

The Dictyoptera



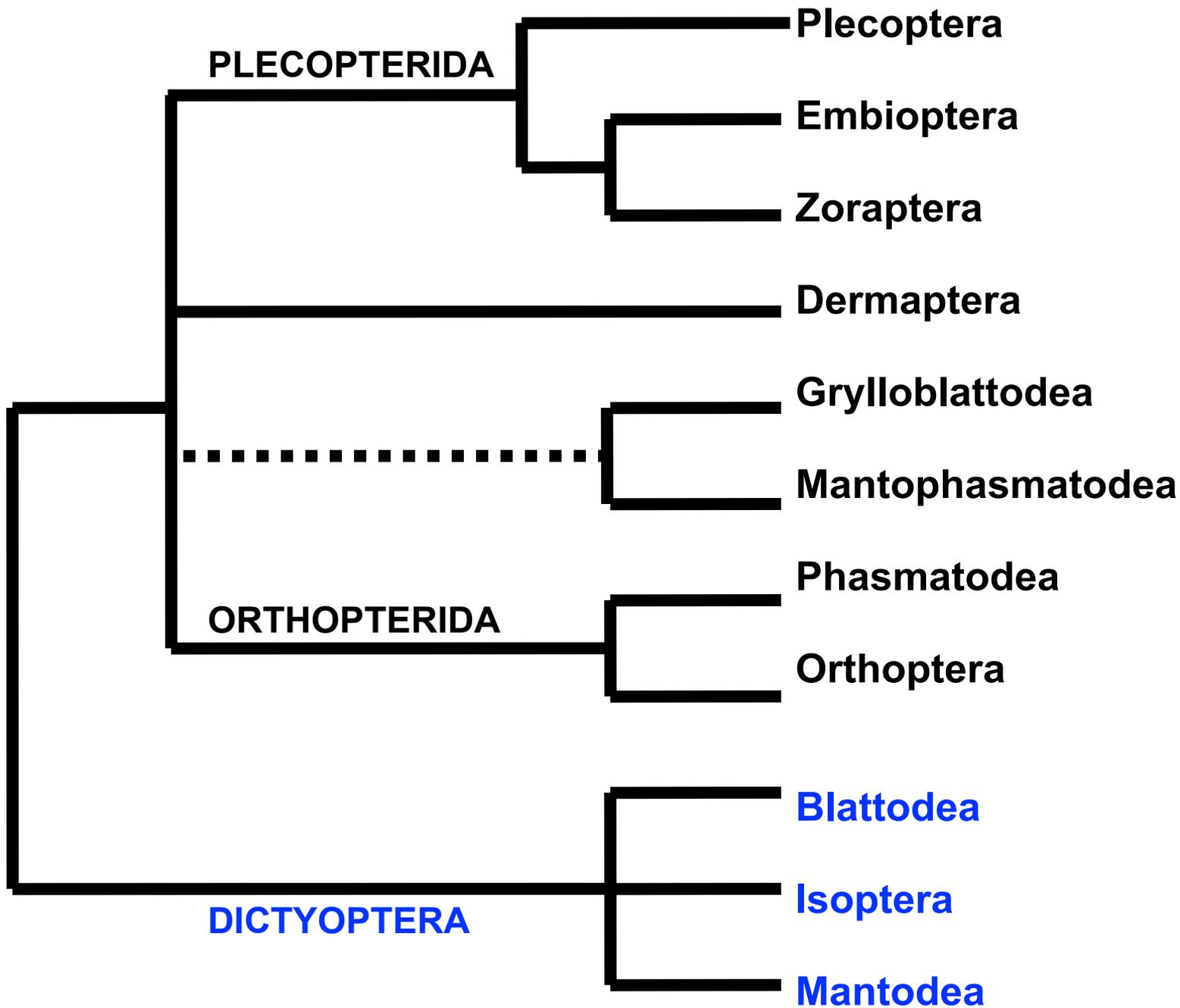
Blattodea



Mantodea

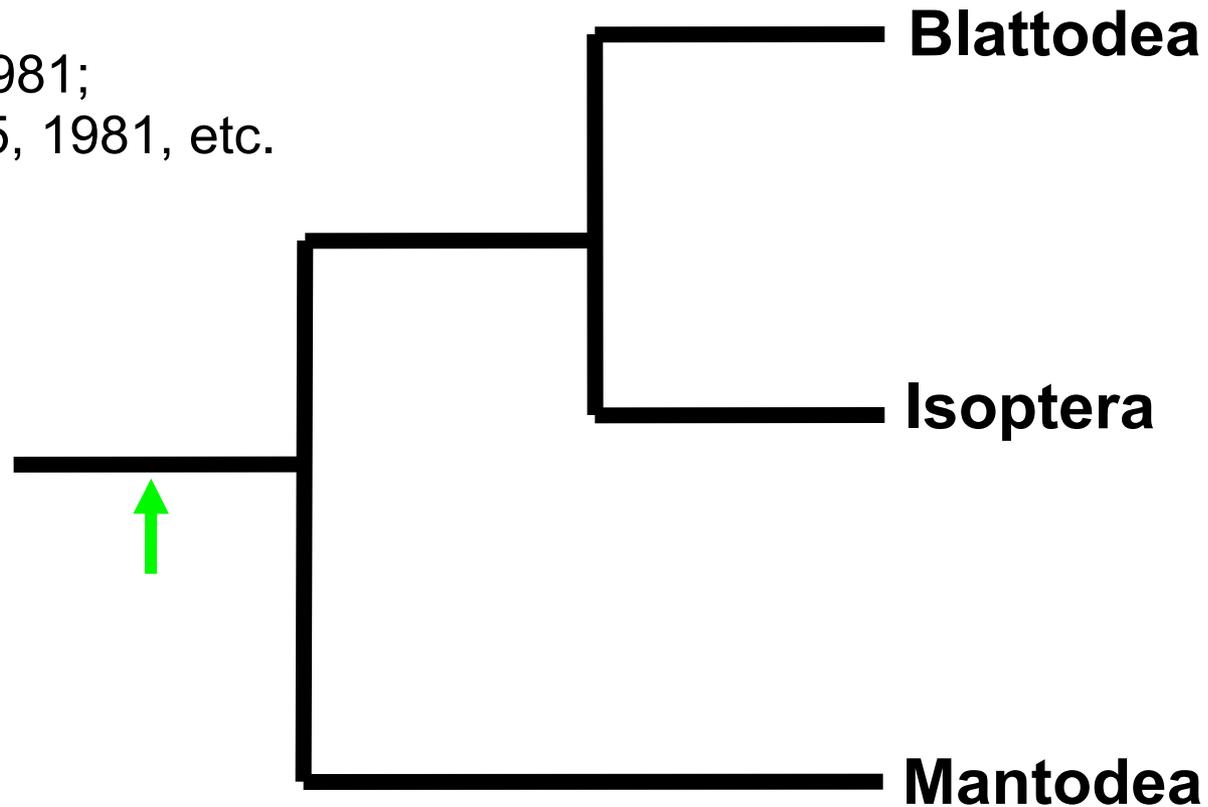


Isoptera



Relationships of the DICTYOPTERA, the **traditional view**

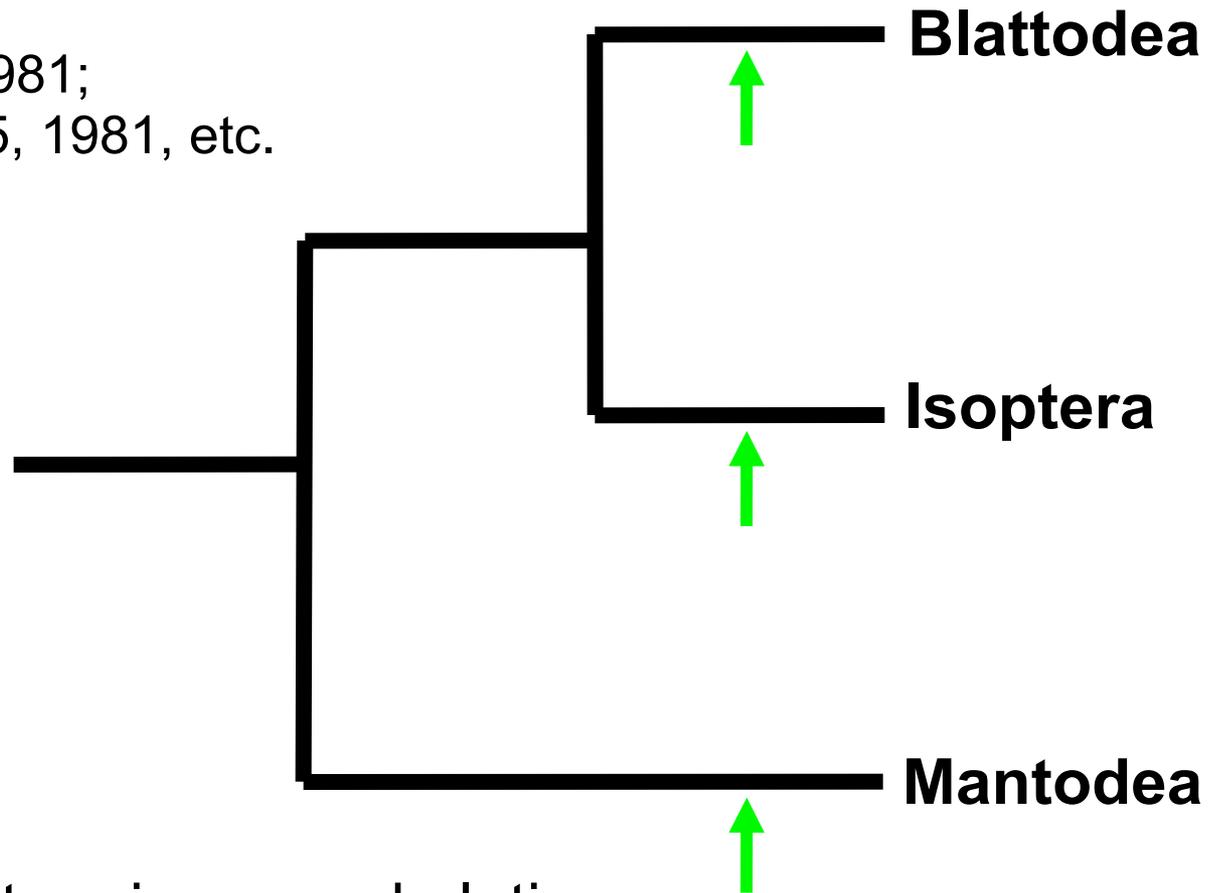
Hennig 1969, 1981;
Kristensen 1975, 1981, etc.



- **Dictyoptera is monophyletic**
- Each of its included orders is monophyletic
- Blattodea + Isoptera form a monophyletic clade

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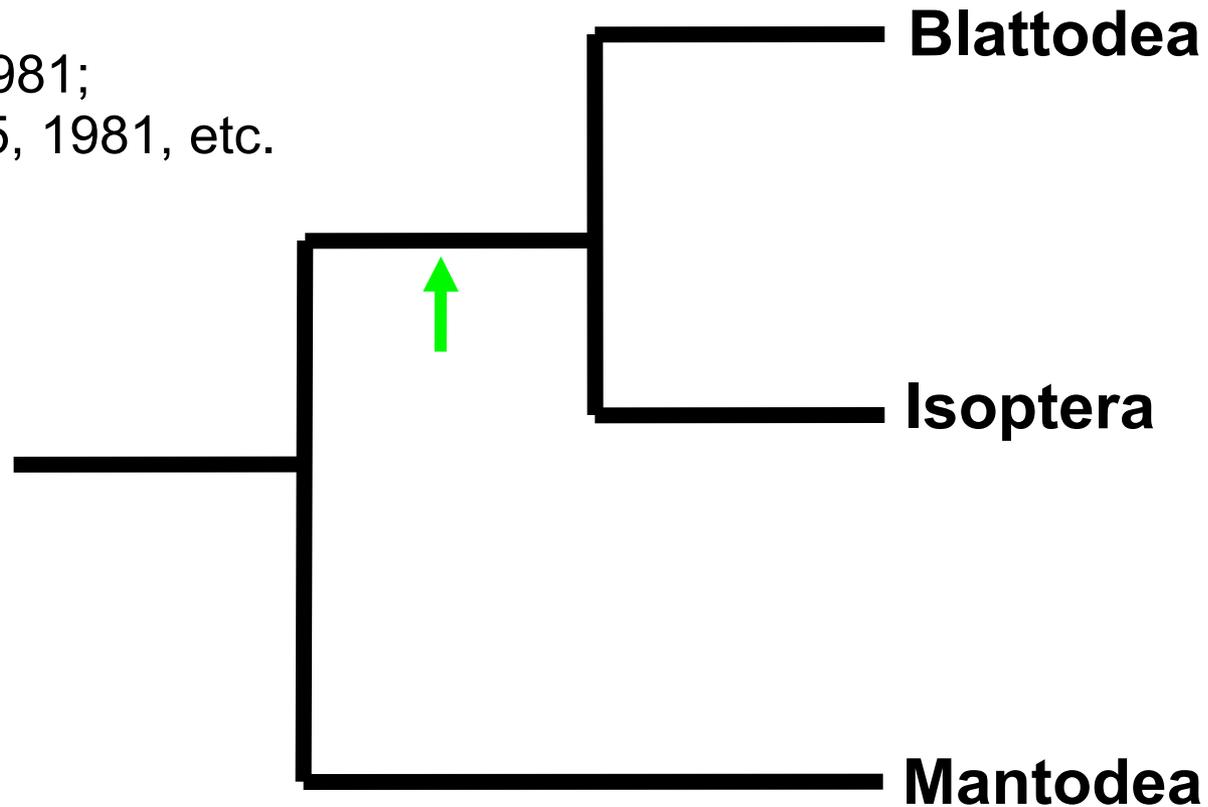
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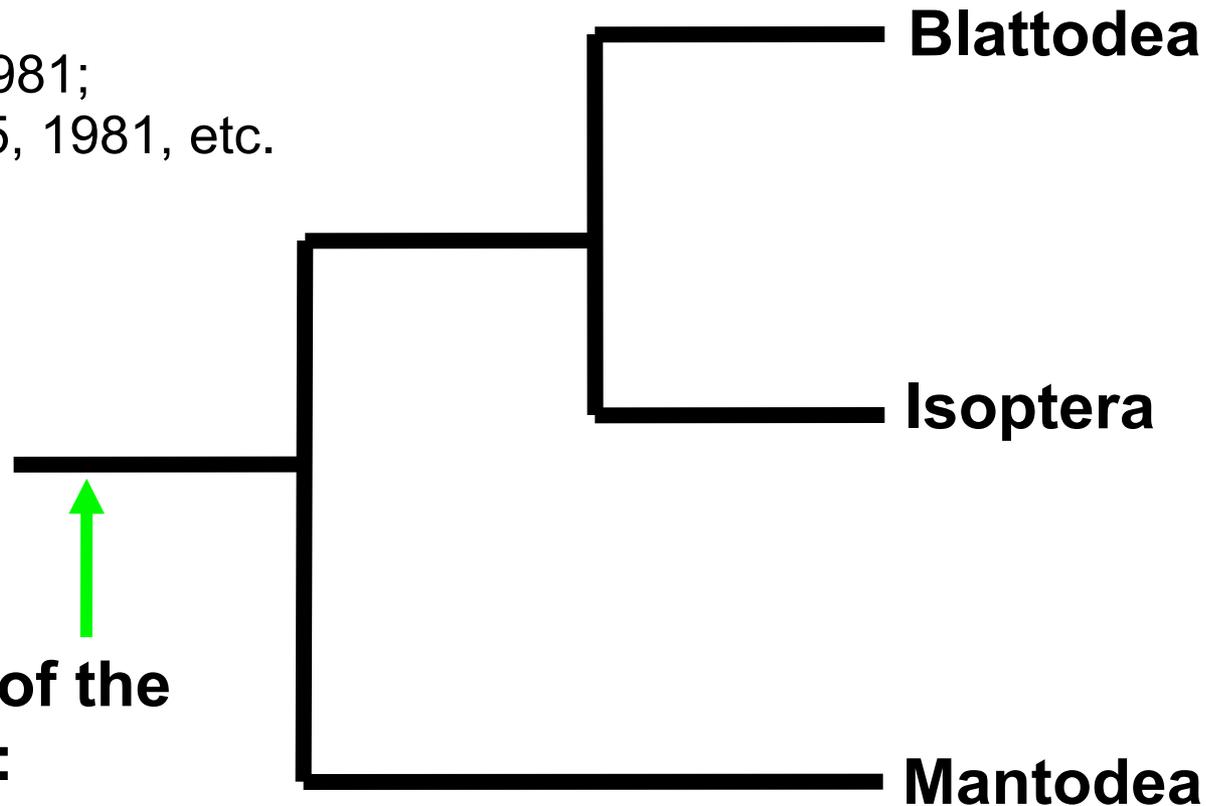
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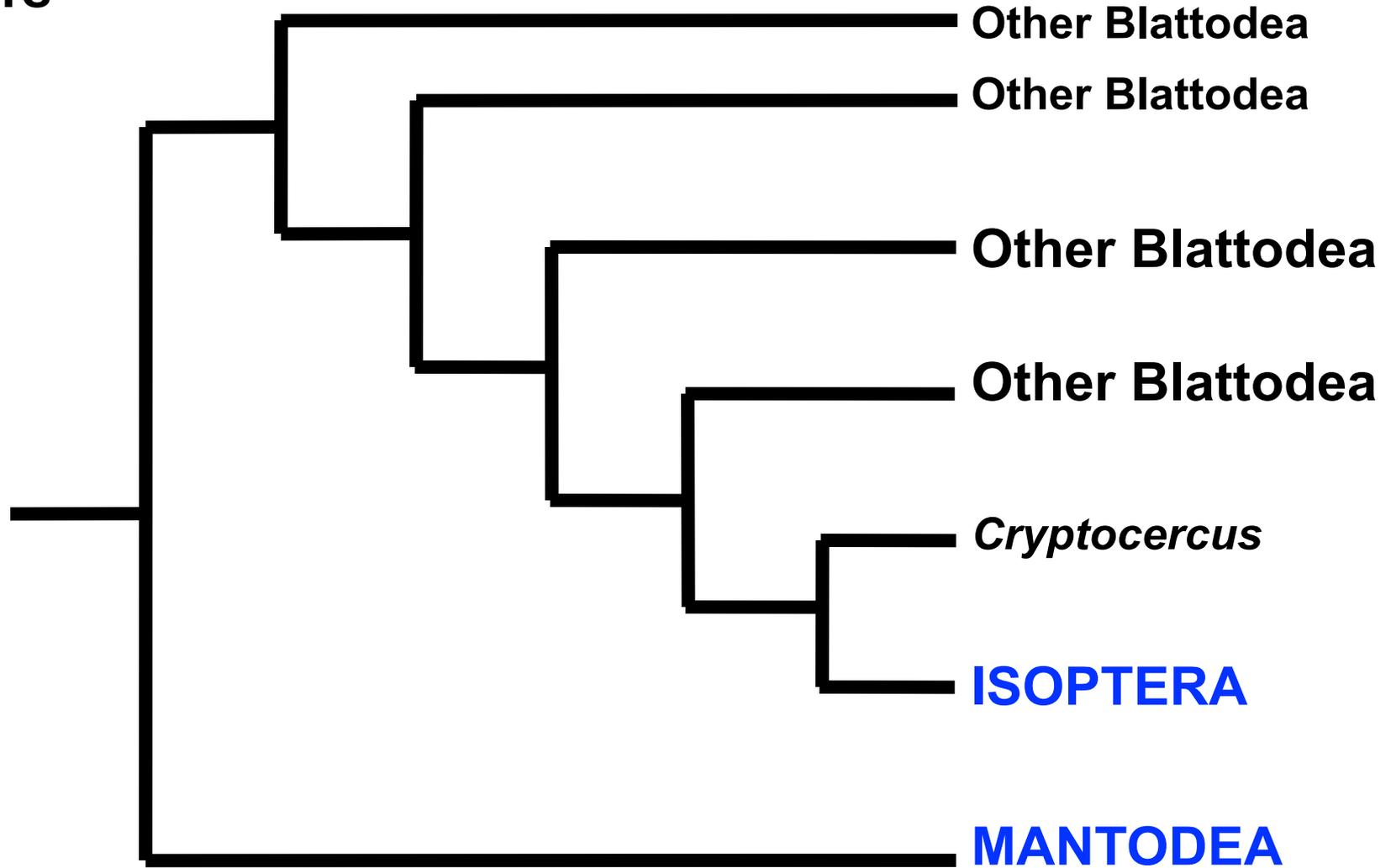
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**Monophyly of the
Dictyoptera:**

- **Perforate tentorium** (processes on the anterior arms fuse medially in front of the esophageal nerve connectives)
- Cone-shaped **proventriculus** with anterior ring of strongly sclerotized teeth.
- Female gonopore on rear border of 7th sternum. 7th sternum enlarged to form a large subgenital plate. Venter of abdominal segment 8 and 9 desclerotized and form roof of genital chamber ("**vestibulum**") above subgenital plate. Ovipositor reduced and retracted into the space above the 7th sternum.

New perspective on the relationships of the Dictyopteran orders



Composite of several studies, including Klass (1995), Klass & Meier (2000); also molecular evidence (see Grimaldi & Engel)

What is *Cryptocercus*?

- Southern Appalachians, Cascades, southern China, Korea
- Wingless
- 3-segmented tarsi
- Live and feed in galleries in soft, rotting logs
- Adults and nymphs live together in log; nymphs remain with adults for 3 years, mature in 6
- Nymphs pale, small, soft, reduced eyes
- Feed on liquids exuded from anus of adult - *proctodeal trophallaxis*
- Acquire mutualistic protists required for digestion of cellulose
- Recent discovery of cryptic species in the Southern Appalachians and elsewhere



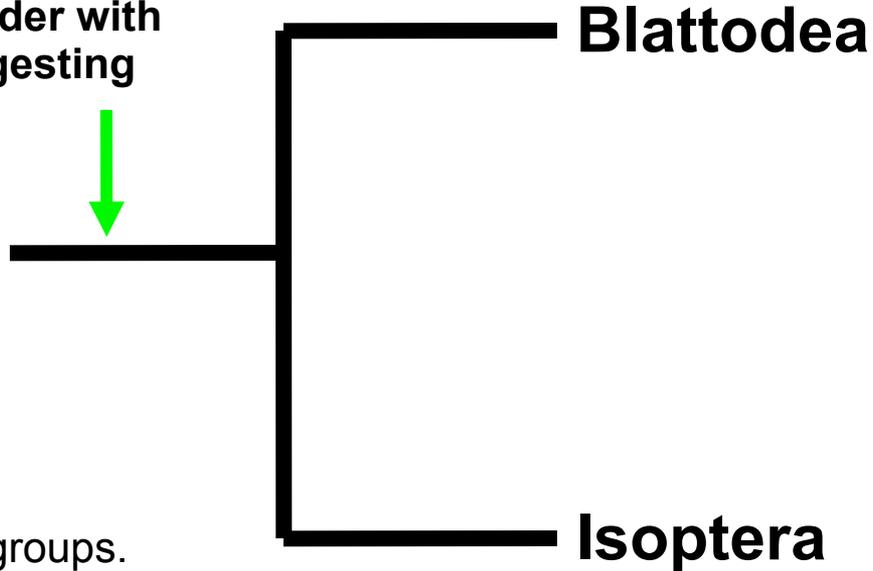
Similarities between *Cryptocercus* and basal termites

- Shares with two families of lower termites several genera of distinctive protists (e.g., *Trichonympha*)
- Shares distinctive proventriculus morphology with termites
- Similar mandibular dentition
- Similar, homologous moniliform structure of the antennae
- Monogamy
- Extended biparental care
- Allogrooming (young nymphs groom older nymphs and adults)
- Proctodeal trophallaxis



Significance?

Ancestor a wood feeder with specialized wood-digesting symbionts

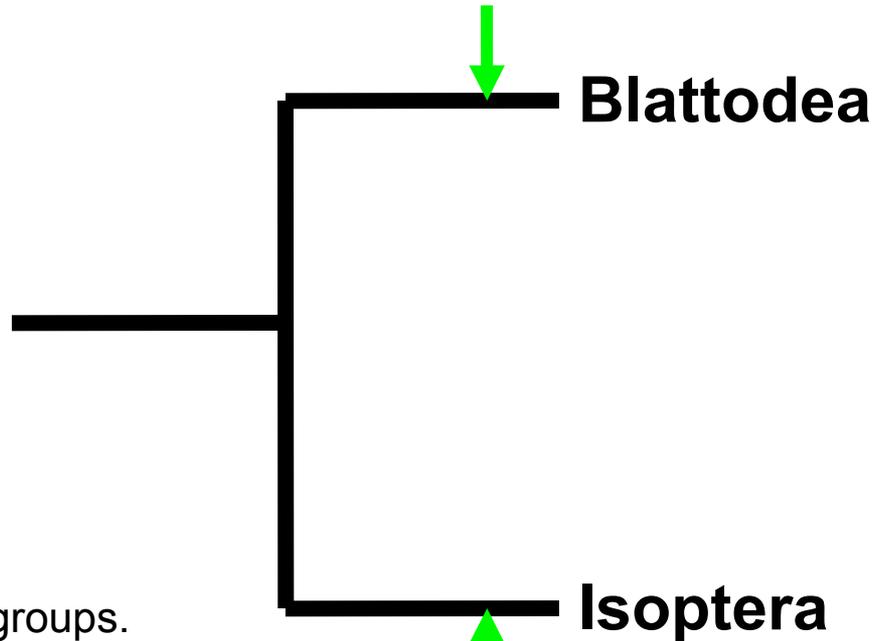


Possibility 1:

Blattodea and Isoptera are sister groups. Mode of life and symbionts in *Cryptocercus* represents the primitive condition present in the common ancestor. Rest of roaches lost this mode of life several times and independently.

Significance?

Cryptocercus a wood feeder with specialized wood-digesting symbionts



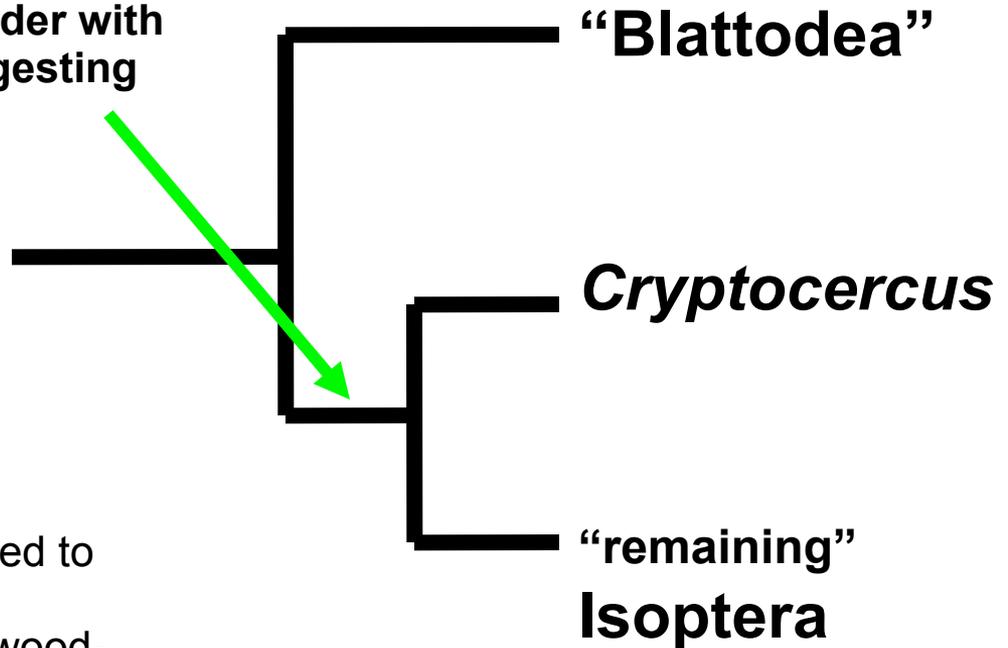
Possibility 2:

Blattodea and Isoptera are sister groups. Similarities in the mode of life and nutritional physiology shared by *Cryptocercus* and termites are the result of convergence.

Ancestor a wood feeder with specialized wood-digesting symbionts

Significance?

Ancestor a wood feeder with specialized wood-digesting symbionts



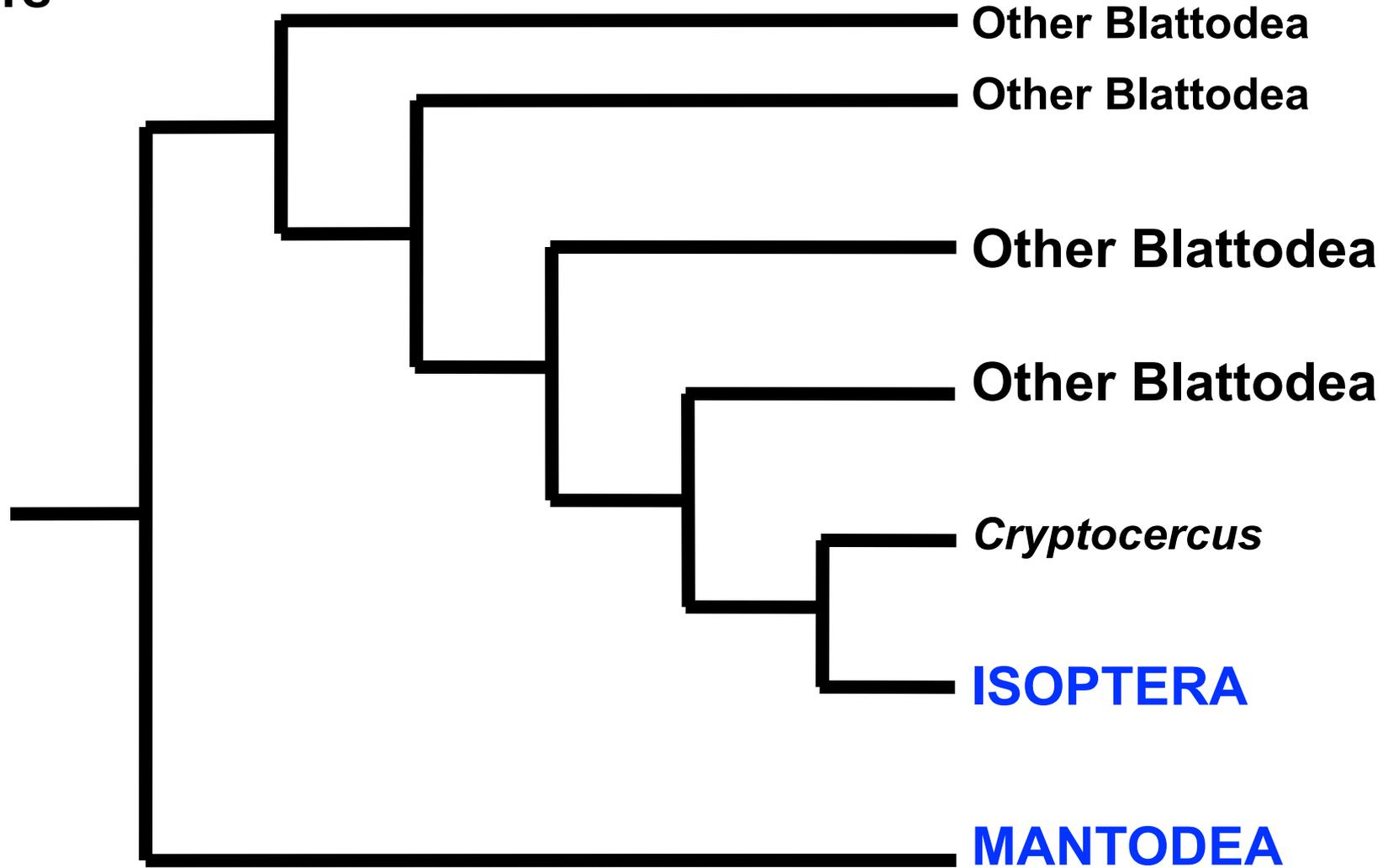
Possibility 3:

Cryptocercus is more closely related to the termites than to the rest of the roaches. Common ancestor had wood-digesting symbionts. Cryptocercidae is a primitive sister group to the termites that is still subsocial and has not developed a caste system.

These scenarios were first proposed by Hennig, who, along with other early workers, recognized the similarity between these roaches and termites.

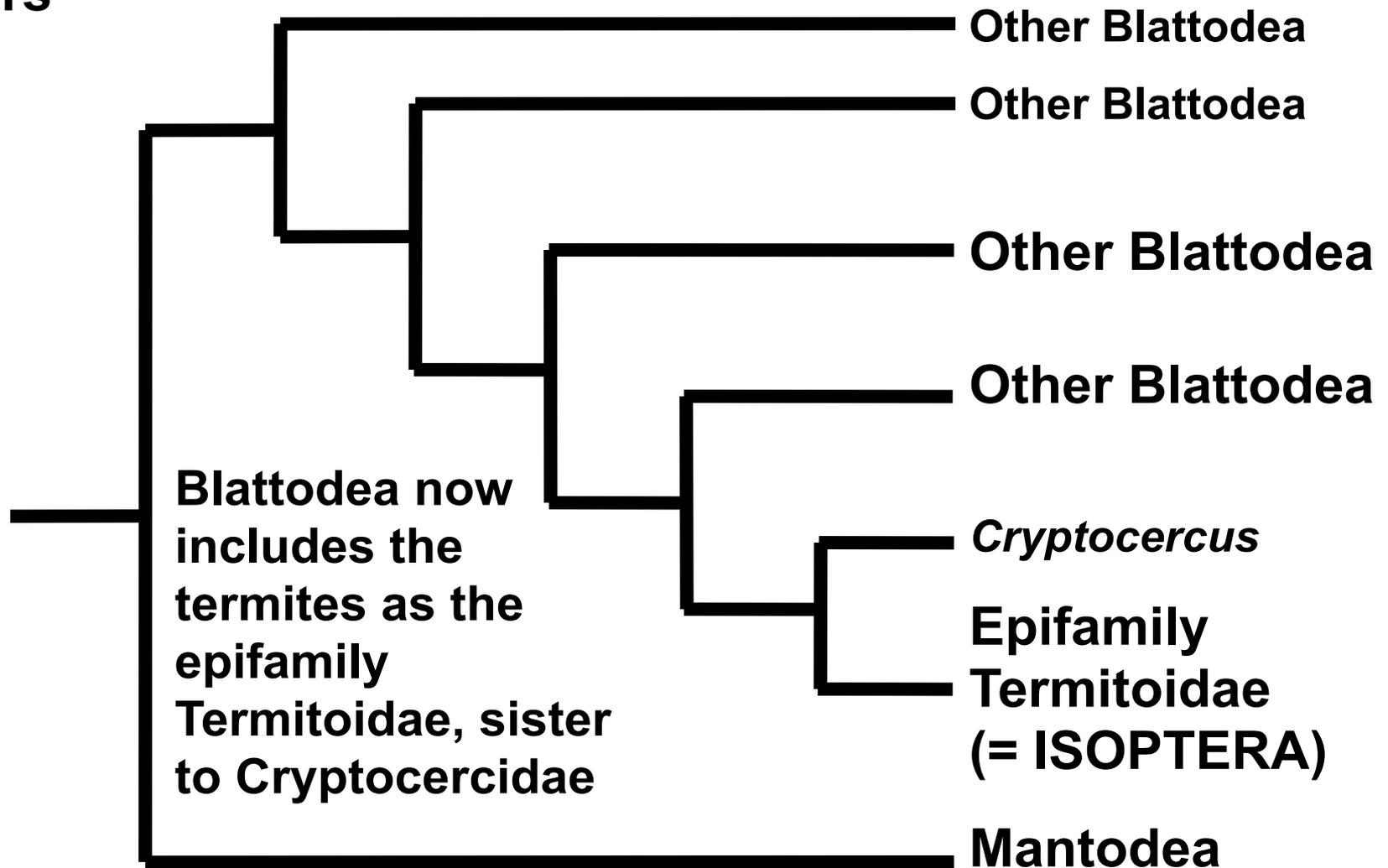
This 3rd possibility is well supported today by morphological and molecular studies.

New perspective on the relationships of the Dictyopteran orders



Composite of several studies, including Klass (1995), Klass & Meier (2000); also molecular evidence (see Grimaldi & Engel)

New perspective on the relationships of the Dictyopteran orders



See Beccaloni and Eggleton (2011) in Zhang (2011)

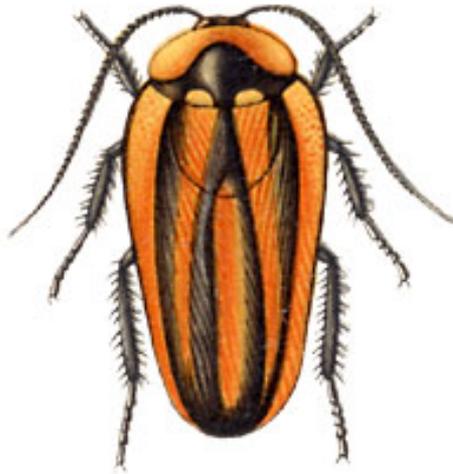
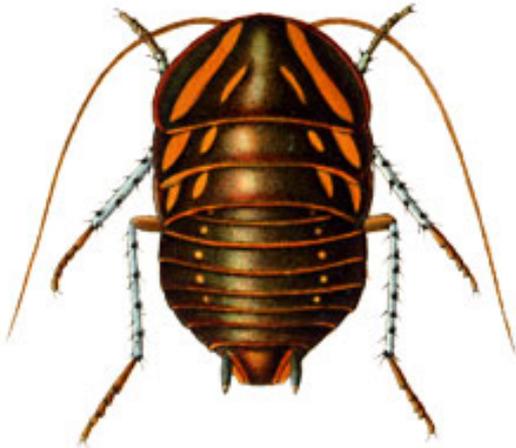
BLATTODEA (=Blattaria), Roaches (excluding Termitoidae)



BLATTODEA (=Blattaria), Roaches (excluding Termitoidae)

Characteristics:

- Flattened, oval
- Pronotum large with laterally expanded sides, and protruding forward over the hypognathous head
- Legs adapted for rapid running
- Antennae long and slender
- Fore wings tegminous, some forms wingless



BLATTODEA (=Blattaria), Roaches (excluding Termitoidae)

Habitat & Habits:

- Found in moist forests among leaf litter, under bark, stones, in caves, in the canopy
- Very omnivorous, feed on dead and decaying vegetation, fruits, fungi, rotten wood, bird and bat guano, dung, etc.
- Nocturnal, few diurnal
- Easy to culture for laboratory research, once had diverse colonies at U of M; Madagascar hissing cockroach, *Gromphadorhina portentosa*, popular pet
- Ootheca - egg case - sclerotized before deposition while in genital chamber
- Blaberidae females have brood sac which retains ootheca until eggs hatch - ovoviviparity; one species is viviparous, embryos nourished through uterine walls

BLATTODEA (=Blattaria), Roaches (excluding Termitoidae)

Diversity & Distribution:

- 4,000 species in 460 genera and ca. 6 families, mostly in the tropics (less than a dozen are household pests!)
- About 70 species in US and Canada, *Parcoblatta* is our native wood roach



BLATTODEA (=Blattaria), Roaches (excluding Termitoidae)

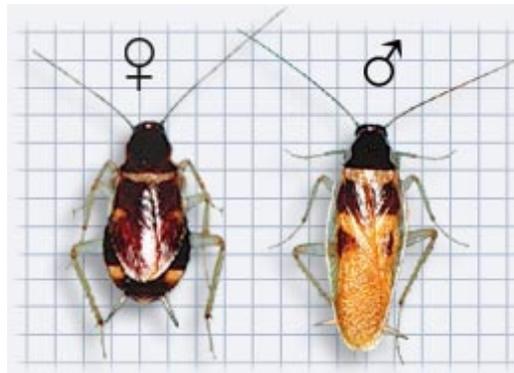
Common economically important species:

Blatta orientalis - Oriental cockroach

Supella longipalpa - Brown-banded cockroach

Blattella germanica - German cockroach

Periplaneta americana - American cockroach



BLATTODEA (=Blattaria), Roaches (excluding Termitoidae)

Collecting & Preserving:

- Collect from leaf litter, peel back bark, overturn stones and logs, look in caves, set baits at night, etc; some fly to lights
- Pin



Blattodea, Epifamily Termitoidae (= "Isoptera"), Termites



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SYNAPOMORPHIES

- Highly **eusocial**, with winged reproductives, wingless soldiers and workers
- Wings dehiscent
- Eggs laid singly or ootheca highly reduced
- Male genitalia highly reduced and symmetrical
- Pronotum highly reduced



Classification of Social Behavior in Insects

(from Wilson, 1971)

Solitary—showing none of the traits listed below;

Subsocial—the adults care for their own nymphs or larvae for some period of time;

Communal—members of the same generation use the same composite nest without cooperating in brood care;

Quasisocial—members of the same generation use the same composite nest and also cooperate in brood care;

Semisocial—as in quasisocial, but there is also reproductive division of labor, that is, a worker caste cares for the young of the reproductive caste.

Eusocial—as in semisocial, but there is also an overlap in generations so that offspring assist parents.

Blattodea, Epifamily Termitoidae (= “Isoptera”), Termites

Other characteristics:

- Soft bodied
- Elongate cylindrical with slight constriction between thorax and abdomen
- Body usually pale in N. Am. species
- Antennae short, usually not longer than head, moniliform
- Large mandibles and head to accommodate muscles
- Wings when present large, both pairs exactly alike (==> *isoptera*)



Habitat & Habits:

- Advanced **eusociality**
- Workers both males and females
- Caste determination by pheromones
- Diploid
- Primary reproductives sclerotized and winged
- Secondary reproductives (supplementary, neotenic) lack or have reduced wings
- Workers and soldiers have reduced gonads and lack wings
- Some colonies without workers, immatures (pseudergates) assume role
- Soldiers with large mandibles or well developed *fontanelle* (nasutes)

Habitat & Habits:

- Mating occurs during nuptial flights, 1000s of individuals, after which wings are shed
- After mating, female begins excavating colony
- Queen cared for by first born nymphs
- Queen becomes confined to royal chamber
- *Physogastry* - huge abdomens of queens, can lay up to 3000 eggs per day; long-lived, up to 10 years!
- Colonies of 3-5 million individuals!
- Social and nest structure extremely varied:

Wilson, E.O. 1971. *The Insect Societies*. Harvard University Press.

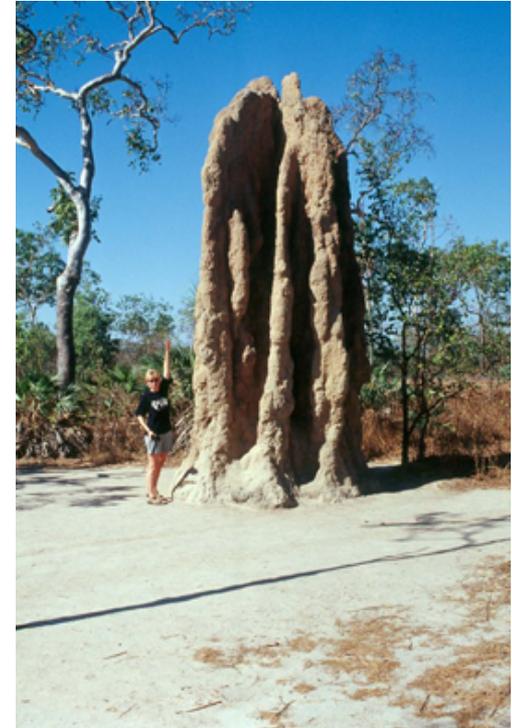


Habitat & Habits:

- Digest cellulose (lignocellulose) via symbionts in hindgut
 - “Lower” termites - mutualistic protists
 - Termitidae - symbiotic bacteria (lost protists)
- Protists lost at each molt, cannot survive in frass, restored through “proctodeal trophallaxis” (lost in Termitidae, bacteria passed through ovaries to offspring)
- Termite guts also contains other bacteria and protists - very diverse, unknown world!
- Termites perhaps comprise 10% of all animal biomass, most of it in the tropics
- Important in carbon mineralization and humification (soil formation and enrichment)
- Contribute to about 2-5% of annual global methane
- Consume from 40-100% of dead wood in certain tropical forests, up to 20% of all plant biomass in certain grassland ecosystems

Habitat & Habits:

- Construct complex nests and mounds, in the ground, in wood, or in the trees, including nests with huge towers or fluted structure up to 8 m high.
- The towers function as chimneys to facilitate diffusion of O_2 and CO_2 in and out



Diversity & Distribution:

- About 2,900 species, mostly in the tropics, in 7 families
- About 45 species in the U.S., including some serious and insidious pests, probably the top 3 being:
 - *Reticulitermes flavipes*, the eastern subterranean termite
 - *Coptotermes formosana*, the formosan subterranean termite
 - *Incisitermes minor*, western drywood termite



Collecting & Preserving:

- Carefully remove all castes from nest - preserve in 80% EtOH or pin alates
- Look for symbiotic beetles, earwigs, bugs, etc. living in colony

MANTODEA, Mantises, Praying mantids



MANTODEA, Mantises, Praying mantids

SYNAPOMORPHIES



- Highly predaceous
- Fore legs raptorial, with large apical spine or spur on tibia and heavily armed fore femur; forecoxae long
- Mandibles strongly toothed
- Compound eyes enlarged, bulging - *exophthalmic*
- “Pseudovein” near base of forks of M and CuA
- Ultrasound “ear” on metathorax (“higher” mantids)
- Pronotum long (“higher” mantids)

MANTODEA, Mantises, Praying mantids

Other characteristics:

- Head triangular
- Fore wing leathery



Habitat & Habits:

- Feed exclusively on other arthropods, even small frogs or lizards - excellent binocular vision, move head side to side to fix prey and judge distance
- Eyes large with well developed *fovea* - a spot where ommatidea have sharpest resolution
- Forelegs highly modified for extending reach and grasping prey
- Mid and hind legs long and slender, for walking and lunging
- Clean and groom their head and eyes after eating with patch of hairs on fore femur
- Most display remarkable cryptic forms and coloration for ambush and protection
- Also show seasonal polymorphism in coloration; some can change color, but slowly

Habitat & Habits:

- “Sexual cannibalism” has been suggested - females will feed on males during mating - whether this is adaptive is debatable. It probably represents indiscriminate predation by females. But males do approach females carefully, copulate on top of female out of reach or her grasp, and will still copulate if decapitated. Probably selection favored strong *post mortum* copulatory reflexes.
- Individuals are solitary, meet only to mate
- Ootheca deposited soft, then hardens, contains calcium oxalate and is “glued” to twigs and branches
- In temperate areas, overwintering takes place in egg stage in the ootheca, nymphs hatch in egg case, chew their way out, then disperse

Habitat & Habits:

- “Higher” mantises (Mantoidea) possess an ultrasound “cyclopean ear” on the metathorax between sternites, just before hind coxae
- Detect sound waves between 25-50 kHz, the same frequency used by echolocating bats; but cannot determine frequency or direction (=cyclops)
- When flying at night (especially males), avoid bat predation via elusive “divebombing”
- Ear highly correlated with wing development: strong fliers = acute hearing

Diversity & Distribution:

- 2,300 species worldwide, 434 genera, mostly pantropical, in about a dozen families
- 30 species in U.S. and Canada, several introduced

Collecting & Preserving:

- Beat net, beat sheet, observe flowers and other exposed vegetation; some will fly to lights
- Pin, spread left wings of a few specimens; eviscerate abdomens of large, gravid females
- Photograph to capture color and form