

Topics

2008 PEET Workshop
Nov. 1-2, 2008

Auchenorrhynchan Morphology

Approach

- General Morphology concepts
- Morphological features
 - Generalized Derivation (Evolution) of structures + Features of Fulgoromorpha
 - Focus on phylogenetically important structures
 - Abdomen (excluding terminalia)
 - Thorax
 - Legs
 - Wings
 - Head
 - Genitalia

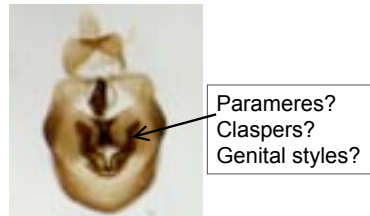
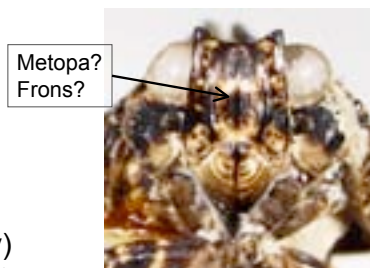


Phylloscelis atra (Dictyopharidae)
(Photo Tom Bentley @ bugguide)

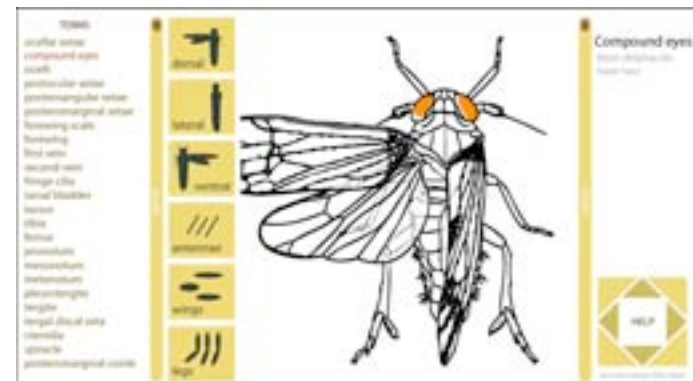
General concepts in Morphology

Morphological “tasks”

- Description of “parts”
 - Descriptive taxonomy
- Function(s) of “parts”
- Homology and evolution of “parts”
- Names of “parts” (Ontology)
 - Use same name of same part
 - Standardized Ontology
 - Avoid multiplicity of names
 - Although use of some terms may imply homology that is not intended
 - Avoid ‘provincial’ names (geographic or taxonomic)
 - Caveats: Ontogeny or evolutionary specific terms



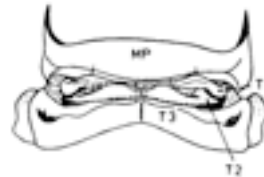
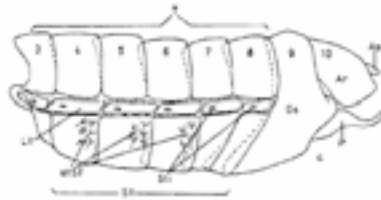
Delphacid morphology and ontology guide



Mock-up representation of interactive morphology and ontology guide based on previously developed thrips guide. Guide includes a variety of views of structures with clickable art and an alphabetic list of terms to show structures on drawings with definitions and comments presented at right.

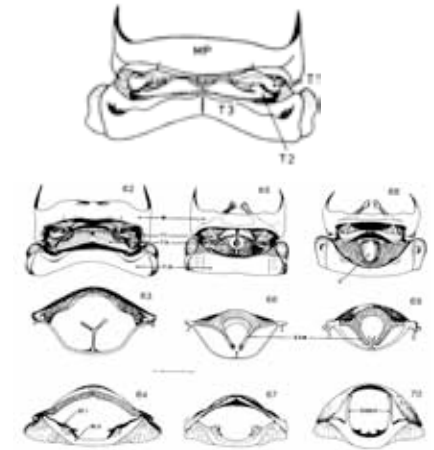
Phylogenetic features of fulgoroid abdomen

- Few features used for most segments, except:
 - Male terminalia
 - Female genitalia
 - Tymbal mechanism

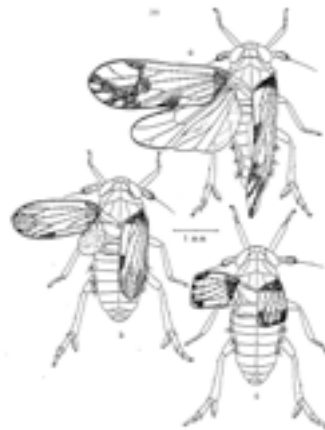
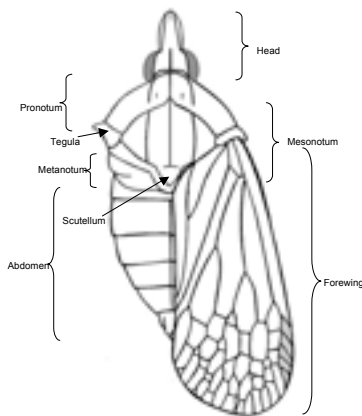


Tymbal Mechanism

- Primitively present in Auchenorrhyncha
- Within fulgoromorphs, best described in the Delphacidae
 - Features –
 - Tymbal sexually dimorphic
 - Central plate of abd tergite 2 (presence)
 - Process of metapostnotum (EAM)
 - Shape of apodeme of sternite 1 & 2

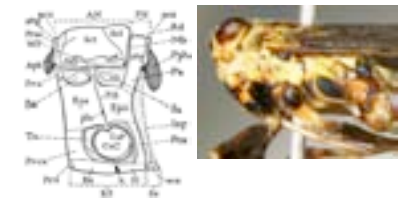
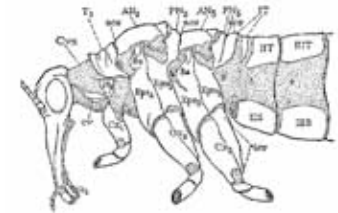


The Thorax



The Insect Thorax

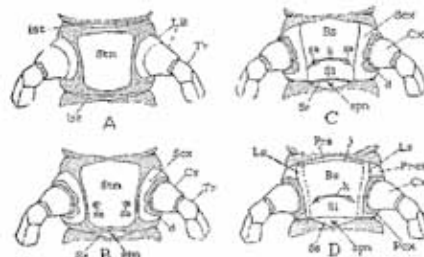
- Generalities
 - 3 segments
 - Prothorax reduced,
 - Legs, wings (center of locomotion)
 - Pterothorax
 - Modified for locomotion by
 - Secondary folds
 - Sclerotized pleuron via incorporation of subcoxa, epicoxa into body wall
 - Sternum: furca in Auchenorrhyncha
 - Pleural and sternal regions little used for phylogenetic coding
 - Tergum and legs with some features



The Insect Thorax

The Sternum

- “**Eusternum**”
 - Anterior **basisternum** (bs)
 - Posterior **sternellum** (Sl)
 - Sternacoxal suture (k)
 - Sternal pits (sa)
- **Intersternite** = **spinasternum** (ist, ss)
 - **Spina** (spn)
- **Sternopleurite** (ventral portion of subcoxa)
- **Prescutum** (prs) separated by anterior submarginal suture

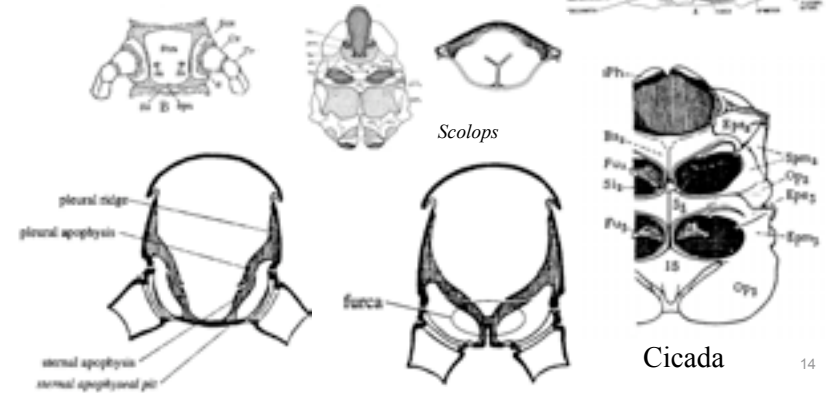


Generalized diagrams

13

The Thoracic Endoskeleton

- Auchenorrhyncha have furca
 - Sternum infolded, ventral longitudinal groove (“discrimen”)

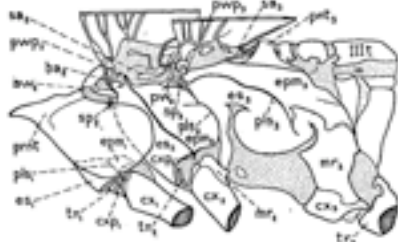
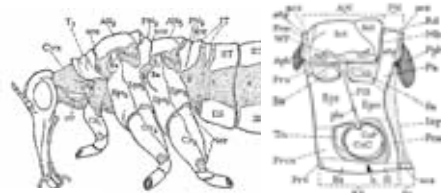


Cicada

14

The Thorax

- Pleural region
 - Large coxae
 - Sclerites small
 - Not traditionally used for phylogenetic features

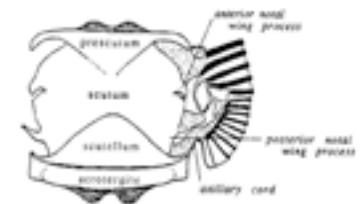


Scolops (Dictyopharidae)

15

The Thorax

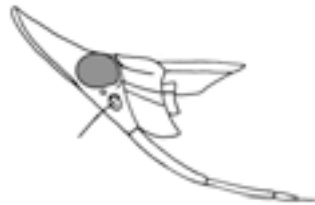
- Tergum
 - Basic structure as in abdomen
 - 2 common additional sutures:
 - an anterior suture, separates prescutum
 - a “v-shaped” suture (**scutoscutellar**) - separates scutum from scutellum
 - Functional plate = **Alinotum**
 - definitive tergum + acrotergite
 - posterior acrotergite = **postnotum**



16

Features of the thorax

- Pronotum
 - "Lateral" carinae curved laterally or reaching hind margin
 - Some taxa (e.g. Dictyopharidae) with additional pair of carinae between eye and tegulae
 - Relative length, width, ratios
- Pits on adults (presence)



Features of the thorax

- Carinae of mesonotum
 - # of carinae (higher level)
 - (2?), 3, 5 (??)
 - Parallel, diverging, reaching hind margin
 - Ratios (length/width vary for brachypters/macropters)
 - Parapsidal Furrows ?
- Tegulae
 - Evident or not
 - Reduced in brachypters



Yucanda (Dictyopharidae)

Legs

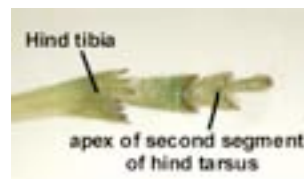
- Phylogenetic features
 - Spination of tibiae
 - Relative lengths of parts
 - Foliaceous segments
 - Spination of tarsomeres



Neopunana

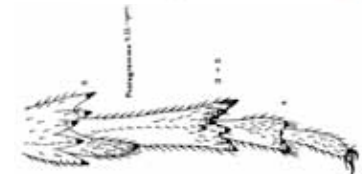


Melanoliarus

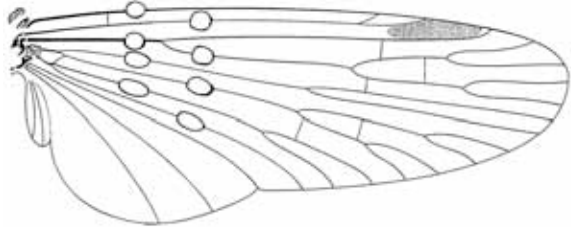


Legs

- Phylogenetic features
 - Spine formula of tibiae, basitarsus and second tarsomere
 - 5-8(3+5)-4
 - 5-5-3
 - 5 (3+2)-7(5+2)-4
 - Variable among early derived and higher taxa
 - Fixed among derived taxa



The Wing



21

The Insect Wing

- Evolved once
 - Wing veins can be homologized
- Appears early in fossil record
 - Perhaps 345 mya (or earlier)
 - Earliest fossils 320 mya
- Past examination of wing vein homologies emphasized Neopterous insects and used a now questionable technique
- “Recent” efforts emphasize primitive forms
 - Revised vein terminology
 - Revised Martynov; not Comstock

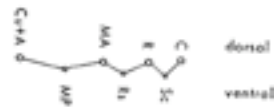
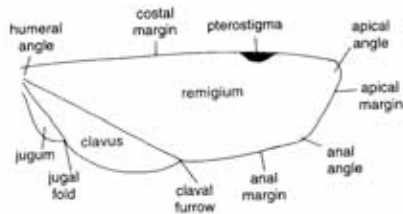


Lithomantis (Lithomanteidae: Paleodictyoptera), ca. 330 mya

22

The Wing Regions

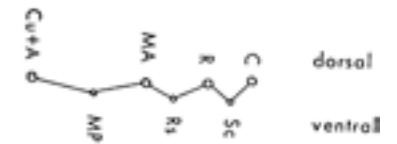
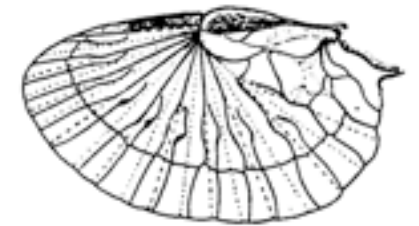
- Base of wing: Axillary region
 - axillary sclerites
- Rest Alar region
 - pterostigma
- Remigium
 - Clavus or Vannus
 - Vannal lobe
 - Jugum (jugal lobe)
 - Fold - functional at rest
 - longitudinal
 - Flexion - functional in flight
 - Transverse



23

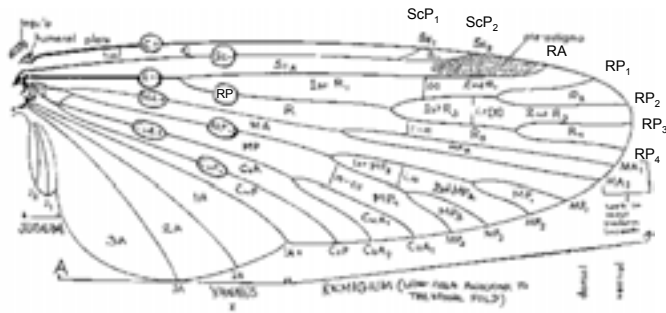
The Insect Wing

- “Modern” Ideas
 - Wootton, Kukalova-Peck
 - modified nomenclature, based on Martynov
 - For Auchenorrhyncha see Dworakowska 1988
 - Ancestral wing pleated
 - Each longitudinal vein possesses
 - Anterior branch
 - » “+” veins (convex)
 - Posterior branch
 - » “-” veins (concave)



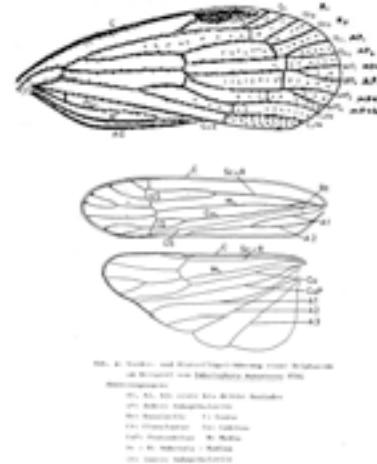
24

The Insect Wing

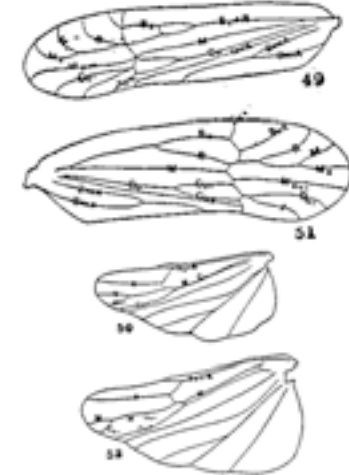


Wing Venation

Fennah 1944 Cixiidae



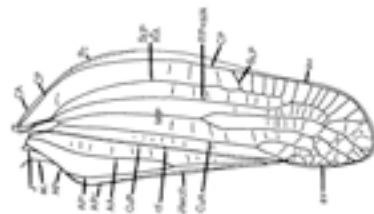
Metcalf 1913 Cixiidae



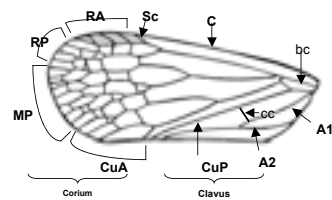
25

Modern Interpretation

- Pc ? (Precosta)
- CA, CP
- Sc[P]
 - No "node"
- R1 = RA
- Rs = RP
- M = MP
 - MA = absent
- Cu1 = CuA
- CS (CF) ≈ CuP
- 2 anal veins



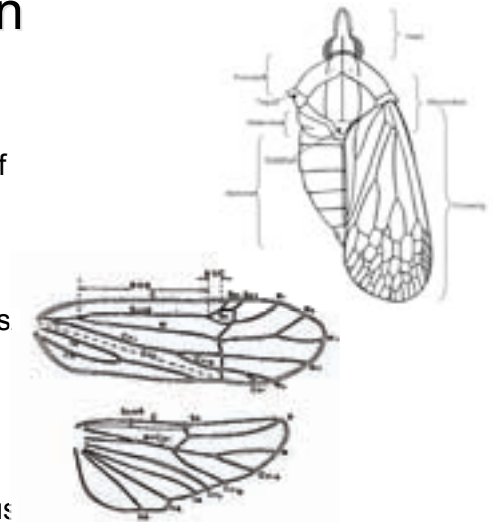
Issidae (Colpoptera)



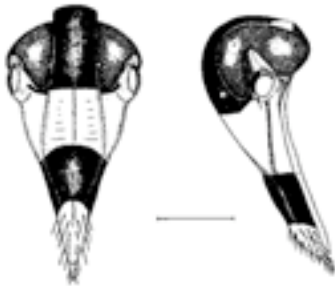
Dictyopharidae

Wing Venation

- Phylogenetic Features
 - Presence/absence of branches
 - Branch sequence / arrangement
 - location of crossveins
 - row of crossveins
 - Groups specific
 - Wing coupling mechanism
 - Stridulatory apparatus
 - Derbidae, HW

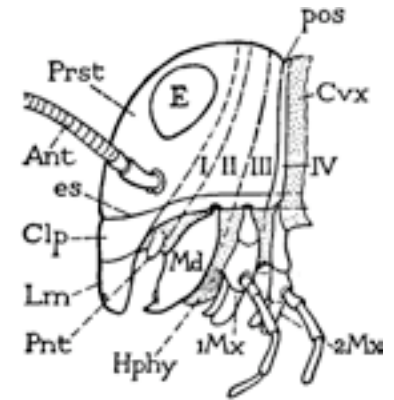


The Head



Head Origin

- Head made up of segments
- Segmental origin greatly obscured
 - mouthparts “obviously” derived from legs
 - True number of head segments
 - 3-7 proposed
 - Snodgrass: 4 (very conservative)
 - Rempel: 6
 - Chapman: 7

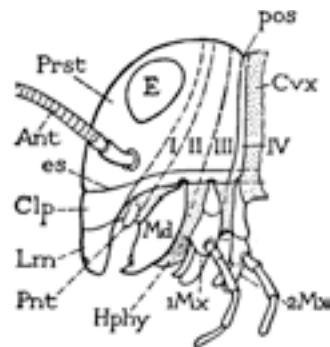


30

Head Segmentation

Two groups of head segments –
“Preoral” & “Postoral”

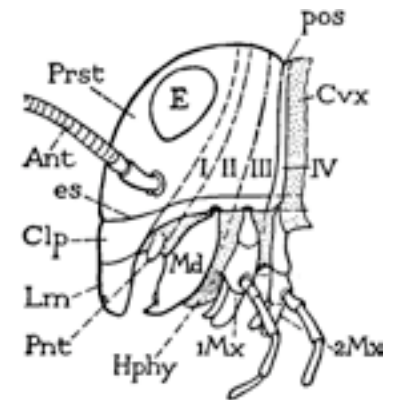
- Postoral (after mouth)
 - not debated (except intercalary)
 - 4 segments:
 - I. **Intercalary**
 - no appendages in insects (Pnt = “preantenna” or “premandibular appendage”, an embryologic structure)
 - » tritocerebrum
 - 2nd antennae in Crustacea
 - **chelicerae of arachnids**
 - II. **Mandibles** (pedipalps of chelicerates)
 - III. **Maxillae** (1st maxillae)
 - IV. **Labium** (2nd maxillae)



31

Head Segmentation

- **Preoral**
 - Everything debated
 - Perhaps 3 segments
 - **Acron** (not segment – “prst”)
 1. **Labrum**
 - Frontal ganglion
 2. **Compound Eyes**
 - Protocerebrum
 3. **Antennae** (absent in Chelicerata)
 - Deutocerebrum

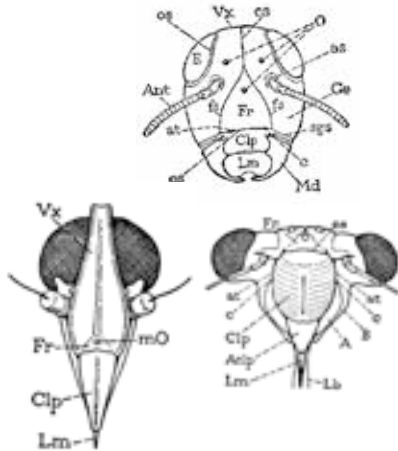


32

Regions of the Head

Frontoclypeal region

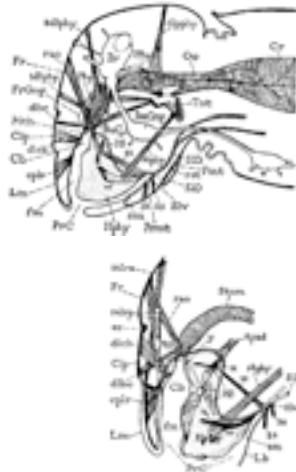
- Clypeus
 - May be separated into dorsal postclypeus, ventral anteclypeus,
 - Attachment of cibarial muscles
- Frons
 - Includes median ocellus
 - Between frontoclypeal and frontal suture (if present)
 - Muscles of labrum originate
 - “Vertex” – top of head posterior to frons



33

Insect Gnathal Region

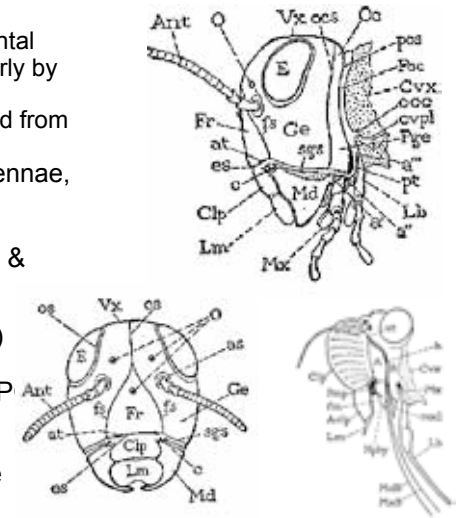
- Mouth cavities
 - Mouthparts and chewing region functionally external to head
 - “True mouth” resides in “floor” of preoral cavity
 - Preoral Cavity
 - Cibarial cavity
 - definitive mouth
 - Salivarium (salivary chamber)
 - Associated with “salivary pump”



35

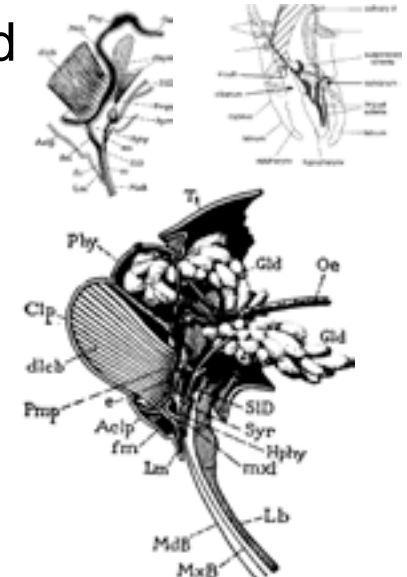
Regions of the Head

- Parietals
 - Separated anteriorly by frontal suture (if present), posteriorly by occipital suture
 - Composite structure derived from 4 head segments
 - Includes lateral ocelli, antennae, eyes, vertex, genae
- Occipital Arch
 - Between occipital suture & postoccipital suture
 - Occiput (Oc, dorsal)
 - post genae (Pge, lateral)
- Postocciput
 - rarely evident, although P present
- Subgenal area
 - pleurostome, hypostome



The Cicada Head

- The cibarial pump
 - Cibarial cavity fully enclosed by fusion of mouthparts & head!
 - Walls sclerotized
 - Anterior wall concave
 - Dilator muscles (from postclypeus) greatly enlarged
 - ant. wall returns to concave position, ventral end first
 - pharynx ⇨ esophagus

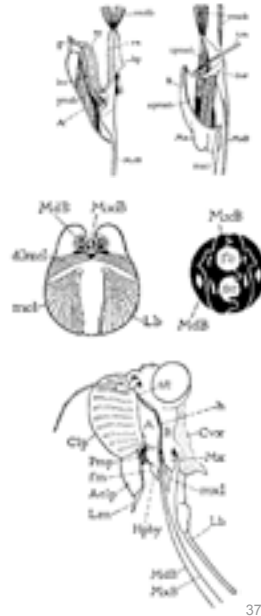


36

The Cicada Head

Cicada head, lateral view

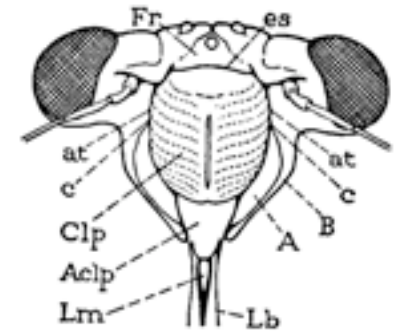
- 2 plates for muscle attachments
 - "mandibular plate"
 - composed of gena & ? mandible
 - called "juga" in Heteroptera
 - "maxillary plate"
 - postgena & maxillae
 - "lorum" in Heteroptera
- labium
 - dorsally adjoins neck membrane
- postoccipital region membranous



The Cicada Head

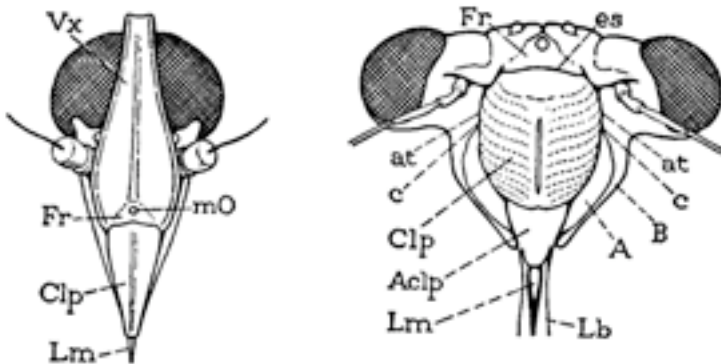
Most of face occupied by enlarged clypeus

- Epistomal suture bowed, pits near antennae
- clypeus subdivided:
 - dorsal **postclypeus**, ventral **anteclypeus**
 - ("tylus" in Heteroptera)
- Small, elongate, pointed labrum ventral to anteclypeus
- Frons, antennae, ocelli, shifted dorsally
- Vertex small & narrow
- Frons small
 - postfrontal suture present



38

Regions of the Head Cicadamorpha vs. Fulgoromorpha



39

Head Modifications

- Front of head
 - Displacement of frons:
 - Upward - by enlarged (post) clypeus
 - Downward - by extension of vertex
 - Elongation & processes
 - Recognize epistomal suture by presence of pits at lateral margins
 - Clypeus gives attachment to cibarial muscles
 - Frons - Labral muscles, median ocellus, between antennae



Dictyophorodelphax mirabilis Swezey (Delphacidae) from Oahu (Hawaii)

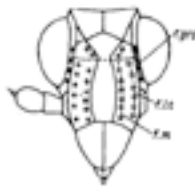
40

Regions of Head

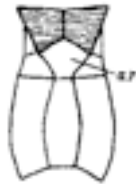
- Head regions – Emeljanov (1996)

- delphacid nymphs
- Issid adults

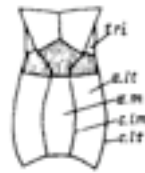
- Metopa ~frons
- Corypha ~vertex
- Ar = areolet
- A. It = lateral area, A.m. = medial area (of eumetopa)
- C. im. = intermediate carina, c. lt. lateral carinae (of eumetope)
- Tri = trigon



Shaded = Macro-corypha
Clear = eumetopa

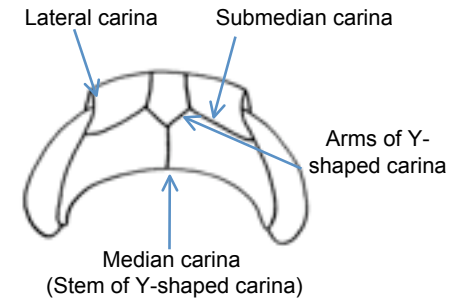
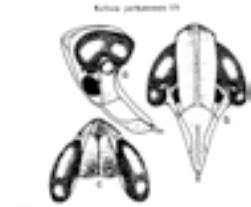


Shaded = Corypha
Clear = metopa



Shaded = acrometopa

Head Carinae

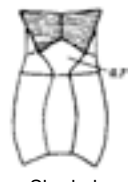


Regions of Head

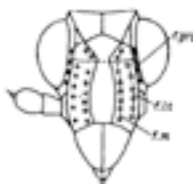
- Head regions – Emeljanov (1996)

- delphacid nymphs
- Issid adults

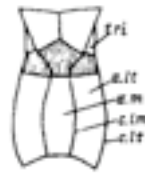
- Metopa ~frons
- Corypha ~vertex
- Ar = areolet
- A. It = lateral area, A.m. = medial area (of eumetopa)
- C. im. = intermediate carina, c. lt. lateral carinae (of eumetope)
- Tri = trigon



Shaded = Corypha
Clear = metopa



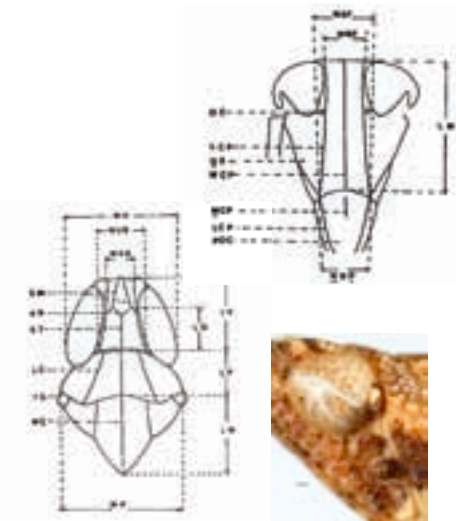
Shaded = Macro-corypha
Clear = eumetopa



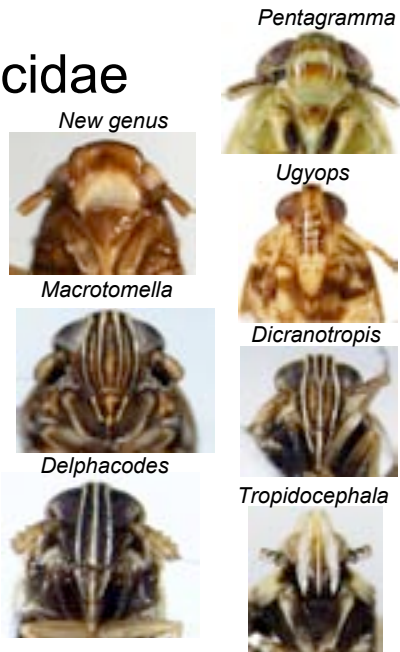
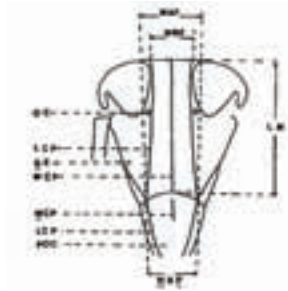
Shaded = acrometopa

Features of the Head

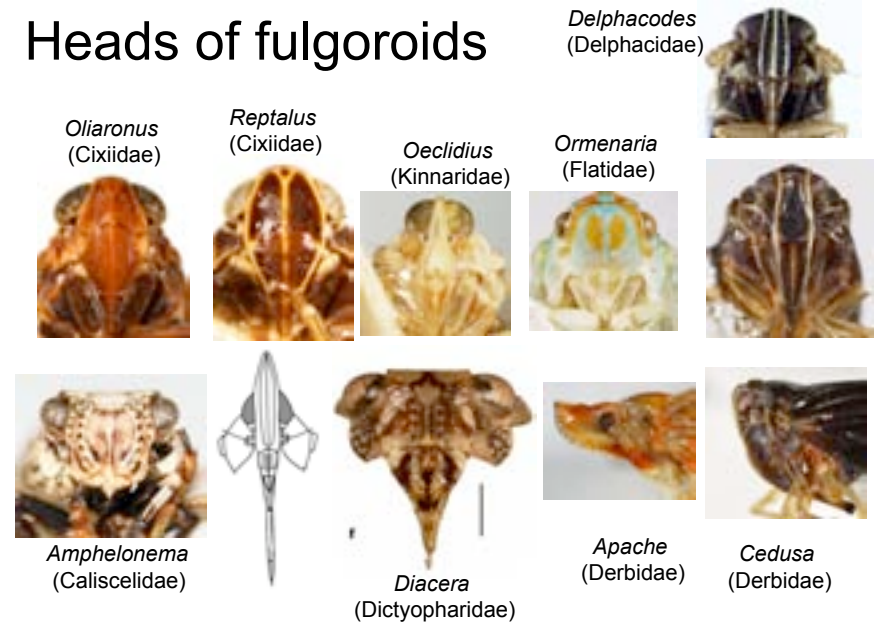
- Presence / absence of carinae
- Arrangement of carinae
- Length/width /ratios of various compartments of head
 - Vertex length/width ratio
 - Frons dimensions
- Length of vertex relative to pronotum
- Other features
 - Posterior callosity of eye



Heads of Delphacidae

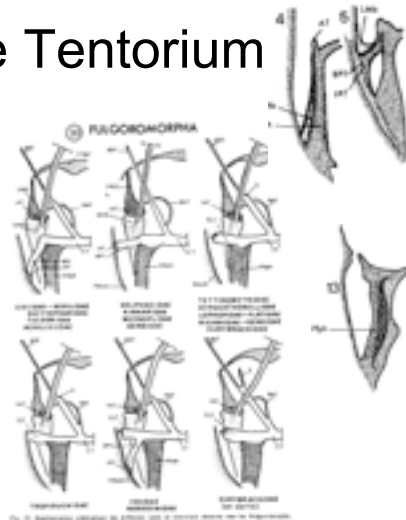


Heads of fulgoroids



Features of the Tentorium

- Bourgoin 1986
 - Examined 20 families
 - Recognized 6 generalized forms
 - Development, orientation of posterior brace (BPT)
 - Development of lateral expansion (ELT)



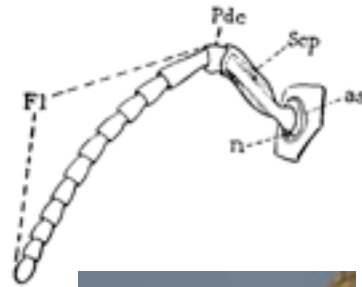
Left view, facing right

Antennae



Antennae

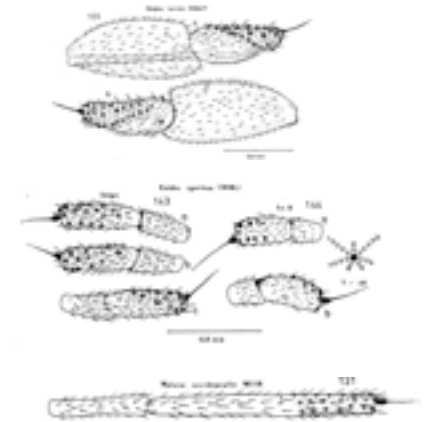
- Antennal socket
- Basal scape
 - muscle insertions at base --> ant. Tent arms (usu)
- Pedicle
 - bears Johnston's Organ
 - muscles from scape
- Flagellum
 - no muscles, exc. In Diplura, Collembola
- In Fulgoroidea: scape, pedicle & terminal bristle



49

Antennae

- Features
- Flattened/terete
 - Relative length of segments
 - Arrangement and distribution of sensory structures (rhinaria)

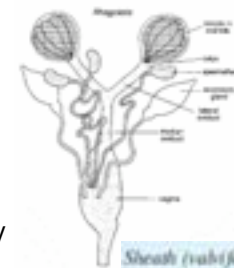


The Reproductive system Female



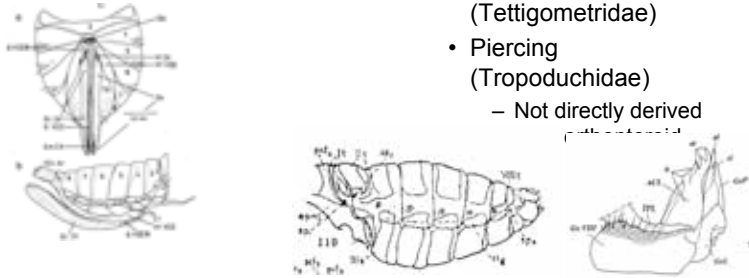
The Insect Reproductive System

- **Reproductive parts:**
- I. Female
 1. External appendicular parts
 2. Internal (mesodermal) parts
 - Soft reproductive anatomy
 3. Internal (ectodermal) parts
 - "Hard" internal anatomy
- II. Male
 1. Ectodermal parts

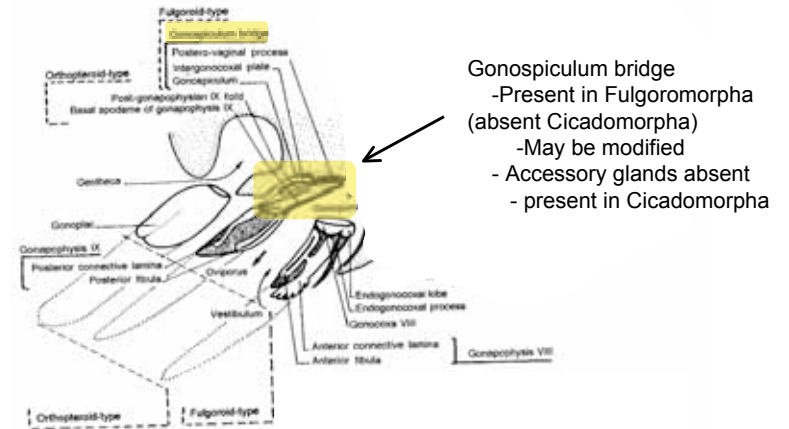


Ovipositor of Fulgoroidea

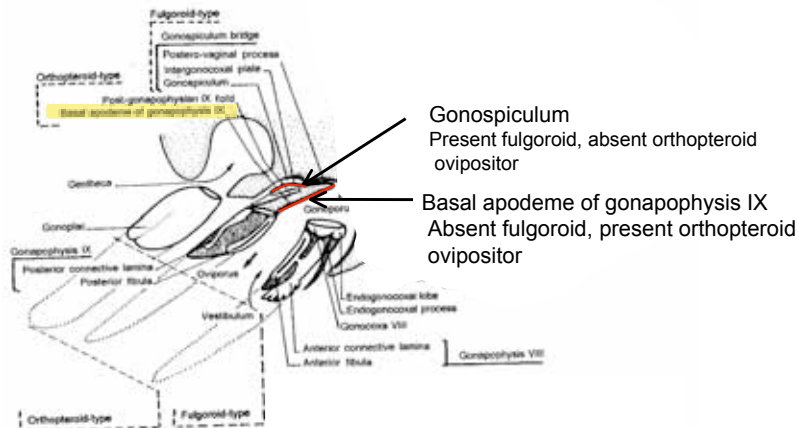
- “Orthopteroid” type
 - Primitive
 - Insert eggs into plant material
- “Fulgoroid” type
 - Derived
 - Varied functionality
 - “raking” (many groups)
 - Secondarily reduced (Tettigometridae)
 - Piercing (Tropoduchidae)
 - Not directly derived



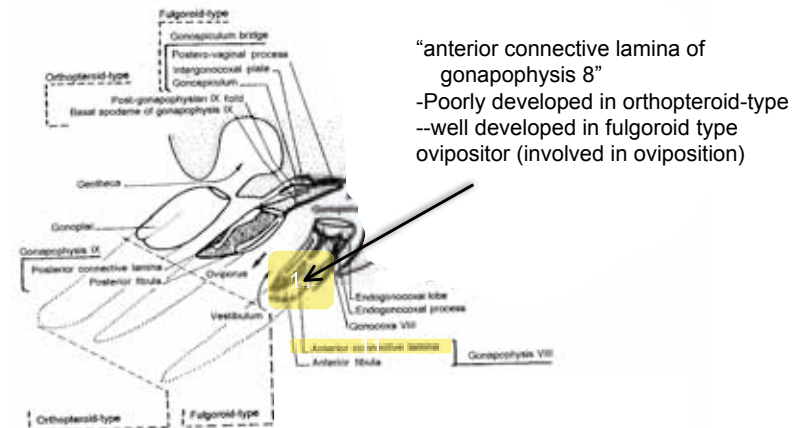
Ovipositor of Fulgoromorpha Bourgoin 1993



Ovipositor of Fulgoromorpha Bourgoin 1993

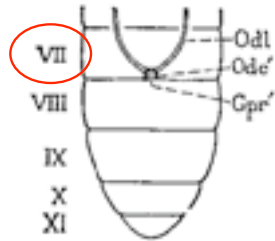
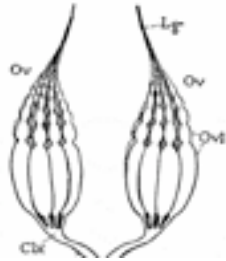


Ovipositor of Fulgoromorpha Bourgoin 1993



The Insect Reproductive System Female Internal

- Paired lateral oviducts
 - Mesodermal
 - Primitively paired openings on 7th segment (ovaries in series, not parallel)

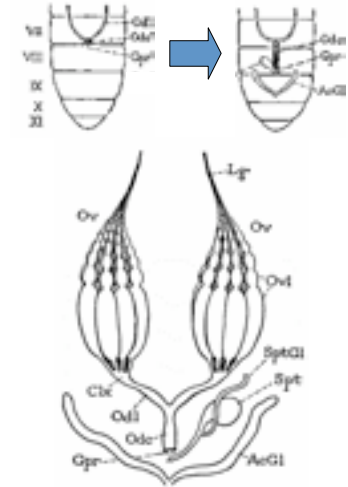


Odl = lateral oviduct
Odc = median (common) oviduct
Gpr = gonopore

61

The Insect Reproductive System Female Internal

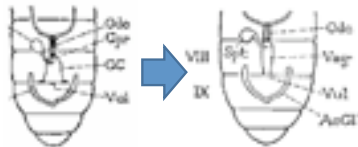
- Fused median oviduct
 - Ectodermal origin
 - Cuticular lining, muscles
 - Opens externally or into genital chamber (*next slide*)
 - Gonopore
 - Function: egress of eggs
 - Primitively, posterior 7th
 - Often posterior 8th
 - Spermatheca (open on 8th)
 - Accessory glands (open on 9th)



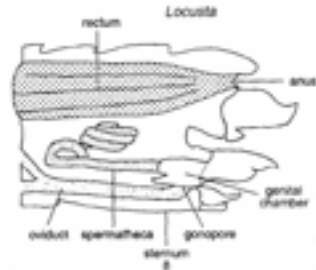
62

The Insect Reproductive System Female internal

- Genital chamber
 - External cavity
 - When internalized → vagina
 - Opens posterior 8th (or on 9th)
 - Receives
 - Median oviduct (gonopore)
 - Spermatheca (origin 8th segment)
 - Accessory Glands** (Origin: 9th segment)
 - Copulatory chamber
 - Opening: **Vulva**



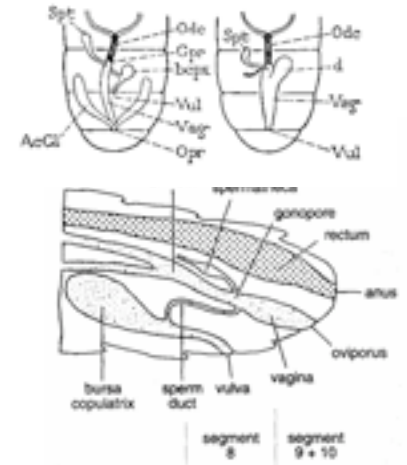
Lateral view: Orthoptera



33

The Insect Reproductive System Female Internal

- Additional modification –**
 - Extension of median oviduct**
 - creates “ditrysic” condition - two openings (egg egress and copulatory chamber)
 - Found in cicadas, some delphacids..
 - May be secondarily fused to monotrysic condition**
- Lateral view - Lepidoptera**
 - Genital chamber enclosed (vagina)
 - Receives median oviduct (gonopore); spermatheca
 - Exit: **oviporus** (not copulatory chamber)
 - Separate copulatory chamber (**bursa copulatrix**)
 - External opening **vulva**

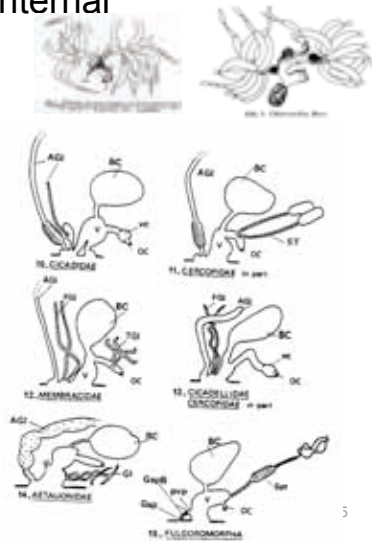


34

The Insect Reproductive System

Female Internal

- Cicadomorpha
 - Accessory glands
 - Spermatheca absent
 - Vaginal crypts
- Fulgoromorpha
 - Accessory glands present
 - Spermatheca present
- Fulgoromorphan modifications
 - 2-pouched bursa
 - Glandular diverticula of vagina
 - Oviduct gland

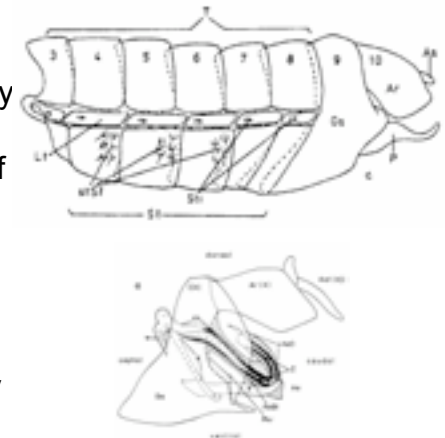


5

The Reproductive System

Male

- Internal male (mesodermal) anatomy “not important”
- Form and derivation of ectodermal anatomy
- Genital segment = 9
 - Sternum and tergum fused = “pygofer”
- Segment 10, 11 (anal style) situated dorsally

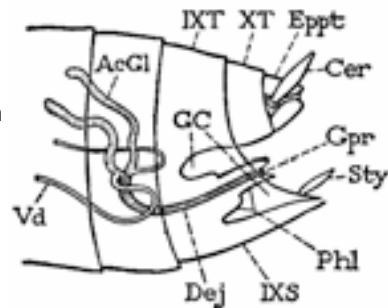


66

The Insect Reproductive System

Male External - derivation

- Complex!
 - See Tuxen 1970; Yang & Chang 2000
 - Homologies uncertain between insect orders
 - terminology variable between taxa, authorities
 - species level variation
 - principle taxonomic feature for species definition & recognition

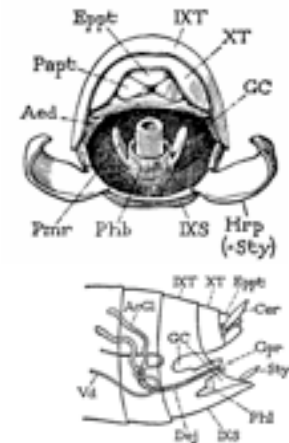


67

The Insect Reproductive System

Male External

- Derivation of structures
 - Genital segment: 9th
 - Terga & sterna fused - “Pygofer”
- Two sets of structures:
 - **Phallic**
 - Derived from phallic lobes
 - » Phallus, parameres
 - **Peripheral** (includes genital appendages on segments 8-11)
 - Derived from legs, other non-phallic structures
 - » Cerci, **harpagones**, etc.



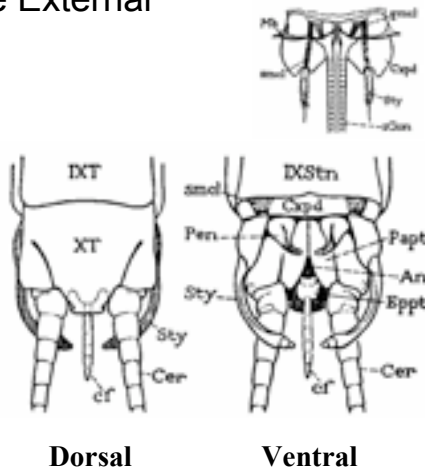
68

The Insect Reproductive System

Male External

- Mayflies
 - Paired penes
 - Ectodermally derived, paired openings to vasa deferentia
 - "claspers"
 - Gonastylus in Mayflies?

Note: development mostly postembryonic

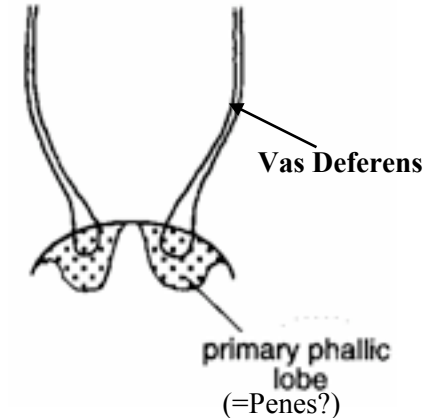


69

The Insect Reproductive System

Male External

- Origin of the phallic organs
 - Initial exit paired (mesodermal) exits of vasa deferentia
 - Venter of 9
 - Exits with single external lobes
 - Origin unclear
 - Appendages or "penes"
 - Similar condition in modern Ephemeroptera



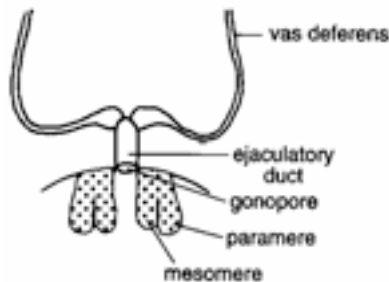
See Chapman 1998 pp. 276-278 (sect. 12.3.1)

70

The Insect Reproductive System

Male External

- Origin of the phallic organs
 - Fusion of V.D. to form ejaculatory duct
 - Ectodermal
 - Exit: male gonopore
 - Primary phallic lobes divide
 - Inner lobes "mesomeres"
 - Outer lobes "parameres"

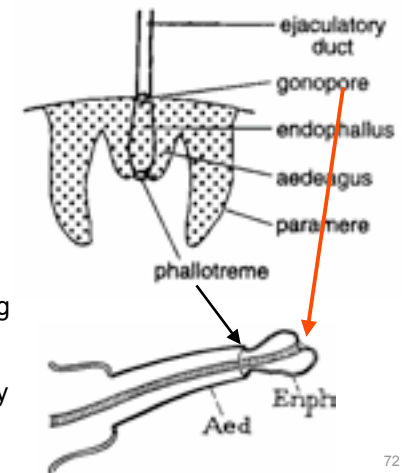


71

The Insect Reproductive System

Male External

- Origin of the phallic organs
 - Mesomeres
 - Fuse to form aedeagus
 - Exit phallotreme
 - Internally "endophallus" (=preputial sac)
 - Can be everted so that gonopore is terminal
 - Parameres
 - Enlarged to form grasping structures
 - Called "parameres" (s.s.)
 - Periphallic structures may be called parameres

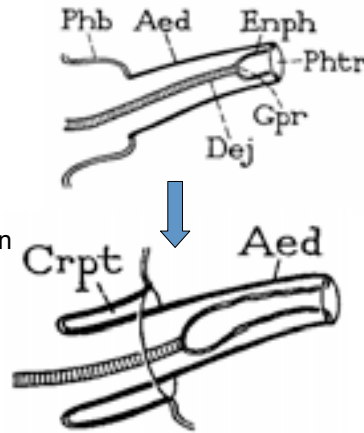


72

The Insect Reproductive System

Male External

- Variants of the phallic organ (I)
 - “Phallobase” variously differentiated basal region of aedeagus
 - Invagination of base
 - Base of aedeagus sunken
 - No evident phallobase
 - Called “phallocrypt” by Snodgrass
 - Phallocrypt & endophallus eversible

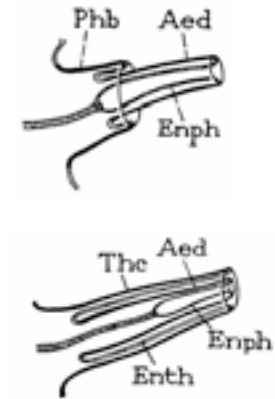


73

The Insect Reproductive System

Male External

- Variants of the phallic organ (II)
 - Aedeagus retractile into phallobase
 - Enlargement of phallobase termed “theca” (Phallotheca of Snodgrass 1935)
 - theca membranous
 - endotheca sclerotized
 - Aedeagus eversible from within theca and endophallus from within aedeagus
 - “endotheca” internally

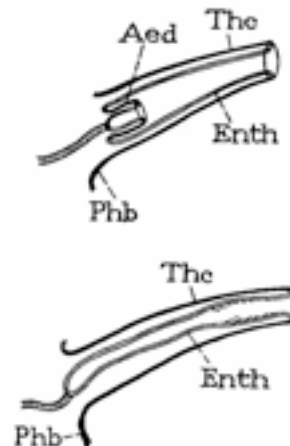


74

The Insect Reproductive System

Male External

- Variants of the phallic organ (III)
 - Fusion of aedeagus and theca
 - Theca becomes sclerotized
 - Results in “theca” becoming functional aedeagus
 - Usually called aedeagus anyway

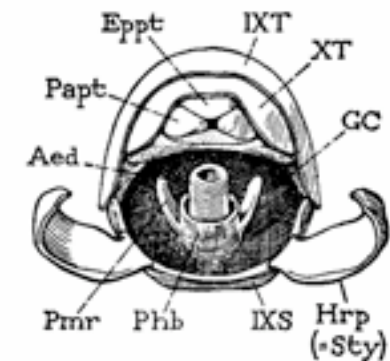


75

The Insect Reproductive System

Male External

- Periphallic structures
 - Usually functionally claspers
 - Various origins
 - From coxal styli of segment 9
 - “Harpagones” of Snodgrass 1935
 - Cerci
 - Paraprocts
 - Leg rudiments, segment 8

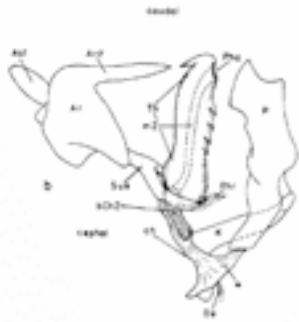


76

The Insect Reproductive System

Male External

Advanced Delphacidae

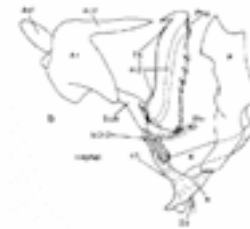


Aedeagus fused with theca

Other features

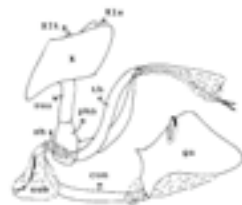
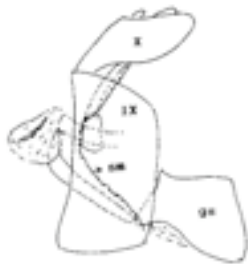
Example features

- Genital diaphragm
 - Armature of diaphragm
- Processes of pygofer / median (subgenital) plate
- Shape of parameres
- Suspensorium
- Processes of segment 10
 - Absent 1, or 2
 - Approximated or separated



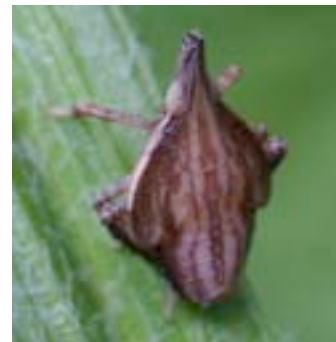
The Insect Reproductive System

Male External



Trypetimorpha (Tropiduchidae)

Immatures



Features of immatures

- Numbers and distribution of "pits" (e.g., Emeljanov, 1996)
 - Pits present in some adults (neotony)
- Sensory pits = rhinaria
- Represented by light flecks in some adults



Achorotile

Laccocera



Amphelonema
(Caliscelidae)

Bakerella



Achorotile

Laccocera



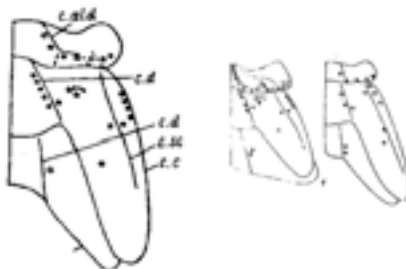
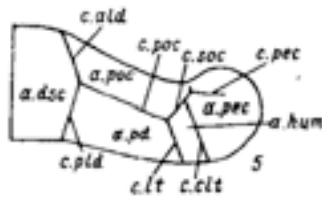
Features of immatures

- Numbers and distribution of "pits" on frons (Emeljanov, 1996)



Features of the thorax

- Immatures
 - Emeljanov 1996
 - Pronotum
 - a. dsc. = Discal area
 - a. hum. = humeral area
 - a. pd. = paradiscal area
 - a. pec. = pectoral area
 - a. poc. = post-ocular area
 - c. ald. = anterolaterodiscal carina
 - c. clt. = collateral carina
 - c. lt. = lareral carina
 - c. pec. = pectoral carina
 - c. pld. = pectoral carina
 - c. poc. = postocular carina
 - c. soc. = subocular carina
 - Mesonotum
 - c. c. = costal carina
 - c. d. = discal carina (also metanotum)
 - C. Sc. = subcostal carina



Features of immatures

- Number and arrangement of sensory pits on abdomen
 - A. m. = median area
 - A. im. = intermediate area
 - A. lt. = lateral area
 - A. ex. = Extralateral area
 - C. lt. = lateral carina
 - C. m. = median carina
 - C. im. = intermediate carina

