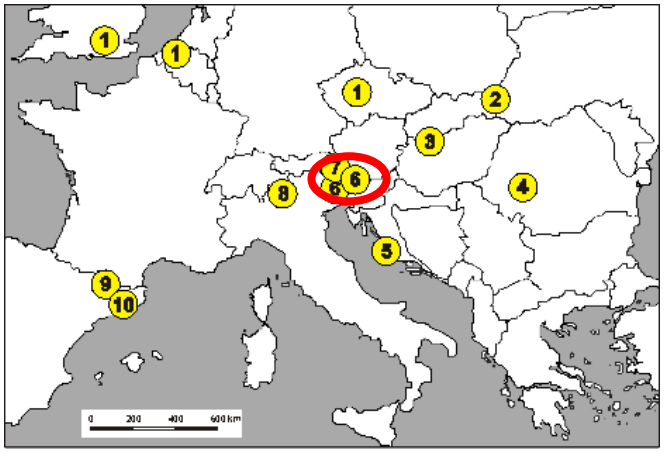


Fig. 15: Karyotype of *Roncus tenuis* 2n=26, XY

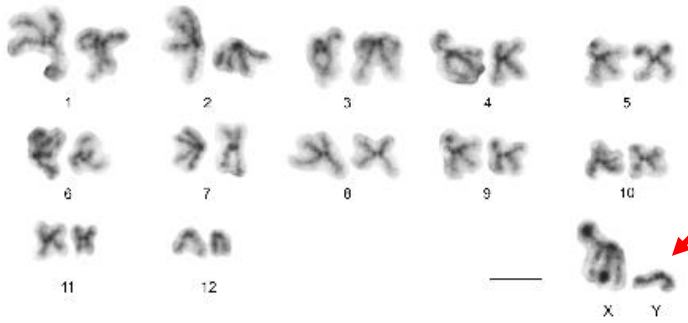
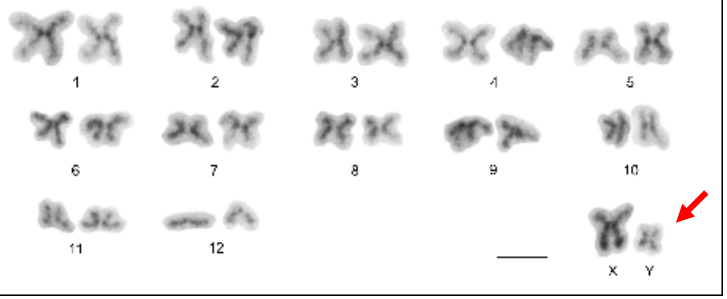
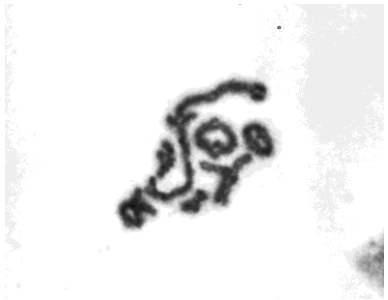
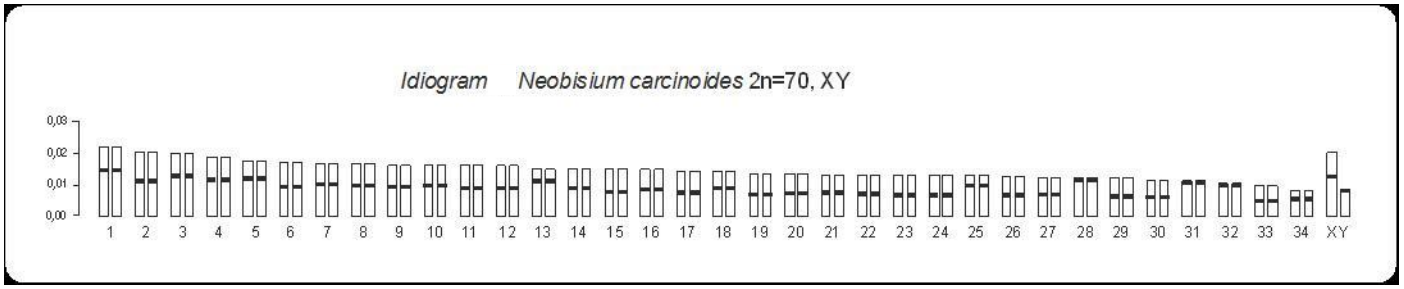
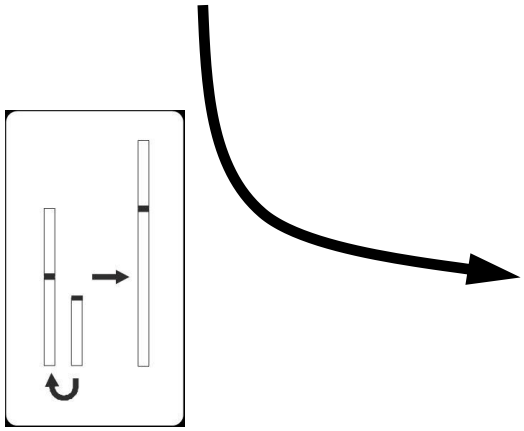


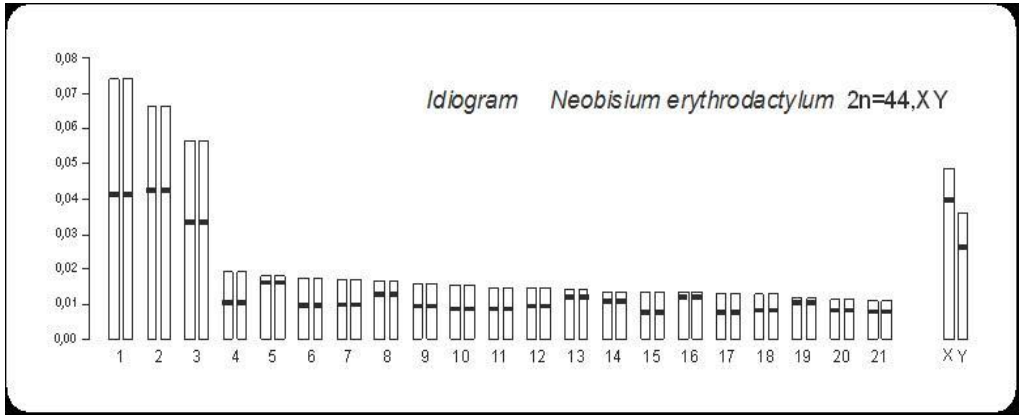
Fig. 17: Karyotype of *Roncus tenuis* 2n=26, XY

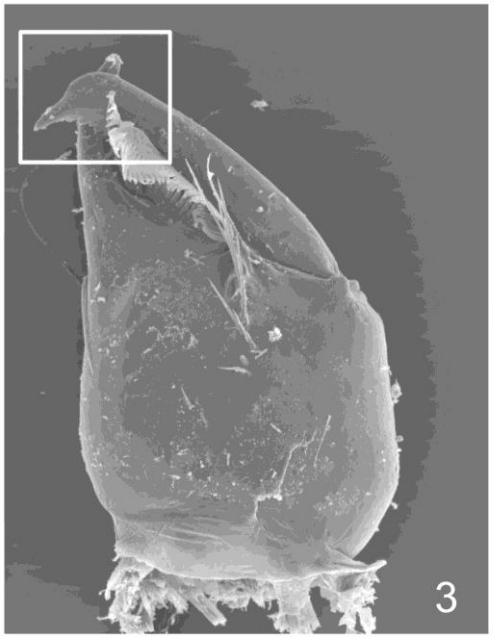





Idiogram Neobisium carcinoides 2n=70, XY
0,03
0,02
0,01
0,00
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 XY




Idiogram Neobisium erythrodactylum 2n=44,XY
0,08
0,07
0,06
0,05
0,04
0,03
0,02
0,01
0,00
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 XY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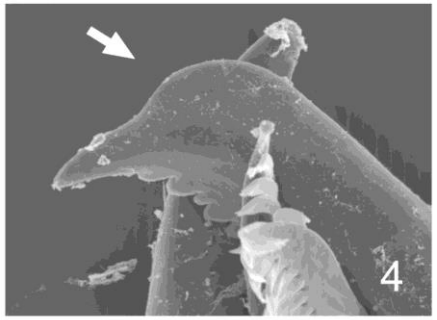
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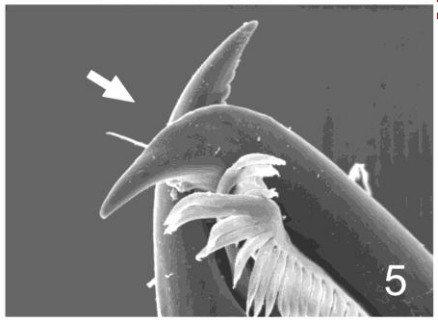
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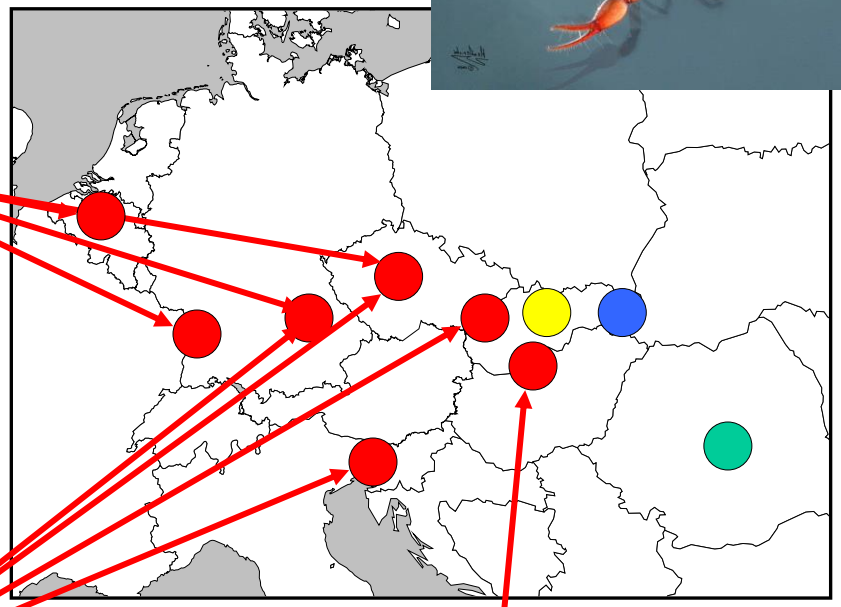

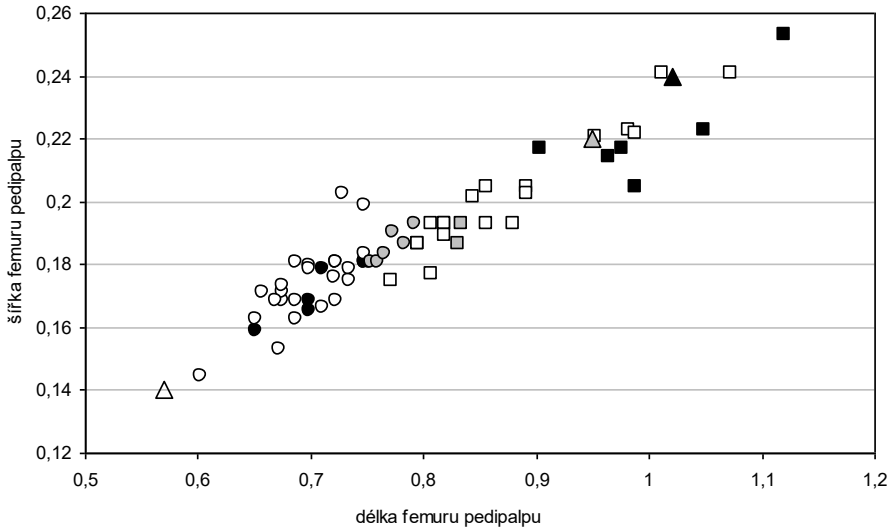
0,26
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0,12
šířka femuru pedipalpu
0,5
0,6
0,7
0,8
0,9
1
1,1
1,2
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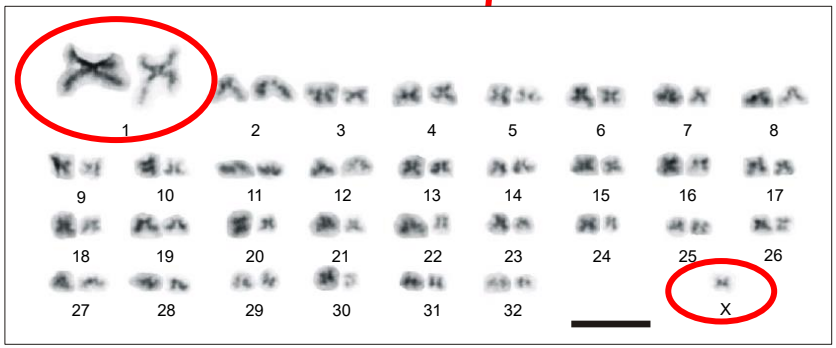
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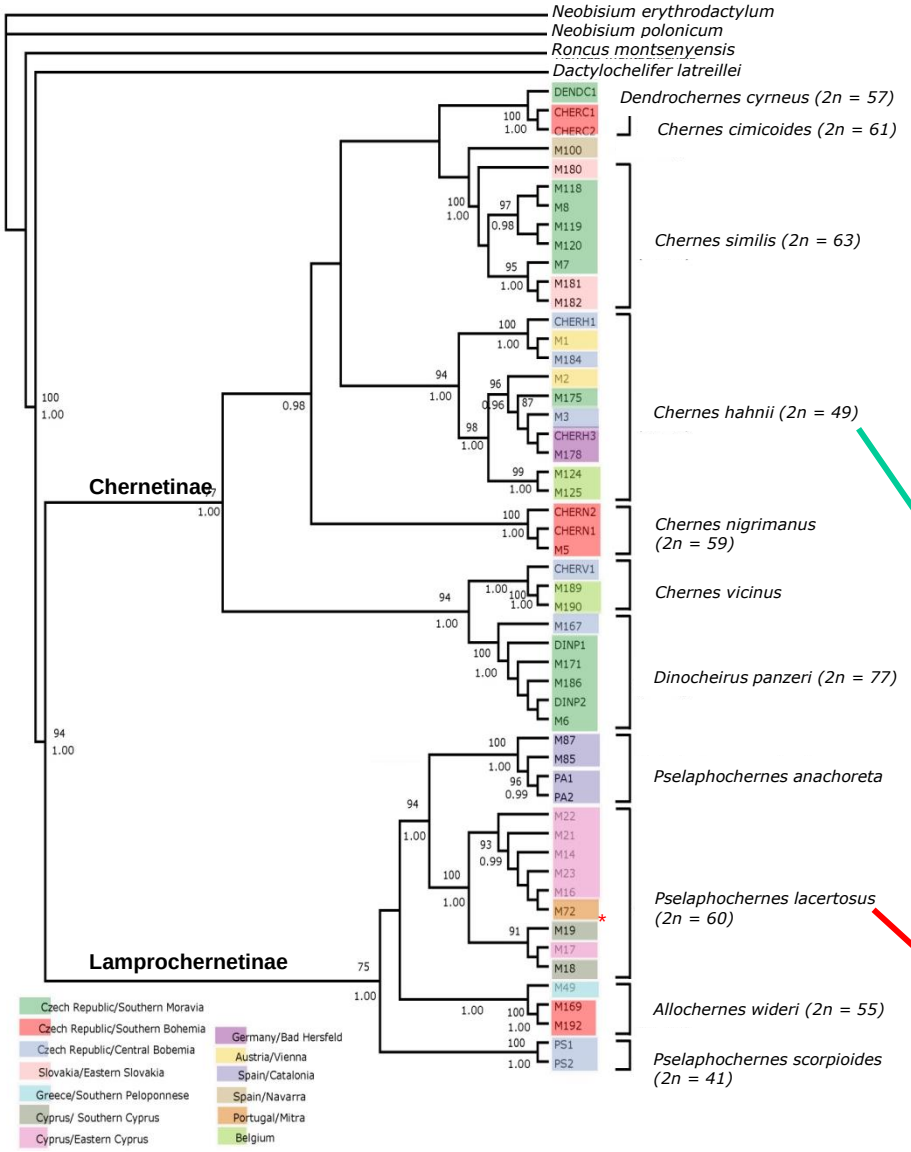
Chernetidae



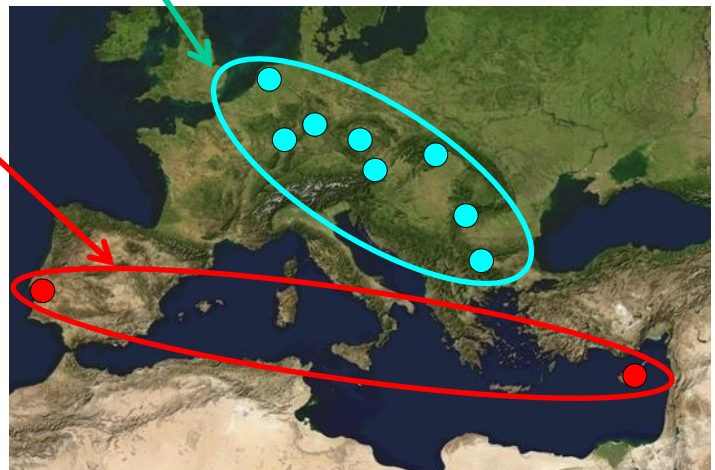
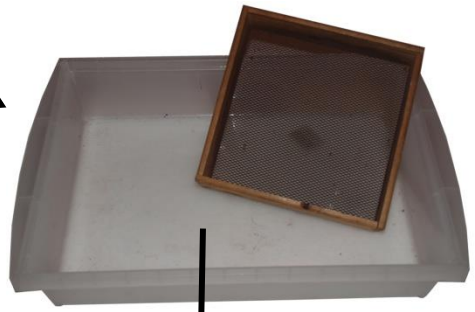
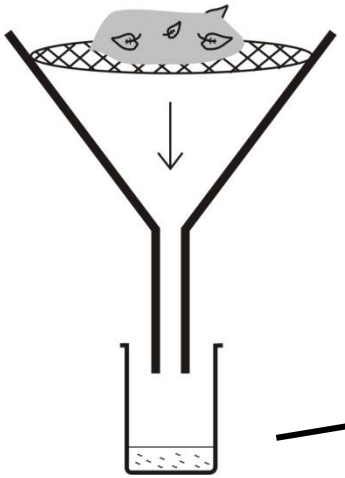


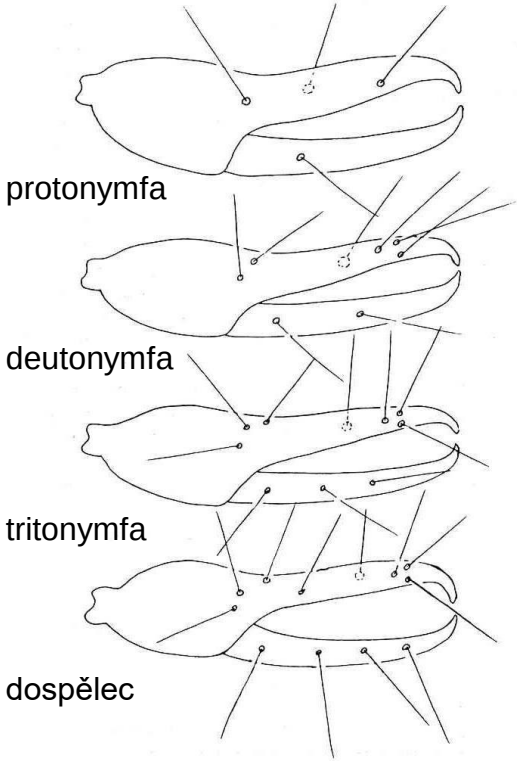
Fig. 1: Results of Bayesian analysis (GTR+I+Γ+covarion model). Bootstrap values above 0,95% are shown below branches. Values above branches correspond to bootstrap support obtained in Maximum Parsimony analysis (only values above 70% are reported).

collection

pit fall traps...







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An updated identification key to the pseudoscorpions (Arachnida: Pseudoscorpiones) of the Czech Republic and Slovakia

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Harvey, M.S. (2011) *Pseudoscorpions of the World*, version 2.0. Western Australian Museum, Perth. http://www.museum.wa.gov.au/catalogues/pseudoscorpions

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www.museum.wa.gov.au/catalogues/pseudoscorpions/

www.jorgenlissner.dk/pseudoscorpions.aspx

www.arachnology.cz