西北农林科技大学
Northwest A&F University

植物保护学院

普通昆虫学（一）General Entomology

—昆虫形态学 Insect Morphology


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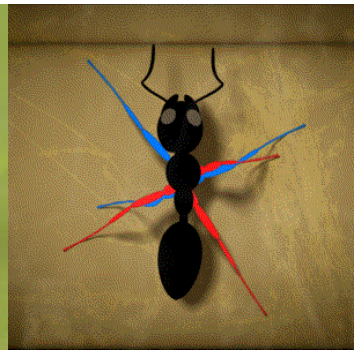
所在学院：植保学院

Lecture 4 Thorax of Insects

第四讲 昆虫的胸部构造

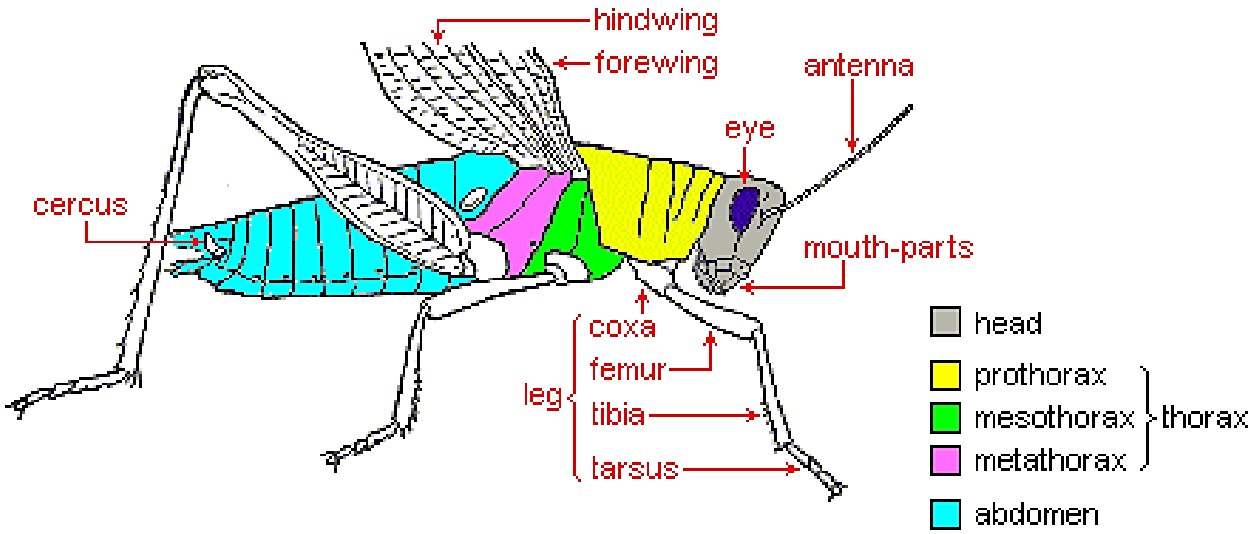
- Structure determines how an insect moves through its habitat.
- Wings determine flight capability.
- Legs determine how it moves and digs on land.



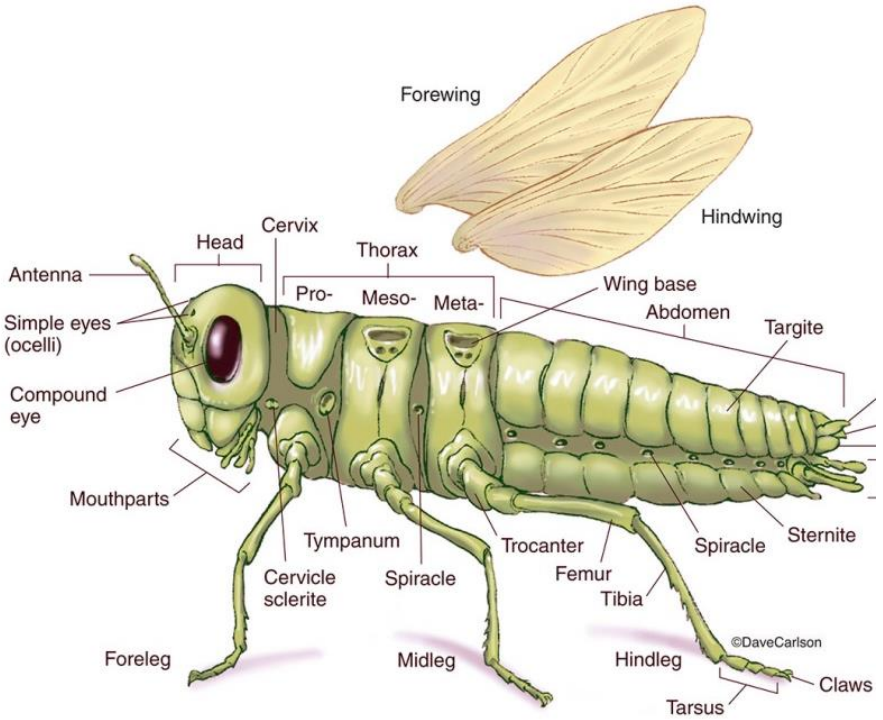


1. Structure of Thorax 胸部的基本构造

- Thorax is composed of three segments
  - prothroax 前胸 mesothorax 中胸 metathorax 后胸

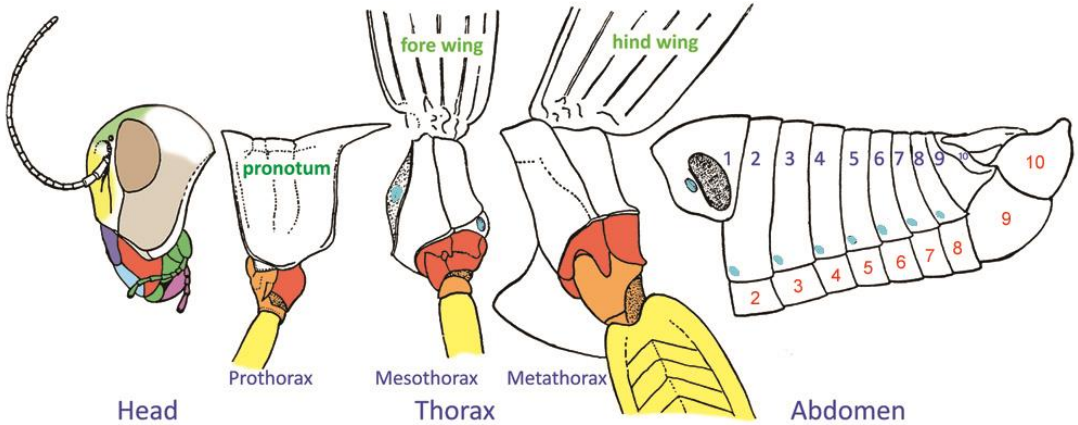


- **Thorax** is the center of locomotory
  - Highly sclerotized
  - fore legs, mid legs, hind legs
  - In pterygotes mesothorax and metathorax
    - enlarged relative to prothorax
    - formed a pterothorax 翅胸



I. Prothorax 前胸

- without wings
- structure usually simple

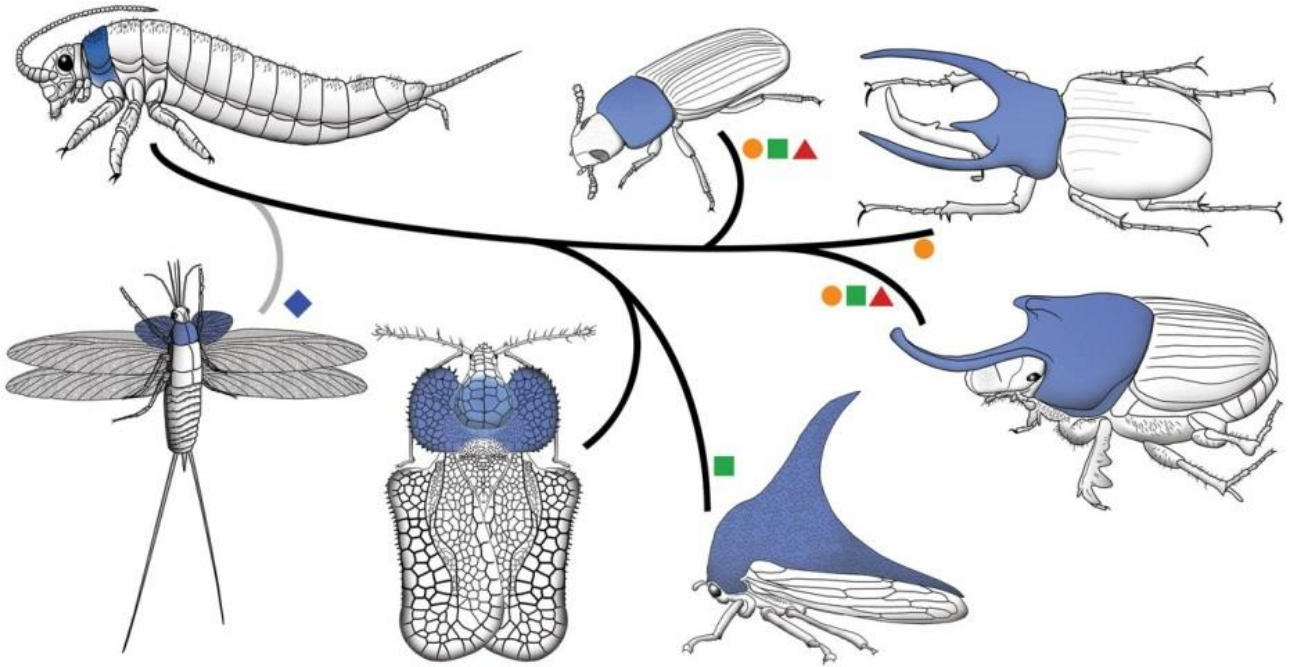


1) pronotum 前胸背板

- may be simple in structure and small in comparison with other nota
- some insects with secondary sulcus on pronotum

- But in some insects the pronotum are highly modified
  - Locusts, mole crickets of Orthoptera
  - Treehoppers of Homoptera rhinoceros beetles of Coleoptera

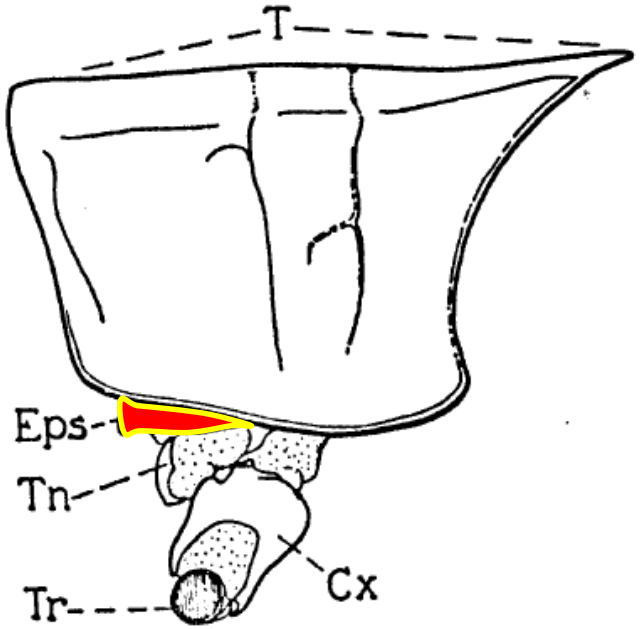
Prothoracic morphology among various extant and extinct insect lineages



Shapes indicate lineages where paleontological evidence (blue diamond), expression data (green squares), functional data (orange circles), or transformation (via Hox manipulation) data (red triangles) are available to support the hypothesis of wing serial homology. Insect lineages shown are (clockwise from top left) a hypothetical apterygote insect ancestor, Tenebrionidae, Dynastinae, Scarabaeinae, Membracidae, Tingidae, and Palaeodictyoptera.

2) propleuron 前胸侧板

– In primal insect or insect with undeveloped prothorax the propleuron is also undeveloped



Eps, episternum; *T,* protergum; *C,* coxa; *Tn,* trochantin; *Tr,* trochanter

3) prosternum 前胸腹板

- Usually undeveloped, and sometimes with some special structures

- e.g., jumping organ of click beetles 叩头虫的关键

II. Pterothorax 翅胸

– In pterygotes the meso- + metathoracic segments are highly modified and partially fused to form the primary flight motor

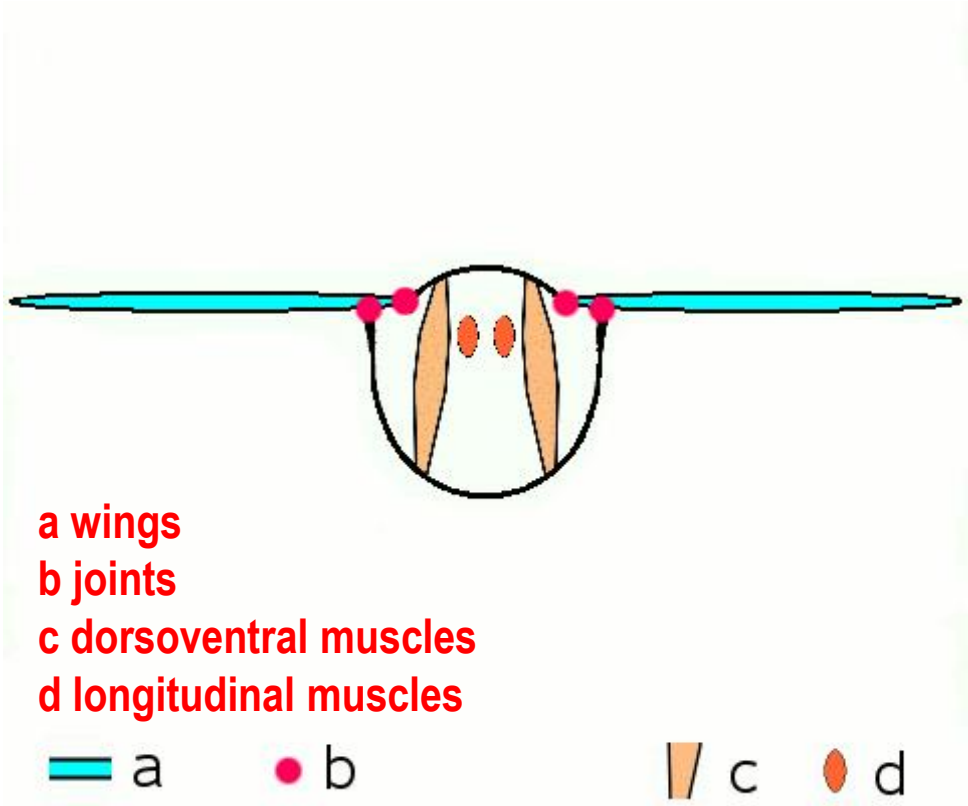
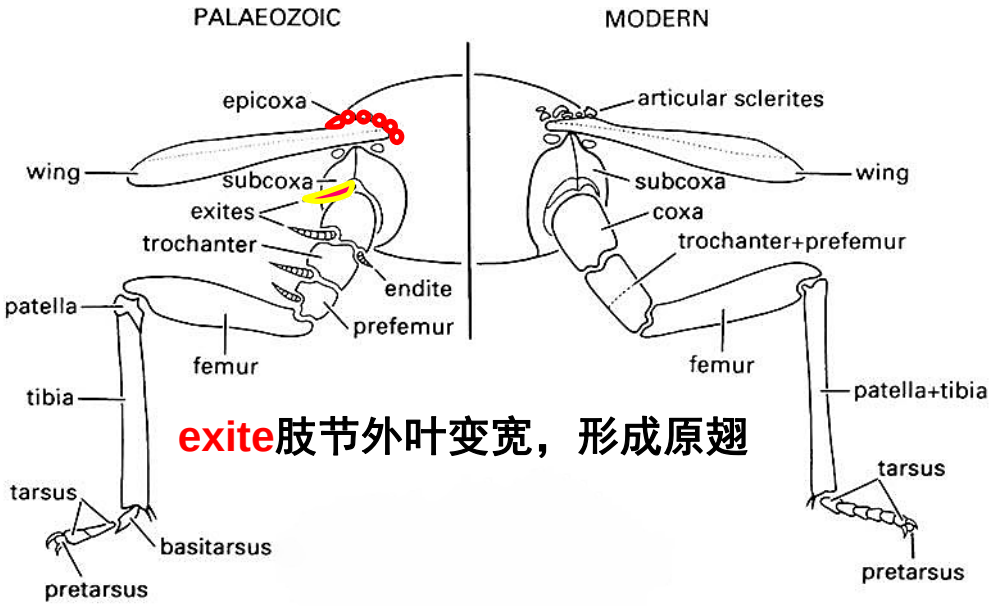
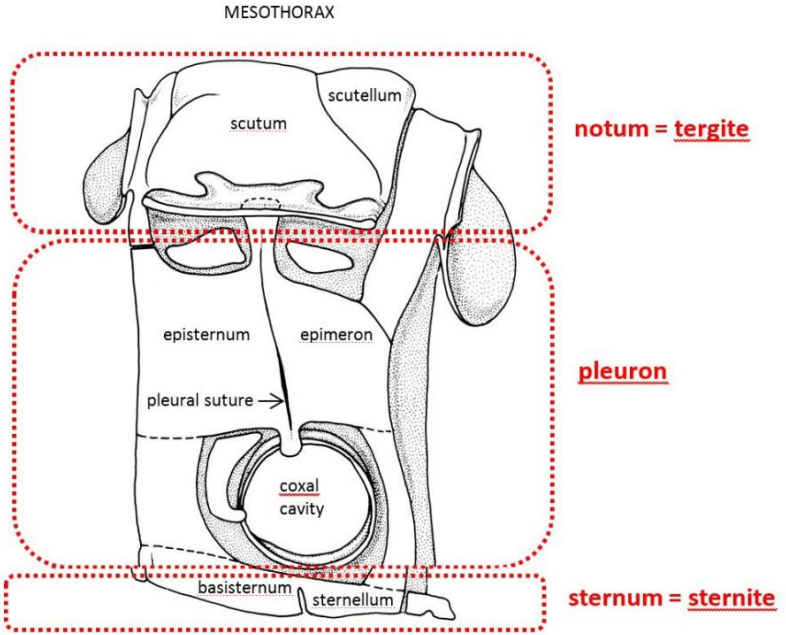


Diagram of a hypothetical step in the development of a winged segment

epicoxa上基节与体壁结合，分化成背、腹关节片



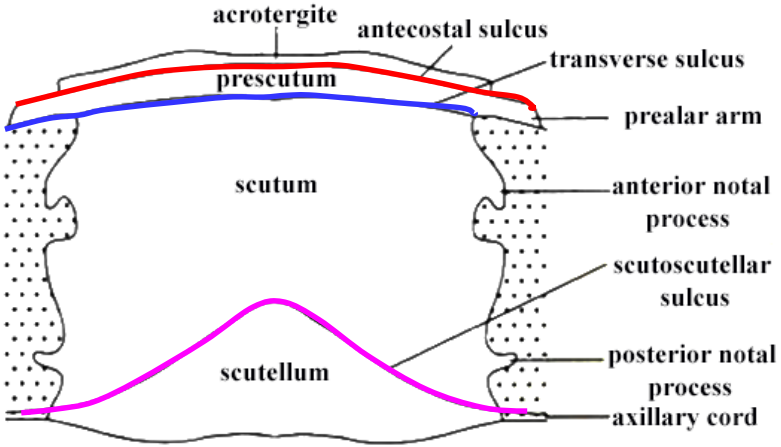
exite肢节外叶变宽，形成原翅

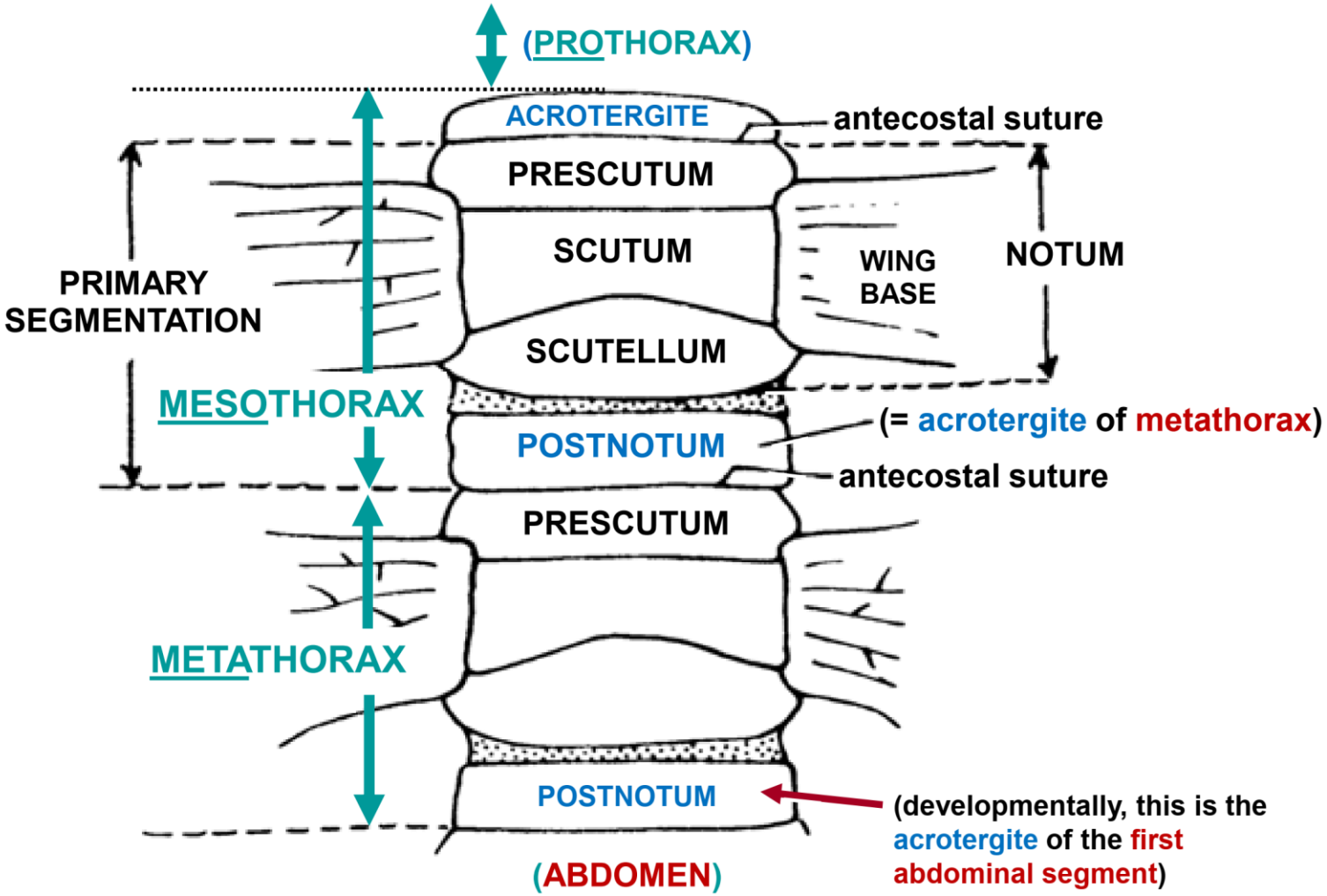


原翅最终与上基节和亚基节 (subcoxa) 组成的侧板分离，在上基节足肌的牵拉下，变为可动。原翅继续变大，最终演化为翅

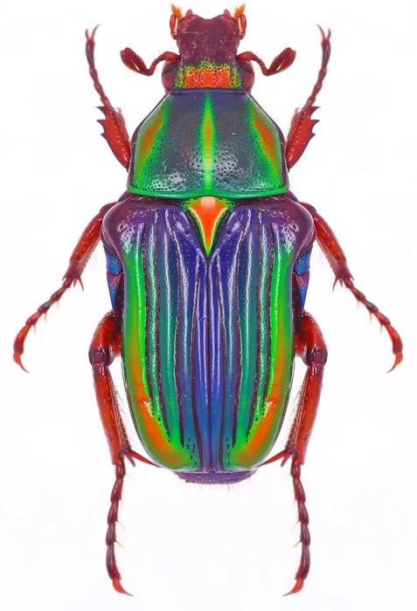
1) tergum of pterothorax 具翅胸节背板

- Three sulci
  - antecostal sulcus 前脊沟：内陷为前内脊（多扩大为悬骨 phragma）
  - prescutal sulcus 前盾沟
  - scutoscutellar sulcus 盾间沟
- Is divided into
  - Acrotergite 端背片：后胸端背片常向前扩展与中胸的背板紧接，成为中胸后背片 postnotum
  - Prescutum 前盾片
  - Scutum 盾片
  - Scutellum 小盾片
- Notal wing process 背翅突




(PROTHORAX)
ACROTERGITE
antecostal suture
PRESCUTUM
SCUTUM
WING BASE
NOTUM
PRIMARY SEGMENTATION
SCUTELLUM
MESOTHORAX
(= acrotergite of metathorax)
POSTNOTUM
antecostal suture
PRESCUTUM
METATHORAX
POSTNOTUM
(developmentally, this is the acrotergite of the first abdominal segment)
(ABDOMEN)

- Hemiptera 半翅目、Coleoptera 鞘翅目昆虫
  - Triganular scutellum exposed
- Hemiptera半翅目龟蝽 Plataspidae、盾蝽 Scutelleridae
  - Scutellum extended and covered the whole abdomen



2) pleuron 具翅胸节侧板

Episternum 前侧片/Epimeron 后侧片

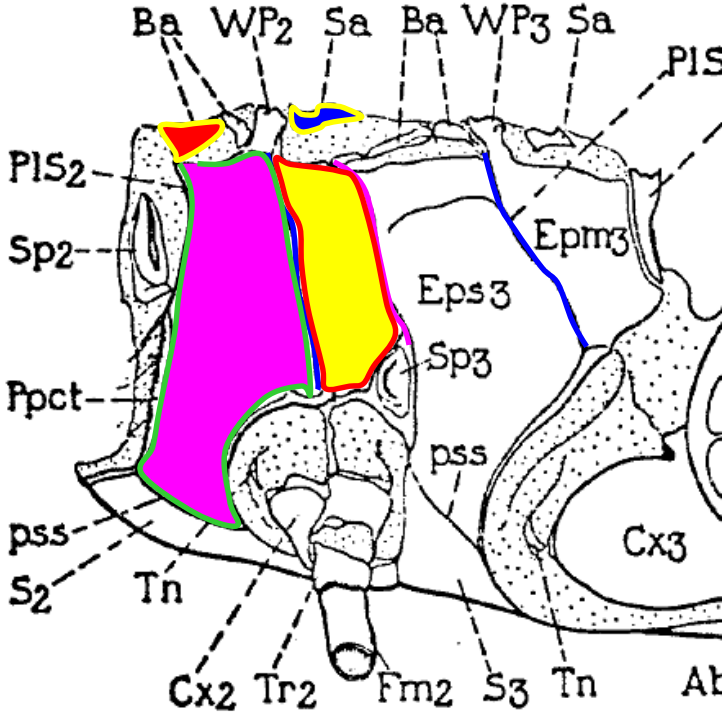
pleural articulation 侧基突

pleural wing process 侧翅突

Epipleurites 上侧片

侧翅突前后的膜质区中的骨片，包括

basalare 前上侧片和subalare 后上侧片



Ba, basalar sclertie; *Sa,* subalare; *Sp,* spiracle; *WP,* pleural wing process; *Epm,* epimeron; *Eps,* episternum; *Pls,* pleural suture;

Prealare 翅前桥

（前侧片+前盾片）

postalare 翅后桥

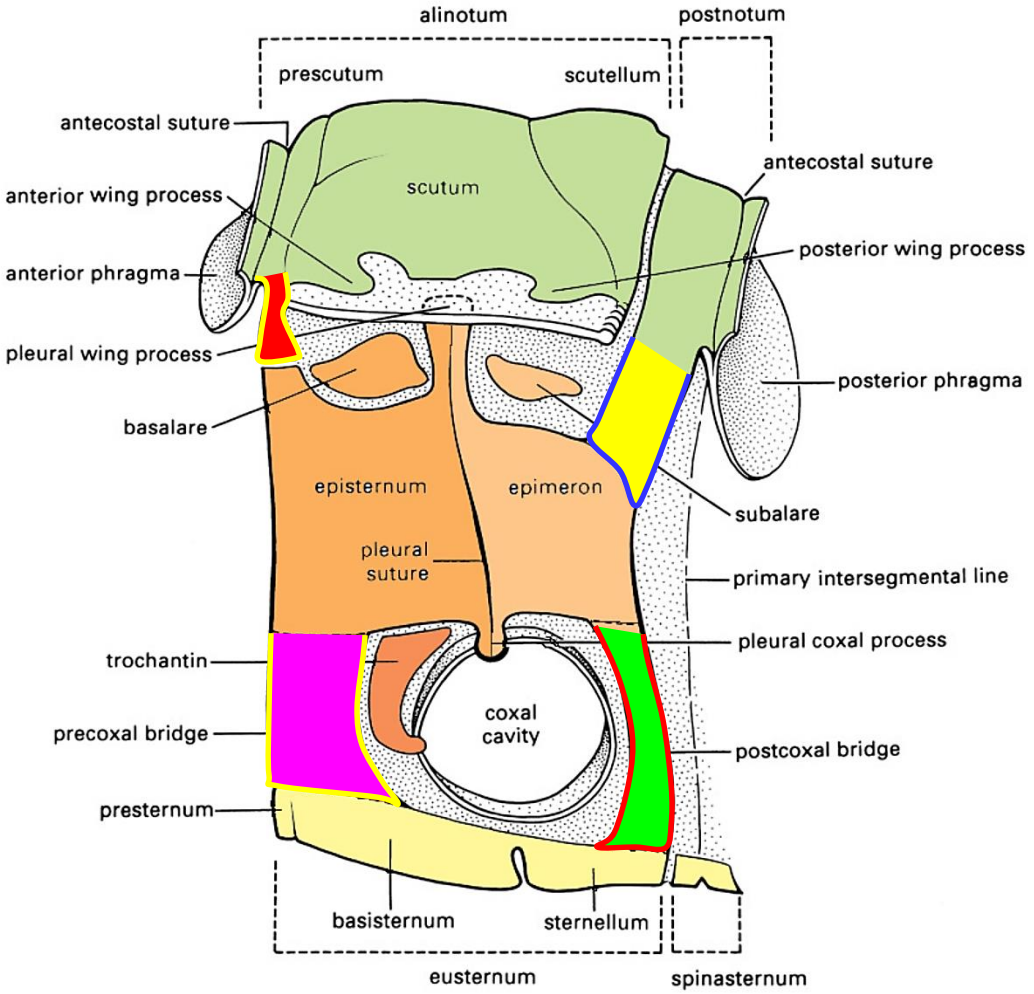
（后侧片+后背片）

Precoxale 基前桥

（足基节臼前的侧板+腹板）

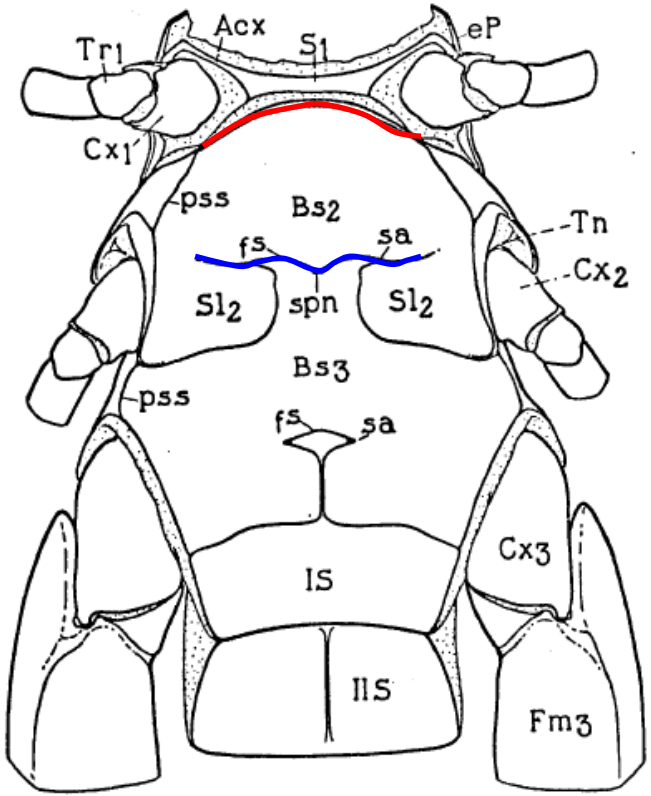
postcoxale 基后桥

（足基节臼后的侧板+腹板）



3）sternum 具翅胸节腹板

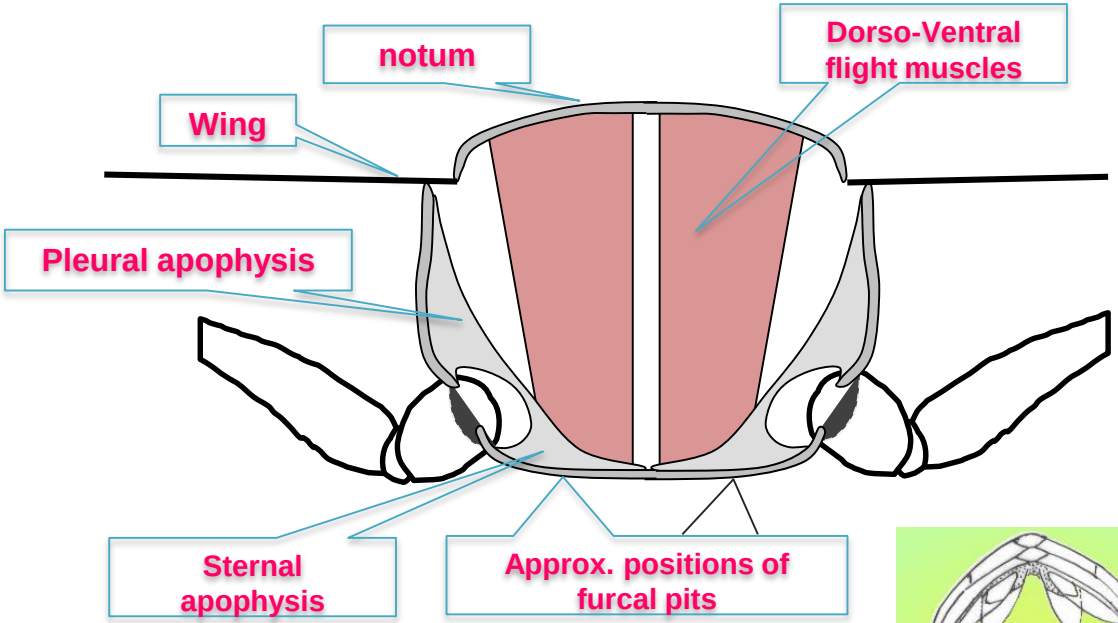
- A couple of sulci
  - presternal sulcus 前腹沟
  - sternacostal sulcus 腹脊沟
- Is divided into
  - Presternum 前腹片
  - Eusternum 主腹片 (furcasternum 具叉腹片)
    - Basisternum 基腹片
    - Sternellum 小腹片
  - Intersternite 间腹片 (spinasternite 具刺腹片)
    - 内有刺突，称内刺突 spina



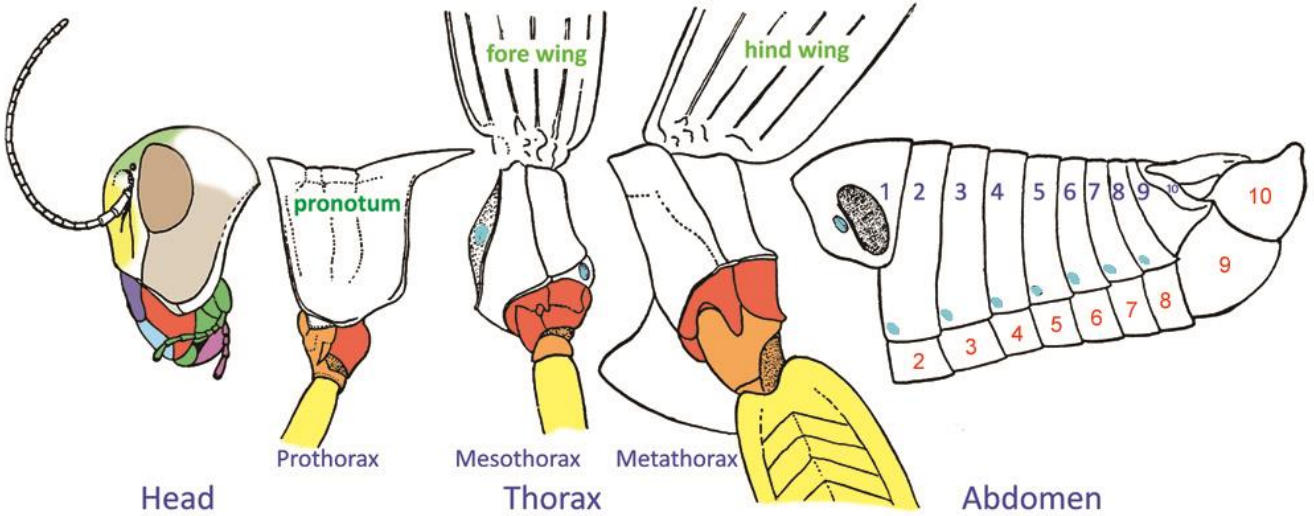
Bs, basisternum; *fs,*furcal suture; *pss,* pleurosternal suture; *sa,* roots of sternal apophyses; *Sl,* sternellum; *spn,* depression marking the site of the internal spina

2. Endoskeleton 胸部的内骨骼

- Tergum 背板—phragma (pl. phragmata) 悬骨
  - 由前内脊向内扩展形成的1对板状脊
- Pleuron 侧板—pleural apophysis 侧内突
  - 由侧沟向内扩展形成的臂状内脊
- Sternum 腹板—ventral apophysis 腹内突 + spina 内刺突
  - 腹内突由腹脊沟内陷形成



Summary


fore wing
hind wing
pronotum
1 2 3 4 5 6 7 8 9 10
10
9
8
7
6
5
4
3
2
Prothorax
Mesothorax
Metathorax
Head
Thorax
Abdomen

Assignment

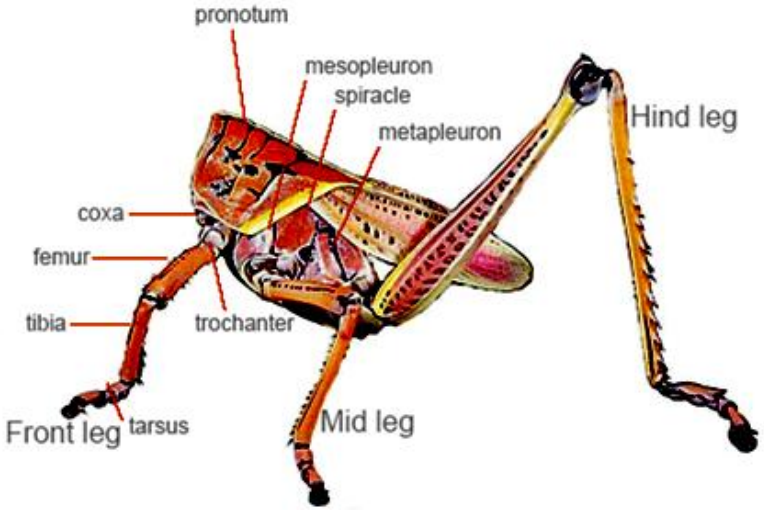
Why the morphology of pterothorax differs from the prothorax?

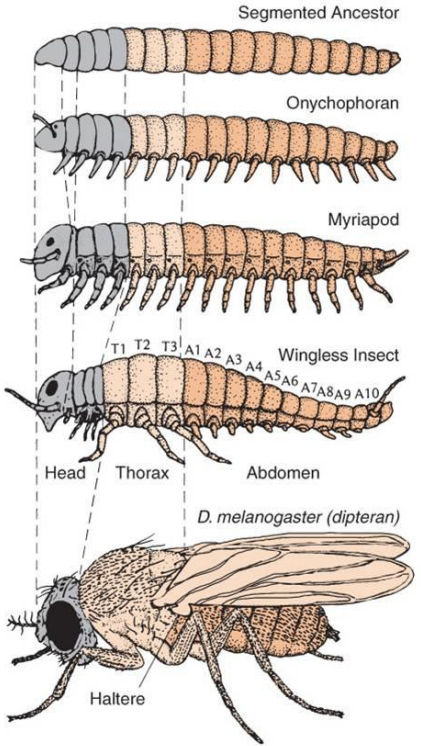
Further reading

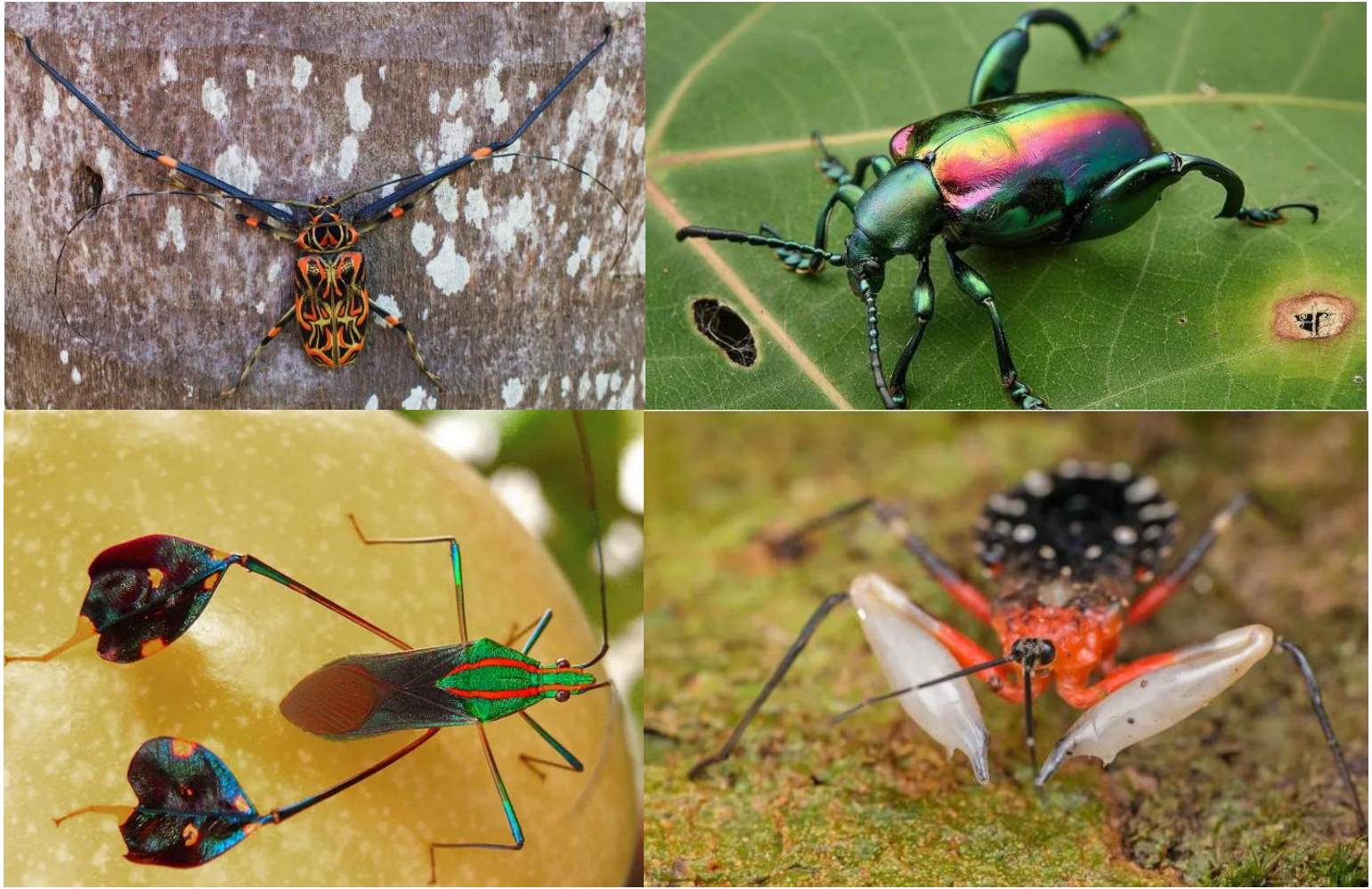
- Hu Y*, et al.* (2019) Beetle horns evolved from wing serial homologs. *Science*. 366(6468): 1004-1007.
- Ross A, (2017) Insect evolution: the origin of wings. *Current Biology*. 27(3): 113-115.
- Capinera JL, (2008) Thorax of Hexapods. Encyclopedia of Entomology.

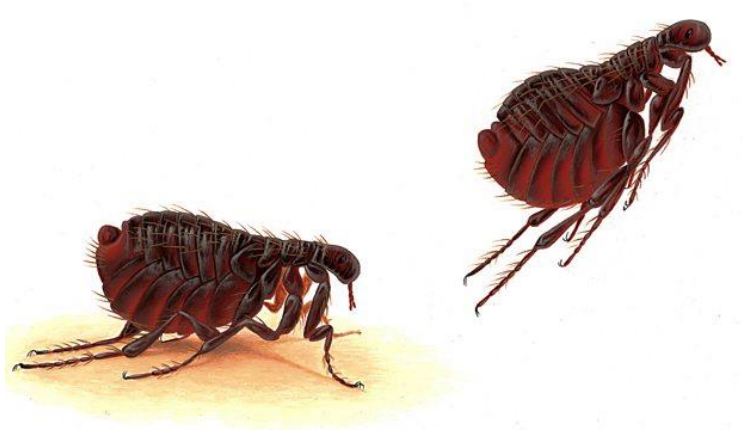
Lecture 4 Legs of Insects

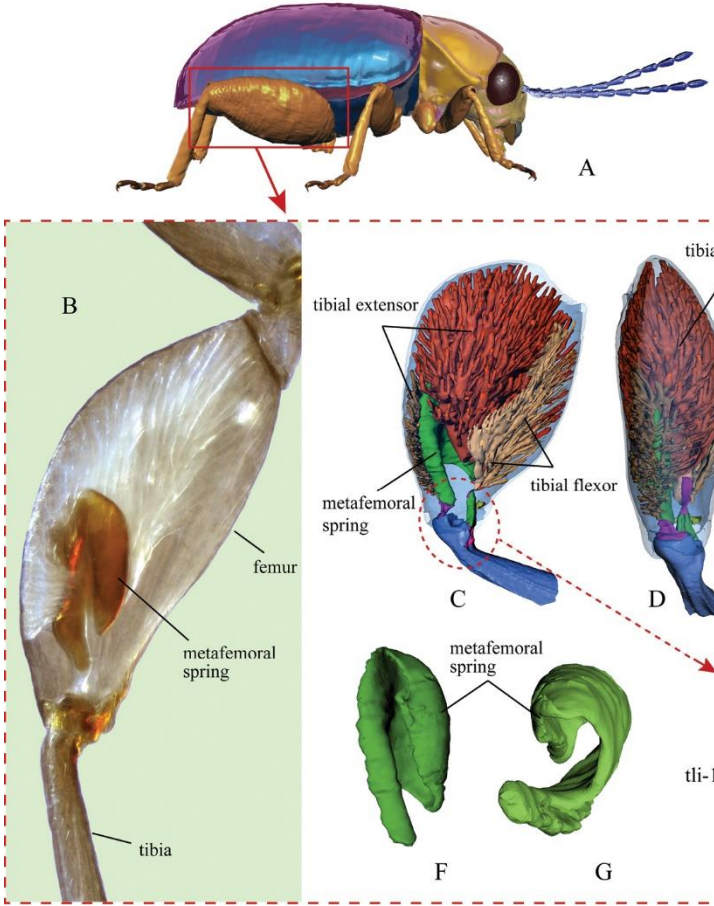
第四讲 昆虫的胸足







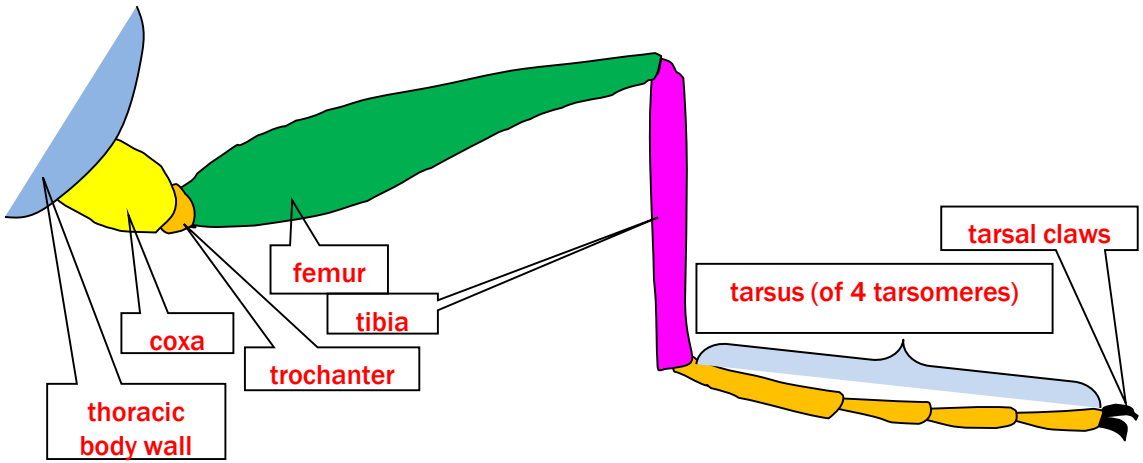


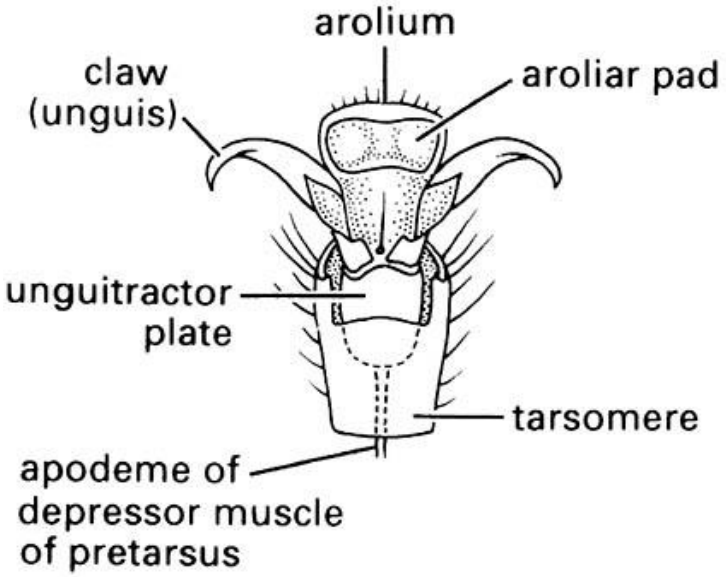

A
B
femur
metafemoral spring
tibia
tibial extensor
metafemoral spring
tibial flexor
C
tibial extensor
tibial flexor
D
E
metafemoral spring
F
G
tli-1
piv
epl
tpl
tli-2
H

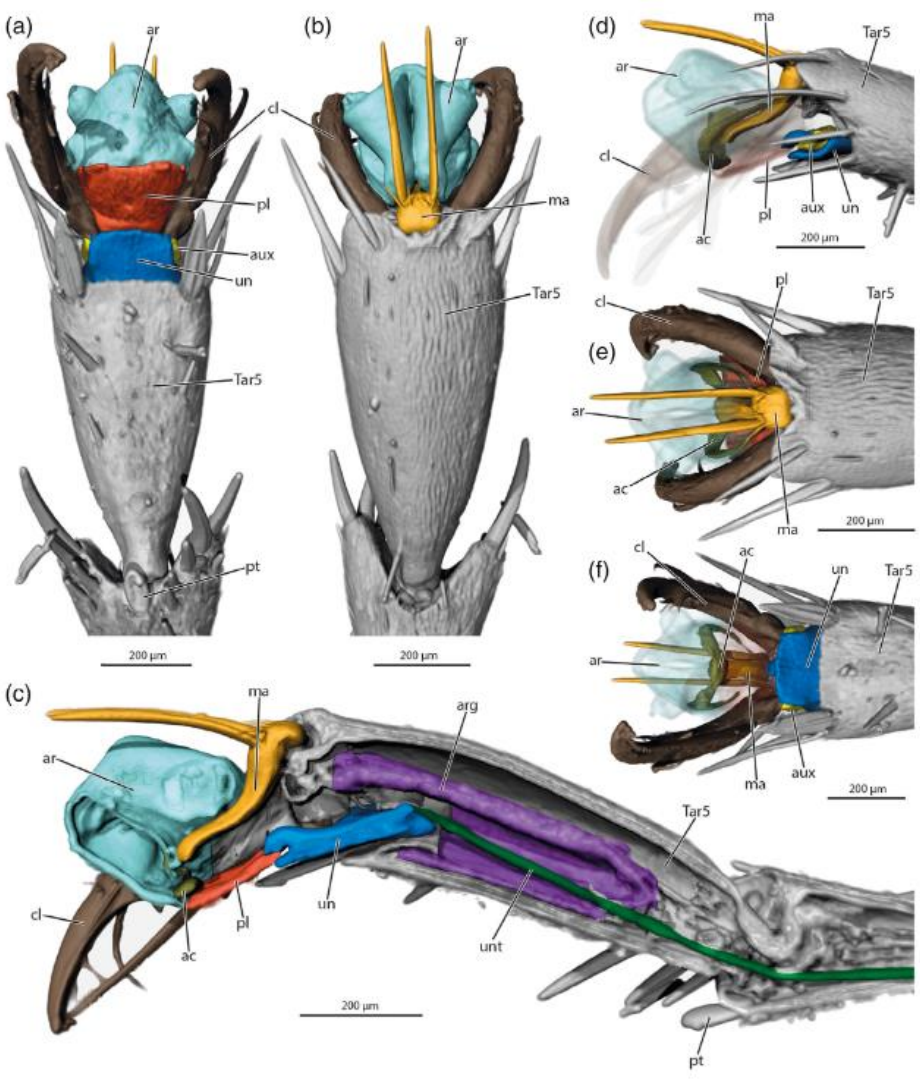
1. Structure of Legs

胸足的构造

- Each leg contains six structural components (segments)
  - Coxa 基节
  - Trochanter 转节
  - Femur 股节
  - Tibia 胫节
  - Tarsus 跗节
  - Pre-tarsus 前跗节




arolium
claw
(unguis)
aroliar pad
unguitractor
plate
tarsomere
apodeme of
depressor muscle
of pretarsus



S. caementarium **(Sphecidae 泥蜂科) female foreleg**

ar, arolium (turquoise);

ac, arcus (green-brown);

aux, auxiliary sclerites (yellow);

arg, arolium gland (purple);

cl, claw (brown);

ma,manubrium (dark yellow);

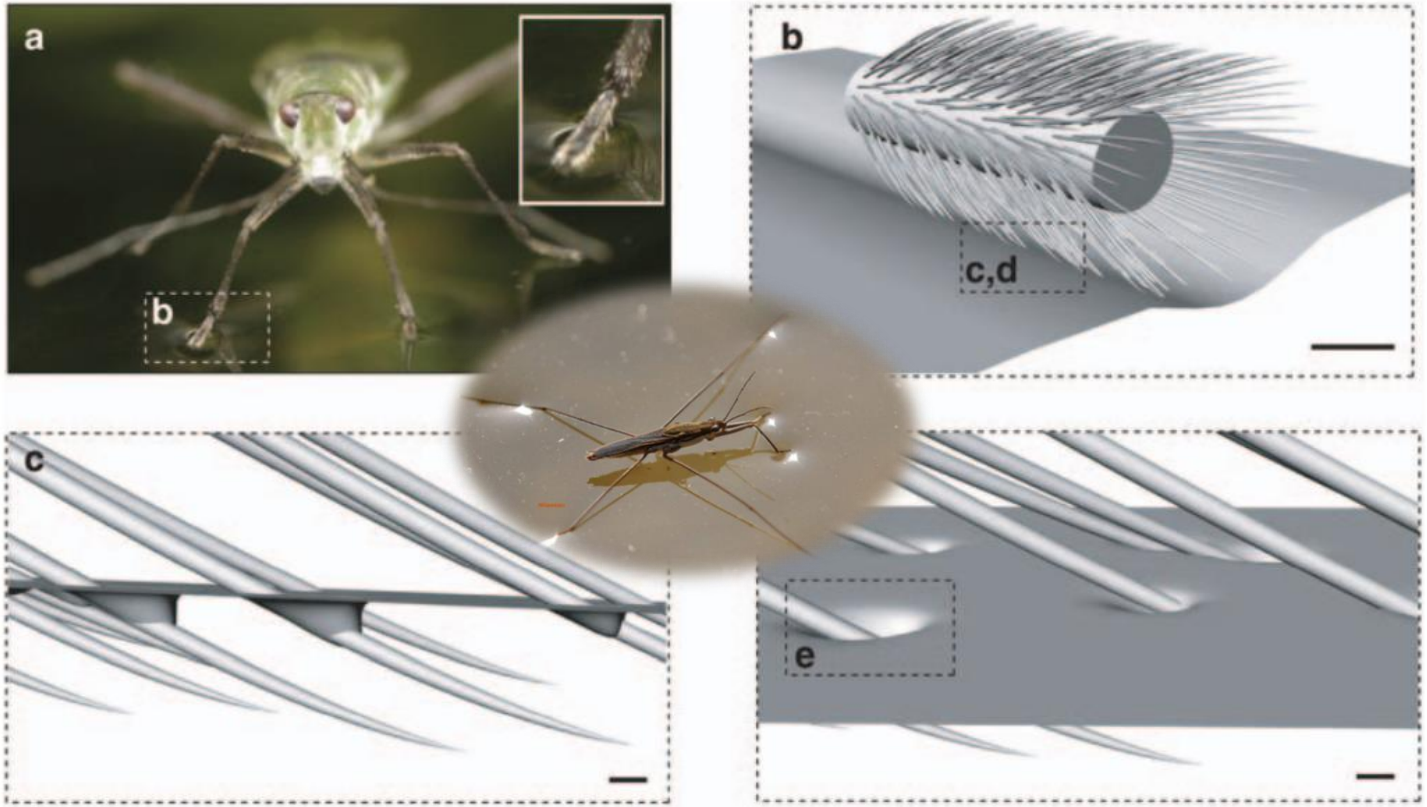
pl, planta (red);

pt, plantula (gray);

Tar5, tarsomere 5 (gray);

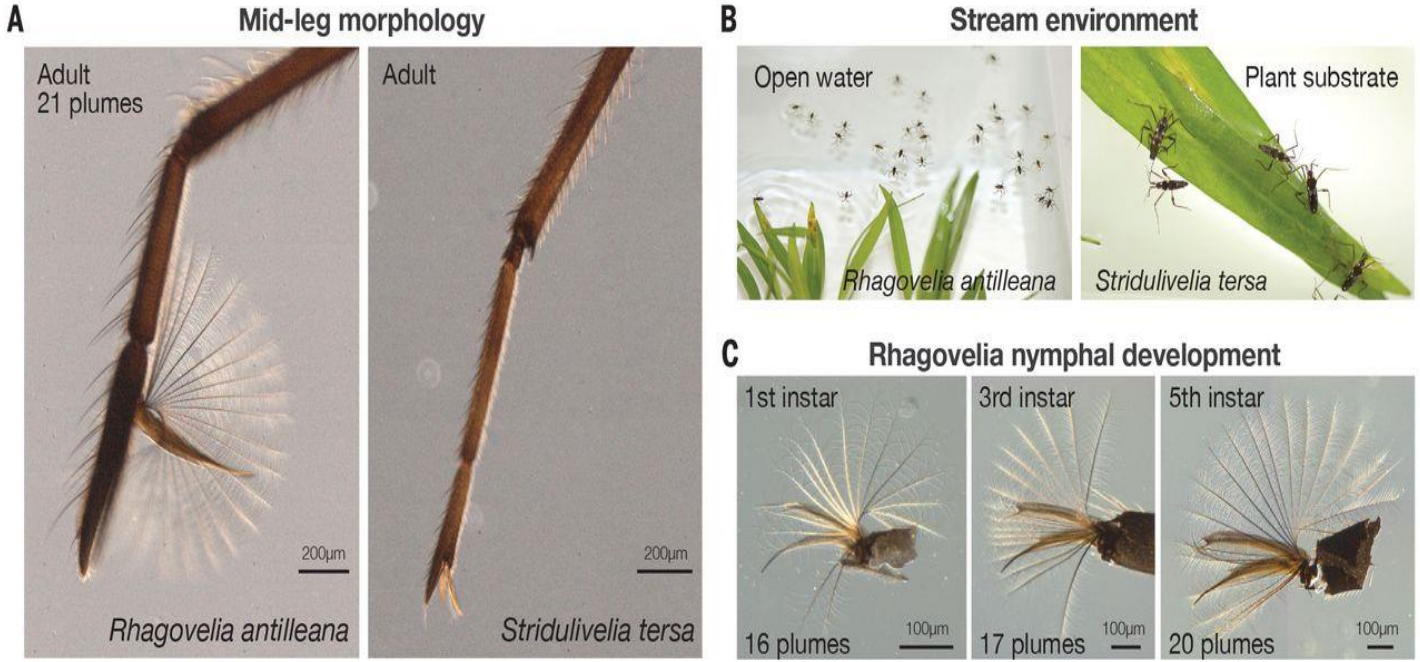
un, unguitractor plate (blue);

unt, unguitractor

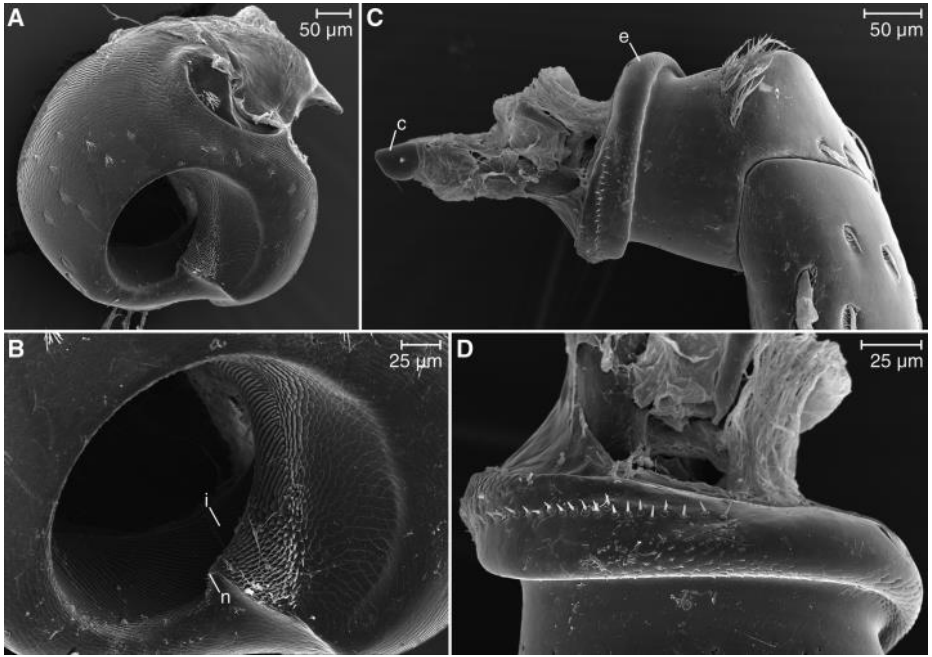


Water treader *Mesovelia*, Water-walking

Why do some water striders have fans on their legs?

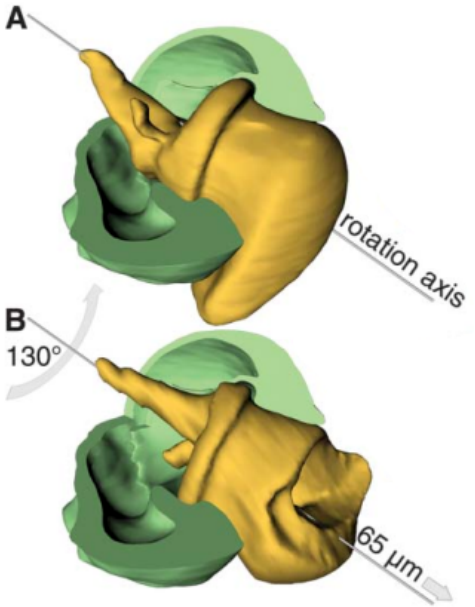


The *Rhagovelia* water strider has feathery fans that grow on its middle set of legs and help it with turns and to travel upstream against the current



Weevil *Trigonopterus* sp.

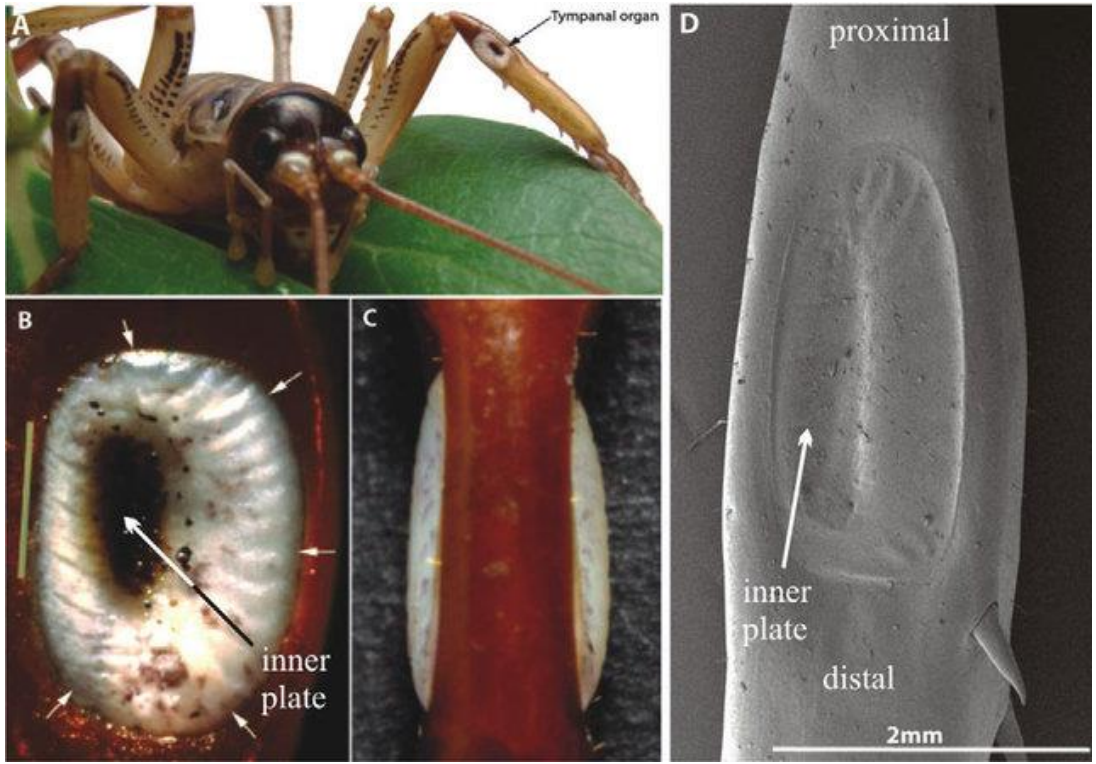
Metacoxa (A,B) showing notch (n) and inner thread (i), and of the corresponding trochanter (C,D) with external thread (e) and condyle (c)



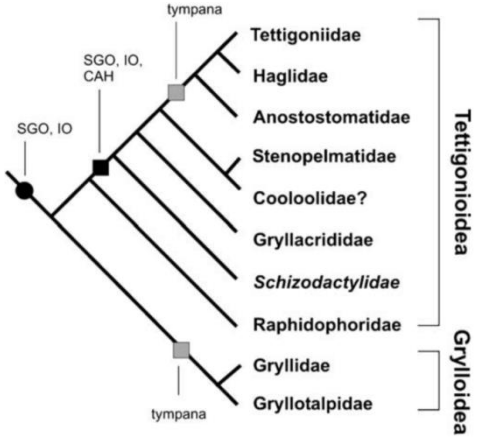
Coxa (green) and trochanter (yellow) of left hind leg of weevil *T. oblongus*.

(A) Depressed position.

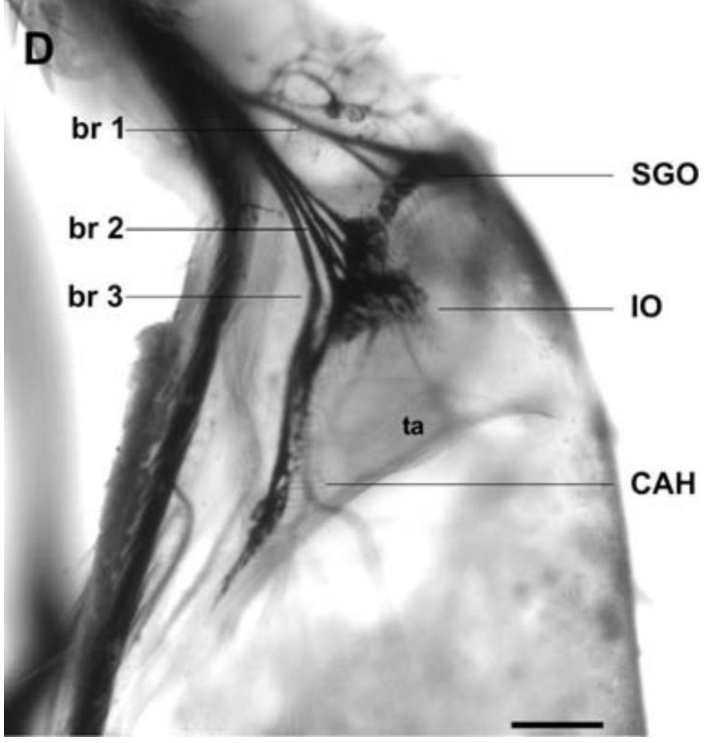
(B) Elevated position.



Hearing organ of *Hemideina thoracica*. (A)Female, the large tympanal membrane located on the tibia. (B)Close-up of the anterior tympanal membrane showing the inner plate (long arrow) and a loosely suspended, lightly coloured rippled zone (short arrows). (C)Close-up of both tympana in frontal view, showing the bulging of the tympanal membranes from the surrounding cuticle. (D)SEM of the left posterior tympanal membrane.



The black square symbolizes the synapomorphy of the tripartite tibial sensory organ, the gray squares symbolizes the origin of the tympana. Filled circle Plesiomorphic character of bipartite organ structure comprising the subgenual organ and intermediate organ.



Comicus calcaris. b, c Foreleg tibia viewed from anterior (b) and posterior (c). Note enlarged leg tibiae without detectable tympana. d. Neuroanatomy of the complex tibial organ in the foreleg. CAH crista acustica homologue; IO intermediate organ, SGO subgenual organ, ta tracheal attachment.

Fat in the Leg: Function of the Expanded Hind Leg in Gasteruptiid Wasps

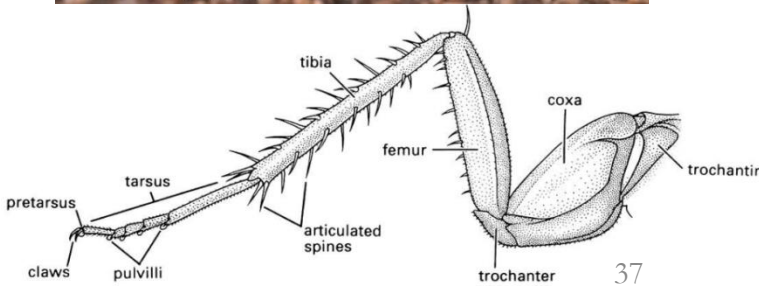
As such, gasteruptiids could use their enhanced subgenual system to locate ideal nest oviposition locations either by detecting signals of host larval movement through nest entrances and substrates, or simply by tuning into host vibrational communication of adults (e.g., 'buzzing') during host interaction, a trait that may serve additional purposes in avoiding host stinging defense.

2. Leg Adaptations and Modifications

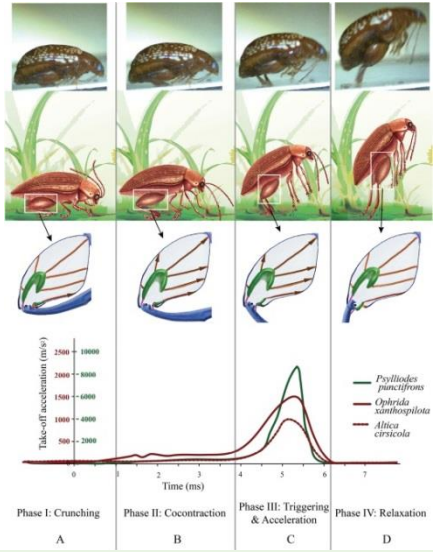
足的特化和适应

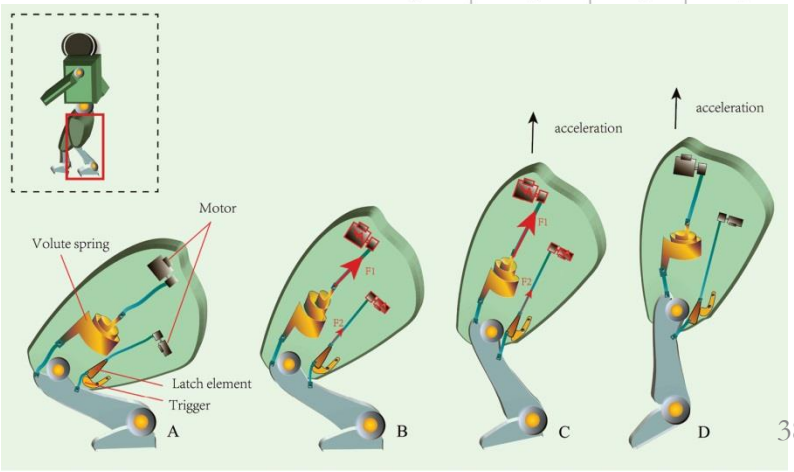
- Typically the legs are concerned with walking and running, but they may be specialized for a variety of functions.
  - Jumping
  - Swimming
  - Grasping
  - Digging
  - Sound production
  - Cleaning

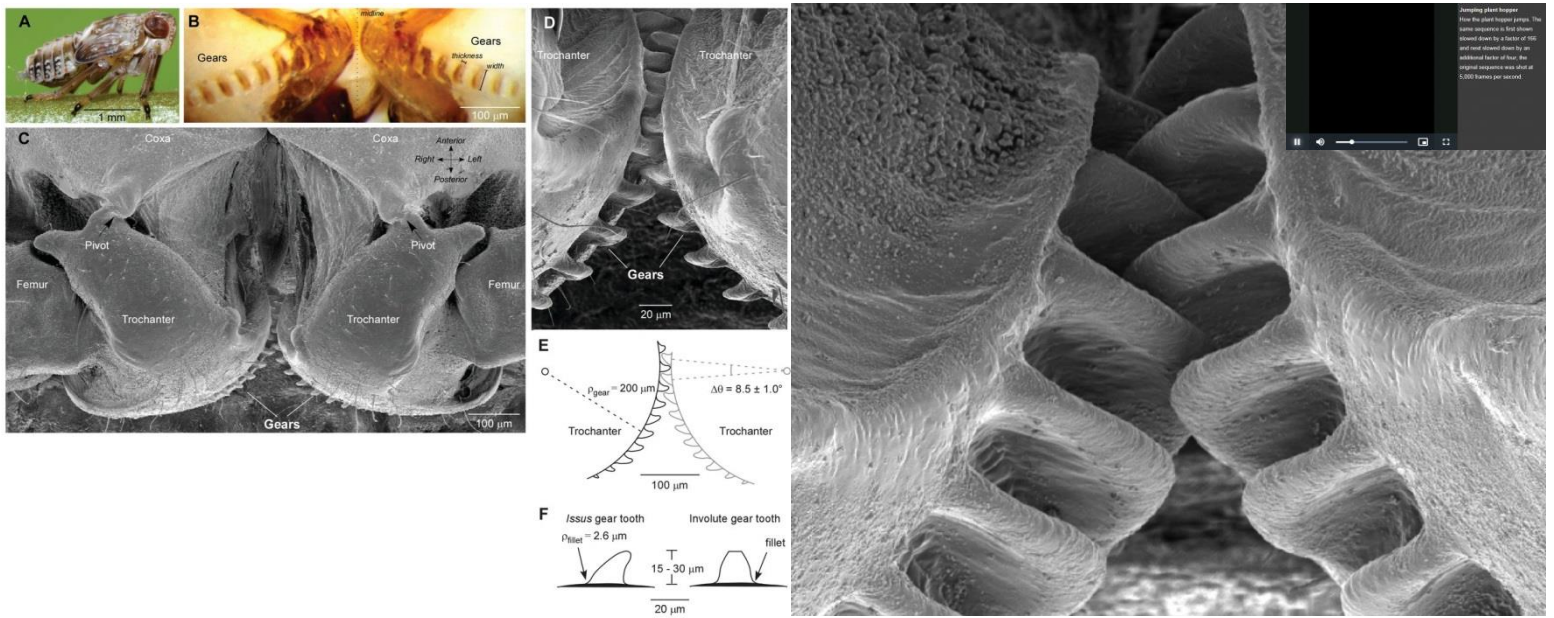
- **Walking (Cursorial) leg 步行足**
  - Ground beetles, Tiger beetles, Cockroaches
  - adapted for **running**
    - **coxa**: articulated with pleural process with **articular socket 关节窝**
    - **trochanter**: small and freely movable, usually reduced and singles.
    - **femur**: most prominent, robust section.
    - **tibia**: femoral articulation permits vertical motion, flexed against the femur.
    - **tarsus**: commonly divided into five or fewer articles viz. **tarsomere 跗分节.**



- **Jumping (Saltatorial) leg 跳跃足**
  - Grasshoppers, fleabeetles
  - adapted for jumping
  - Hind tibia well developed, long and narrow

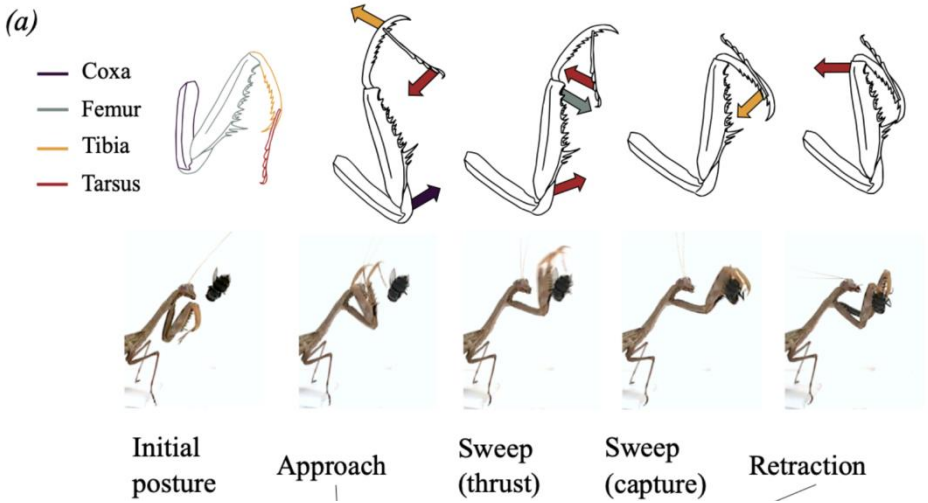




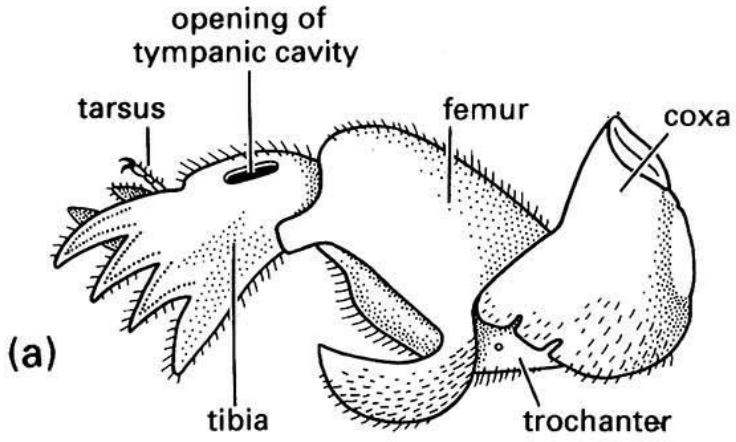


(**A**) *Issus* ((Hemiptera: Fulgoroidea: Issidae)) nymph viewed from the side. (**B**) Gears on the left and right hind trochantera (**C**) SEM of the partially elevated articulation between hind trochantera and coxae and the engagement of gears. (**D**) Higher magnification of the interdigitation of the gears. (**E**). Diagram showing the radius of curvature of the trochanter (ϱ_{gear}), the angular placement of the teeth, and how the gears enmesh. (**F**) Profile of a gear tooth in *Issus* (left) compared with a man-made involute gear tooth (right). The radius of curvature of the fillet (ϱ_{fillet}) is indicated.

- **Grasping (Raptorial) leg 捕捉足**
  - Praying mantids 螳螂
  - adapted for catching and holding prey
  - coxa elongated, tibia and femur of foreleg are equipped with spines

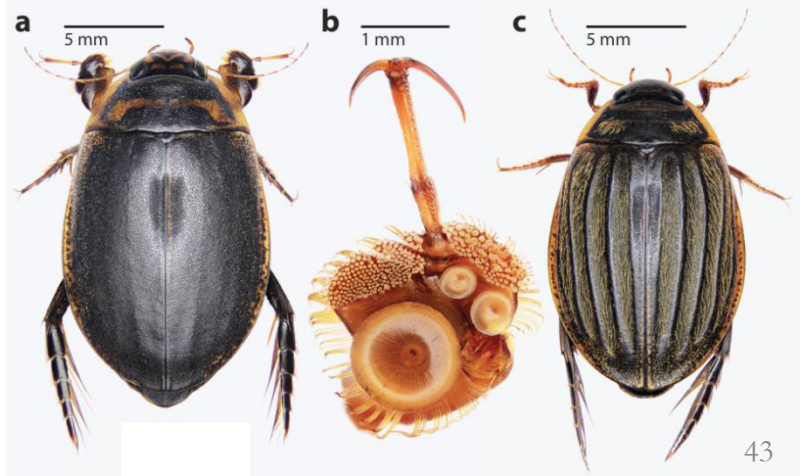


- **Digging (Fossorial) leg 开掘足**
  - Mole crickets 蝼蛄, cicadas 蝉, various beetles 某些甲虫 (?)
  - adapted for digging in soil
  - forelegs are large, heavily sclerotized, and posses stout claws
  - tibia are flattened, with teeth
  - tarsomeres are reduced in number or may disappear entirely

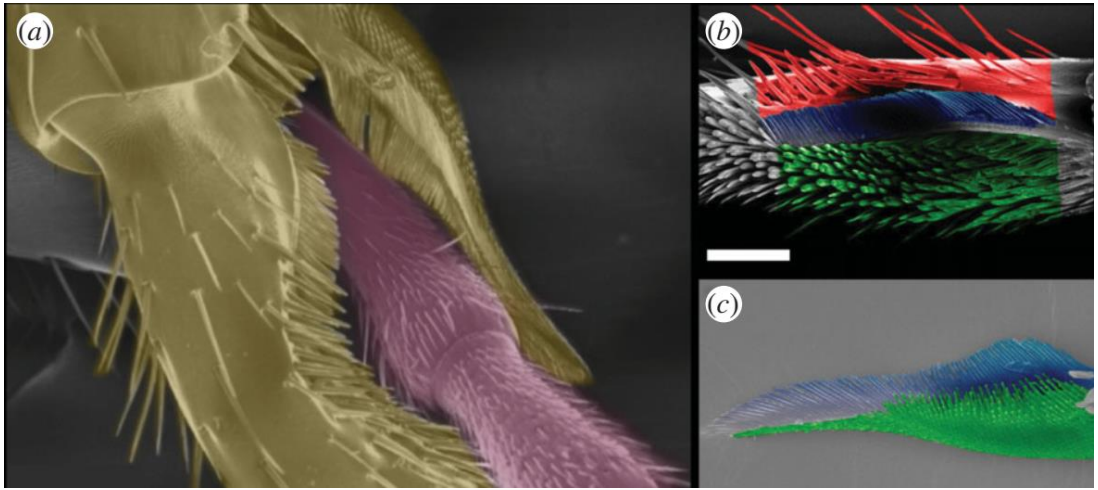


- **Swimming (Natatorial) leg 游泳足**
  - Diving bugs, Water beetles and Predaceous diving beetles 负子蝽、龙虱、水龟甲
  - adapted for swimming
  - tibia and tarsus of hindlegs (occasionally also the middle legs) are flattened, bear rigid hairs around the periphery

- **Clasping leg 抱握足**
  - adapted for **grasping**
  - male predaceous diving beetles used for hanging onto the female during mating
  - **tarsi extremely expanded, sucker-like setae** on the tarsi of their forelegs increases their ability to grasp females

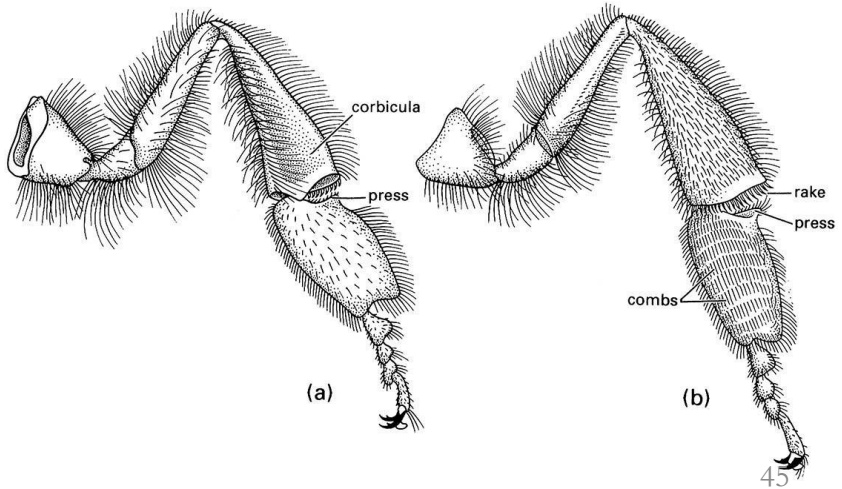


- **Antenna cleaner 净角器**
  - **lined with hairs occurs on the metatarsus of foreleg**



bristles (red), comb (blue), brush (green

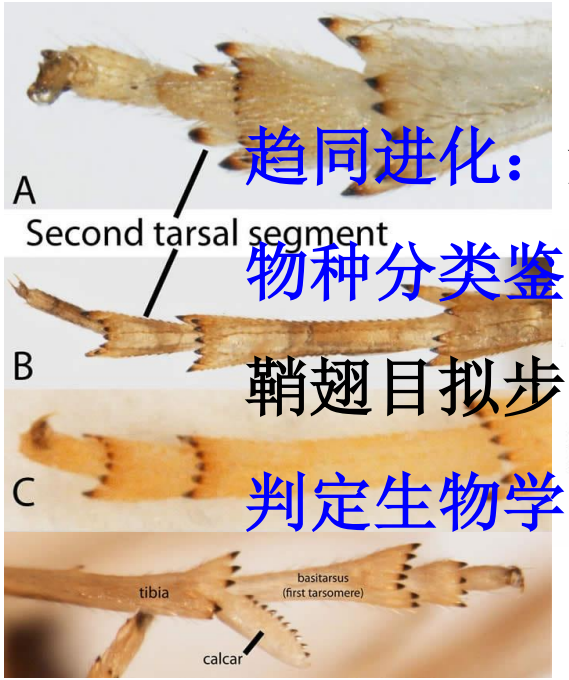
- **Comb 花粉刷**
  - Rows of hairs on the inner side of first tarsomere, can scrape pollen off the abdomen 后足基跗节扁宽，有毛
- **Pollen basket 花粉篮：** formed in the connection between the tibia and the tarsus, and this basket is used for collecting the pollen grains

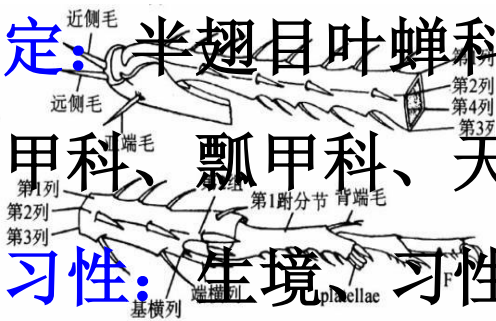


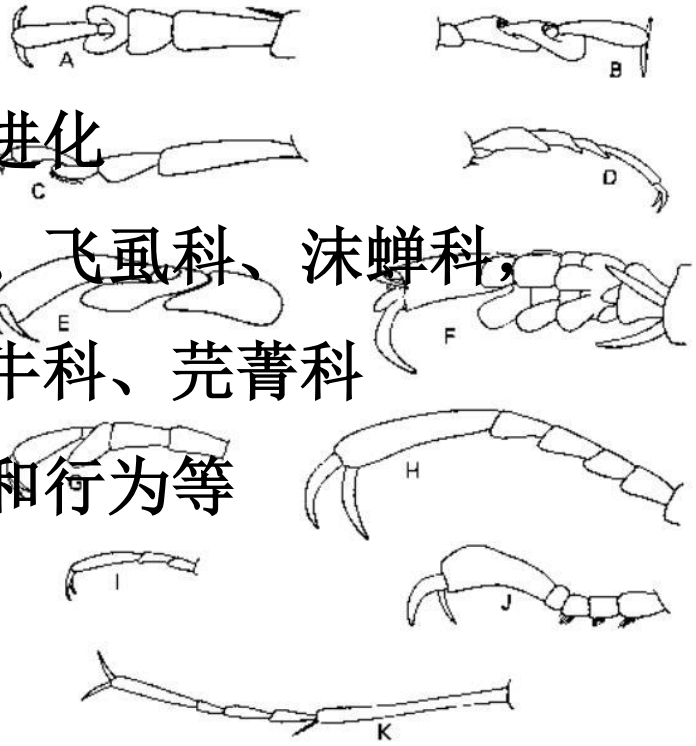
Clinging (Scansorial) legs 攀悬足

- louse
- leg is short and thick
- tip with a single, large tarsal claw which folds back against the tibial process

Significance of insect legs







趋同进化：形态的适应性趋同进化

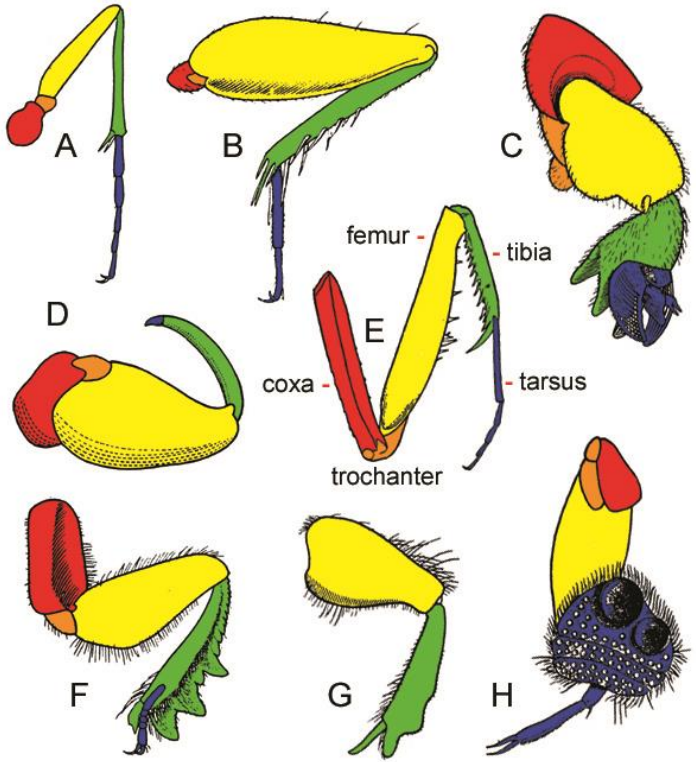
物种分类鉴定：半翅目叶蝉科、飞虱科、沫蝉科，

鞘翅目拟步甲科、瓢甲科、天牛科、芫菁科

判定生物学习性：生境、习性和行为等

Summary

Whose legs are these?



Assignment

- **To discuss the function of different types of insect adult legs.**

Further reading

- van de Kamp T. (2011) A Biological Screw in a Beetle's Leg. *Science*. 333(6038):52. DOI: 10.1126/science.1204245
- Weiraucha D, *et al.* (2011) On the evolution of raptorial legs – an insect example (Hemiptera: Reduviidae: Phymatinae). *Cladistics*. 27: 138–149.