Unit 8 - Polyneoptera

Open Entomology Project

17 August 2016

Introduction

This lab primarily focuses on Polyneoptera (Insecta: Pterygota: Neoptera), a hodgepodge of taxa that may or may not be monophyletic. Do you see characters that might be synapomorphies?

Materials

- specimens (provided)
- fine forceps, probes (provided)
- sorting tray, watch glasses, gloves, safety glasses, glycerine, ethanol (provided)
- pencil/paper for sketches

Safety

We will be working with sharp tools and insects on sharp pins. Wear your personal protective gear at all times. Specimens are to be returned to their vials after lab, and glycerine and ethanol will be collected for proper disposal or reuse.

Methods

Working with a partner, organize your space, specimens, tools, and microscope. Use your probe and forceps to carefully manipulate the specimen when necessary. In this lab we will not be dissecting specimens (unless otherwise noted). You can start anywhere in the handout.

1 Dictyoptera

This lineage is sometimes treated as comprising three orders, especially in the older literature: Blattaria or Blattodea (cockroaches), Isoptera (termites), and Mantodea (mantids). Recent phylogenetic work strongly suggests that termites are derived cockroaches, *i.e.*, that "Blattaria" is paraphyletic. Cockroaches and termites are referred to collectively as Blattodea (including Isoptera). These insects can be recognized by the following characters: fore wings (if present) tegmen-like, with many crossveins; male genitalia asymmetrical (reduced in termites); ovipositor extremely reduced, mostly internal; eggs deposited in proteinaceous matrix or envelope (ootheca) formed from excretions of the accessory glands (apparently lost in derived termites).

Big picture questions

We talked about several adaptations for egg protection in Dictyoptera. Can you describe them?

What evidence do we have to suggest that termites are derived cockroaches? What are three aspects of their natural history that may have contributed to the evolution of eusociality?

We talked about several phenotypic qualities and historical factors that make cockroaches useful models for hexapodous robots. Can you describe two? If you had to choose an optimal model for *flying* robots which taxon would you focus on (of all the taxa covered in class so far) and why?

1.1 Blattidae (American cockroach, *etc.*)

- fore wing (tegmen) more sclerotized than hind wing
- female subgenital plate divided longitudinally
- male styli similar to each other: slender, straight, elongate
- spines on fore femur equal in length

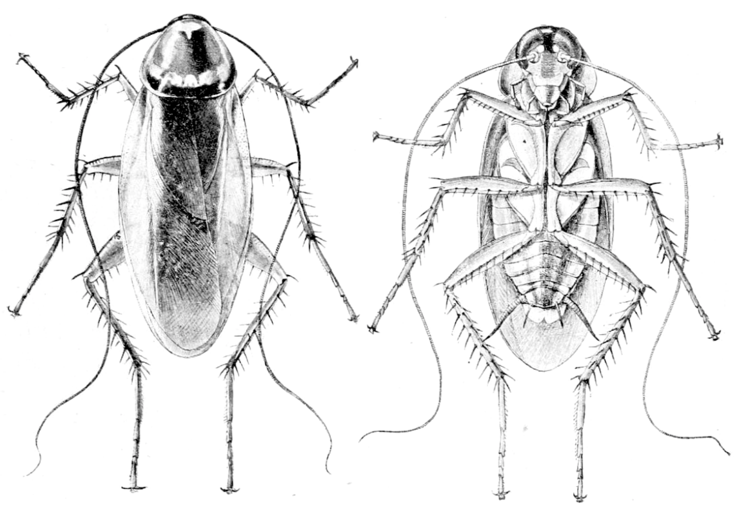
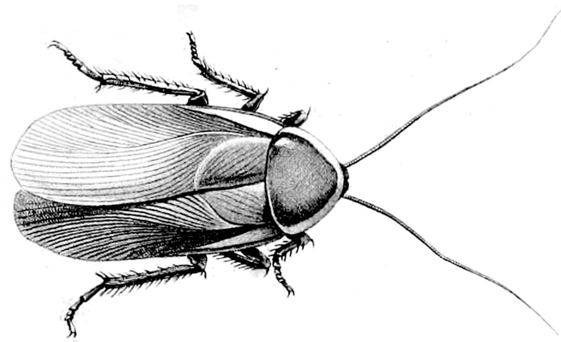


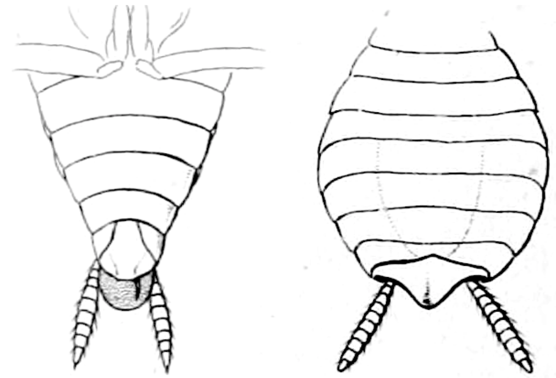
Figure 1: Blattidae, dorsal and ventral habitus (Marlatt, 1902, Fig. 1)

1.2 Ectobiidae (was "Blattellidae"; German cockroach, *etc.*)

- female subgenital plate not divided
- male styli usually small, asymmetrical
- spines on fore femur decrease in size apically



(a) Habitus, dorsal (Brunner von Wattenwyl, 1865, Plate III, Fig. 14A)



(b) Ventral view of abdomen apex; male (l), female (r) (Brunner von Wattenwyl, 1865, Plate II, Fig. 7E,D′)

Figure 2: Ectobiidae

Many insects are capable of walking or running quickly and efficiently. Why do you think cockroaches serve as the primary model for hexapodous robots? Is there something special about their morphology, or is the reason simpler than that?

1.3 Cryptocercidae (hooded cockroaches)

- end of abdomen covered by 7th tergite dorsally, 6th sternite ventrally
- no subgenital plate
- always wingless
- middle and hind femora with few spines relative to other families

1.4 Isoptera (termites)

- pronotum not shield-like (Compare to other Blattodea!)
- each tarsus subdivided into 4 tarsomeres (this character is difficult to see on dried specimen, please focus on glycerine-preserved specimens!)
- cercus composed of 1–6 sclerites

Figure 3: Cryptocercidae dorsal habitus (Glover, 1872, Plate VI, Fig. 20)

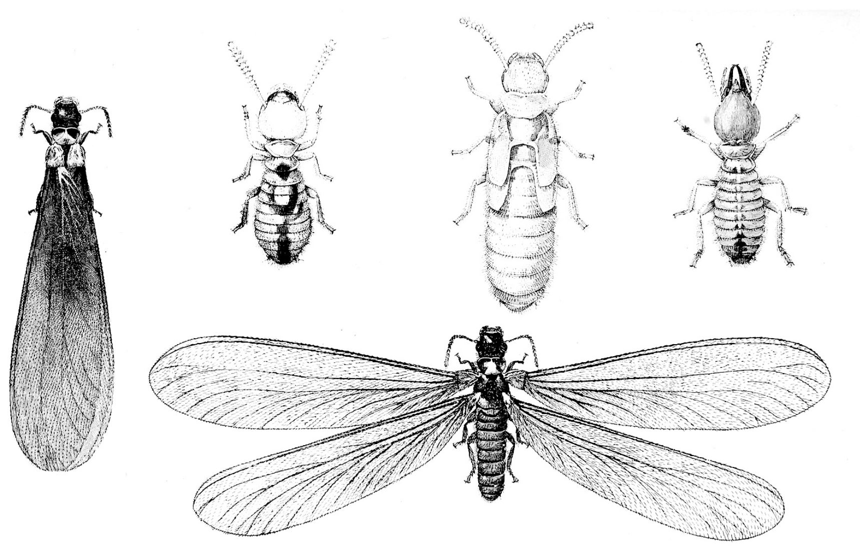


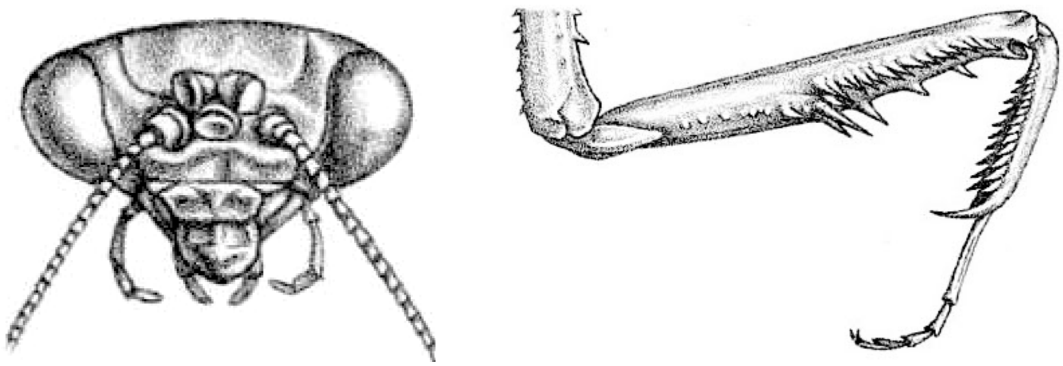
Figure 4: Isoptera, alates, worker, soldier (Froggatt, 1907, Plate II)

The presence of a fontanelle (pore) on the head is used to diagnose families, as is the number of sclerotized wing veins along anterior margin of fore wing (*e.g.*, two or three present). Can you find these features in our specimens? For soldiers, can you count the number of teeth on the inner margin of the left mandible?

1.5 Mantodea

- head roughly triangular, articulated with thorax via narrow neck (head highly mobile)
- face with area (facial or frontal shield) delimited by carinae
- prothorax elongate, with raptorial fore legs
- fore wings (if present) = tegmina
- male genitalia asymmetrical

Figure 5: Mantodea. Photo (CC BY-ND 2.0) by Peter G. W. Jones `https://flic.kr/p/jjh5Hh`



(a) Head, anterior view (modified from McCoy, 87, Plate 130, Fig. 1a)

(b) Raptorial fore leg (modified from McCoy, 87, Plate 130, Fig. 1f)

Figure 6: Mantodea

2 Dermaptera (earwigs)

- body dorsoventrally flattened
- head prognathous
- fore wings relatively short, heavily sclerotized, elytraform
- hind wing fan-shaped
- cerci forceps-like, each cercus comprised of a single segment
- defensive glands open near 3rd and 4th abdominal tergites

Spongiphoridae (little earwigs; includes Labiidae)

- 2nd tarsomere cylindrical
- flagellum subdivided into 18–29 flagellomeres

Figure 7: *Labia minor* (Spongiphoridae). Photo (CC BY-ND-NC 1.0) by Mike Quinn `http://bugguide.net/node/view/449544`

Forficulidae (European and spine-tailed earwigs)

- 2nd tarsomere lobed apically
- flagellum subdivided into 10–14 flagellomeres

Figure 8: Forficulidae. Photo (CC BY-NC 2.0) by Chris Moody `https://flic.kr/p/eYFc5g`

3 Embioptera (webspinners, Embiodea, Embiidina)

- body nearly cylindrical
- head prognathous

- proximalmost tarsomere greatly expanded to accommodate silk-producing glands
- wings (males only) highly flexible, similar in size/shape
- male genitalia asymmetrical

Figure 9: Embioptera. Photo © by Matt Bertone `https://flic.kr/p/dEAs8y`

4 Orthoptera

- head hypognathous
- pronotum saddle-shaped
- fore wing more sclerotized (tegmen) than hind wing
- tarsus with 4 or fewer tarsomeres
- hind leg saltatorial (femora enlarged)

Orthoptera: Caelifera

- antenna usually less than half as long as body,
- flagellum subdivided into less than 28 flagellomeres
- tarsi subdivided into 3 or fewer tarsomeres
- auditory organ is absent from the foreleg and usually present on the first abdominal segment.
- ovipositor short

Tridactylidae (pygmy mole crickets)

– pronotum does not extend over the length of the abdomen
– fore and middle tarsi with 2 tarsomeres
– fore wing reduced, stridulatory organ absent
– hind tarsus absent or represented by one tarsomere, shorter than apical hind tibial spurs; notice anything unusual about the phenotype of the hind leg?
– body usually less than 20 mm long
– auditory organ usually present on 1st abdominal segment; do pygmy mole crickets have 4 cerci?

Figure 10: Tridactylidae. Photo (CC BY-ND 2.0) by Gerald Yuvallos: `https://flic.kr/p/8Bs1y`

Tetrigidae (pygmy grasshoppers)

– pronotum extended posteriorly largely overlaps hind wing and extends over the length of abdomen
– hind tarsus with more than one tarsomeres (tarsomere formula = 2:2:3)
– hind tarsus is longer than apical hind tibial spurs
– body usually less than 20 mm long
– fore wings are absent or vestigial
– auditory organ absent

What is the function of the elongate pronotum? Is this structure perhaps taking over the function of another structure that is missing or reduced?

Why don't these insects need auditory organs?

Figure 11: Tetrigidae. Photo (CC BY-SA 2.0) by Bernard DuPont: `https://flic.kr/p/pBQHhe`

Acrididae (short-horned grasshoppers)

- pronotum not extended posteriorly, barely overlaps hind wing and does not extend over the length of the abdomen
- fore wing well developed
- hind tarsus with more than one tarsomere (each tarsus with 3 tarsomeres)
- hind tarsus is longer than apical hind tibial spurs
- body usually more than 20 mm long
- auditory organ usually present laterally on 1st abdominal segment

Grasshoppers have ears so that they can listen to each other. How do they make sounds?

Figure 12: Acrididae. Photo (CC BY-NC-ND 2.0) by Richard Ricciardi `https://flic.kr/p/pt7Cxc`

Orthoptera: Ensifera (crickets, katydids)

- antennae usually more than half as long as body, composed of more than 30 antennal sclerites
- tarsi with 3–4 tarsomeres
- auditory organ is usually present on the fore leg; can you locate this organ and compare with the auditory organ of Caelifera?
- ovipositor long

Tettigoniidae (long-horned grasshoppers, katydids)

- tarsus with 4 tarsomeres
- antennal foramina widely separated from each other
- fore wing held roof-like over abdomen
- ovipositor sword-shaped, usually curved
- hind tibia with equally-sized spines
- auditory organs present on front tibiae

Katydids have their ears in a very different part of their bodies, compared to grasshoppers. Do they also make sounds in different ways?

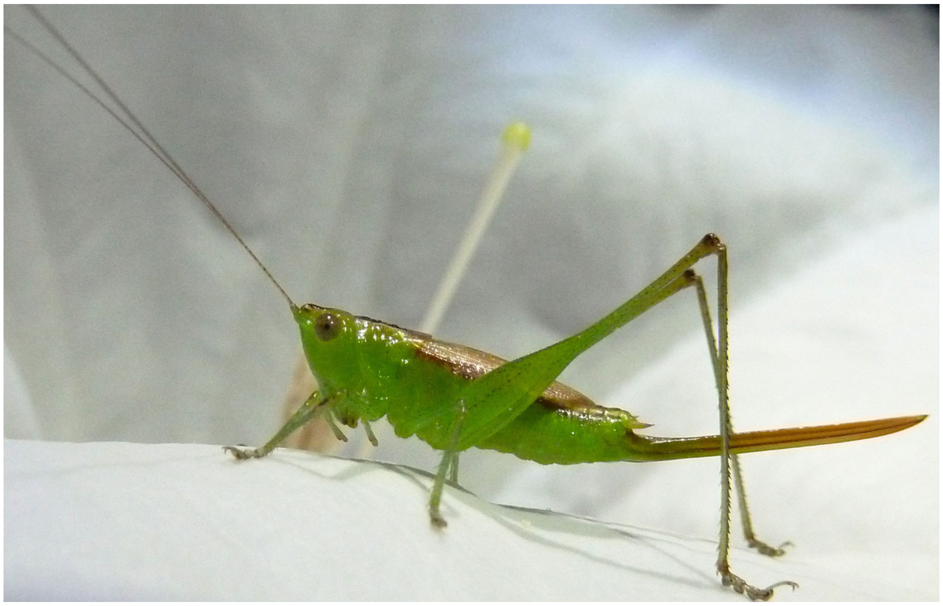


Figure 13: Tettigoniidae. Photo (CC BY 2.0) by Katja Schulz `https://flic.kr/p/cY9v5G`

Figure 14: Tettigoniidae. Photo (CC BY-NC 2.0) by Brad Smith `https://flic.kr/p/oCdoi`

Rhaphidophoridae (camel crickets)

- mid tarsus subdivided into 4 tarsomeres, others 4 or 3

– antennal foramina contiguous
– wingless, usually humpbacked in appearance
– ovipositor sword-shaped, usually curved
– hind tibia with equally sized spines
– auditory organ on fore tibia usually absent
– pseudotympanum on abdomen present

Why don't these insects need an ear?

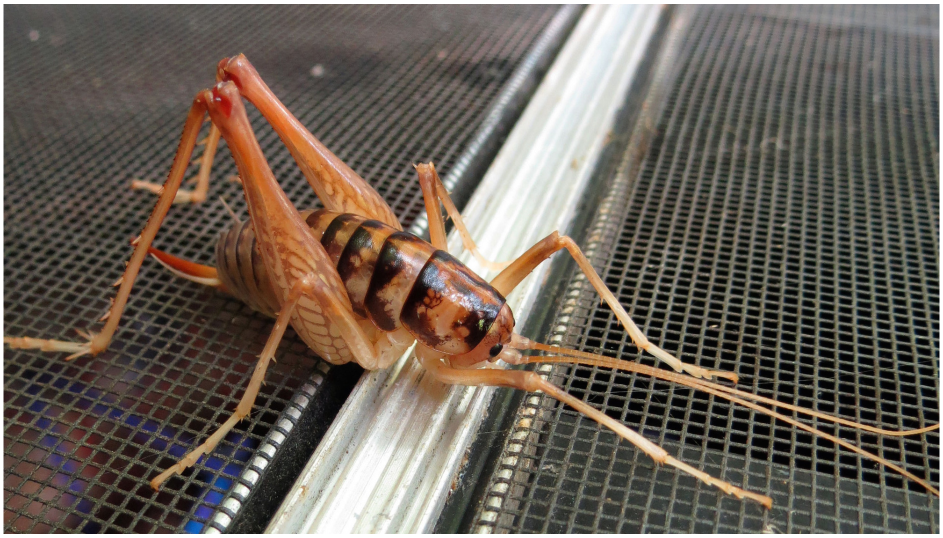


Figure 15: Rhaphidophoridae. Photo (CC BY 2.0) by Katja Schulz `https://flic.kr/p/ouPNVx`

Gryllidae (crickets, tree crickets)

– tarsi subdivided into 3 tarsomeres
– antennal foramina widely separated from each other
– wings flattened on back, not roof-like
– male fore wing with "harp"
– ovipositor cylindrical, not curved
– auditory organ on fore tibia present

Figure 16: Gryllidae. Photo (CC BY 2.0) by Brian Gratwicke `https://flic.kr/p/7XHo1E`

Gryllotalpidae (mole crickets)

- tarsi subdivided into 3 tarsomeres
- antennal foramina widely separated from each other
- wings flattened on back, not rooflike
- male fore wing with "harp"
- fore leg fossorial
- ovipositor short
- hind tibia with alternating sized spines
- auditory organ on fore tibia usually present
- pseudotympanum on abdomen present; can you locate this organ? Why is it called "pseudo" tympanum?

5 Phasmatodea (Phasmida; walking sticks, leaf insects)

- frons anterolaterally convex
- prothroax with defensive gland openings

Figure 17: Gryllotalpidae. Photo (CC BY-NC-ND 2.0) by Sergey Yeliseev `https://flic.kr/p/eGcrxX`

- trochanter+femur nearly fused

Heteronemiidae (common walkingsticks)

- mesothorax at least 4 times as long as prothorax
- each leg with 5 tarsomeres
- head without spines posteriorly
- 1st abdominal segment shorter than metathorax
- usually wingless

Figure 18: Heteronemiidae. Photo (CC BY-NC-ND 2.0) by Mark Yokoyama `https://flic.kr/p/skW7zQ`

6 Grylloblattodea (ice crawlers)

Grylloblattidae

– head prognathous

– compound eyes reduced or absent

– wings absent

– cerci multi-segmented

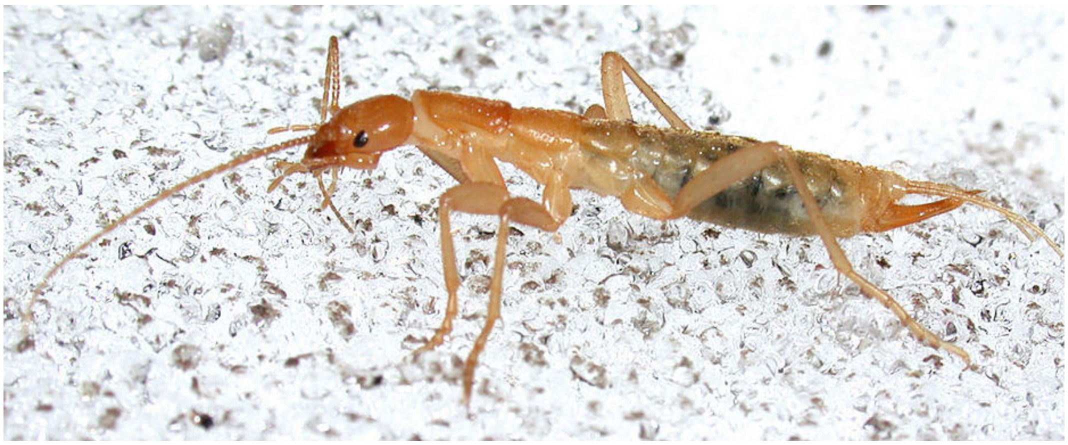


Figure 19: Grylloblattodea. Photo (CC0) by Alex Wild `https://commons.wikimedia.org/wiki/File:Grylloblattidae.jpg`

7 Mantophasmatodea (heel-walkers, gladiators)

Unfortunately, we do not have any specimens of this taxon, which lives in southern Africa.

– head hypognathous

– antennae long, with spindle-shaped flagellomeres distally

– arolium (pad-like structure on the distal end of each leg) expanded, held aloft when moving

– legs adapted for grabbing prey (spiny)

– wingless

Although they are relatively common, heel-walkers were only discovered recently (2001). Why did researchers overlook members of this taxon for so long?

8 Zoraptera

Note that these insects are gregarious, and the overall phenotype of an individual depends on status of the aggregation.

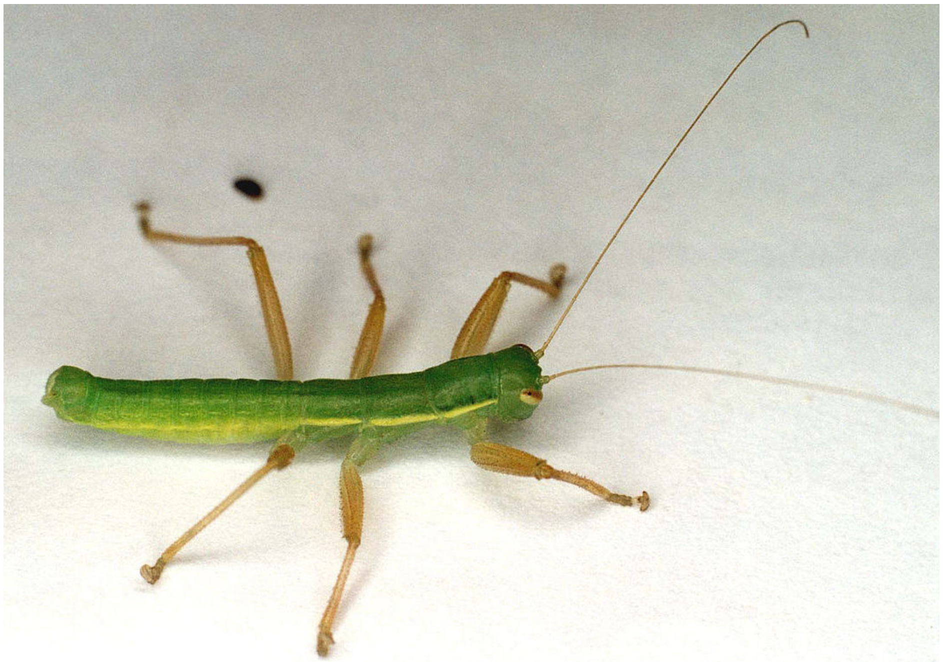


Figure 20: Mantophasmatodea. Photo (CC BY-SA 3.0) by P.E. Bragg `http://bit.ly/1WcySdc`

- pale, eyeless, wingless OR
- pigmented (brown), with small compound eyes and wings (wings are dehiscent though!); wings with relatively simple venation
- tarsus with 2 tarsomeres
- cerci comprised of one apparent segment (*i.e.*, no subdivisions)

There is one extant family: Zorotypidae.

(a) Zorapteran with eyes; wings have fallen off. Photo © by Matt Bertone https://flic.kr/p/dgJ1iJ

(b) Whitish, eyeless zorapteran. Photo © by Matt Bertone https://flic.kr/p/dgJ1vo

Figure 21: Zoraptera

Acknowledgments

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