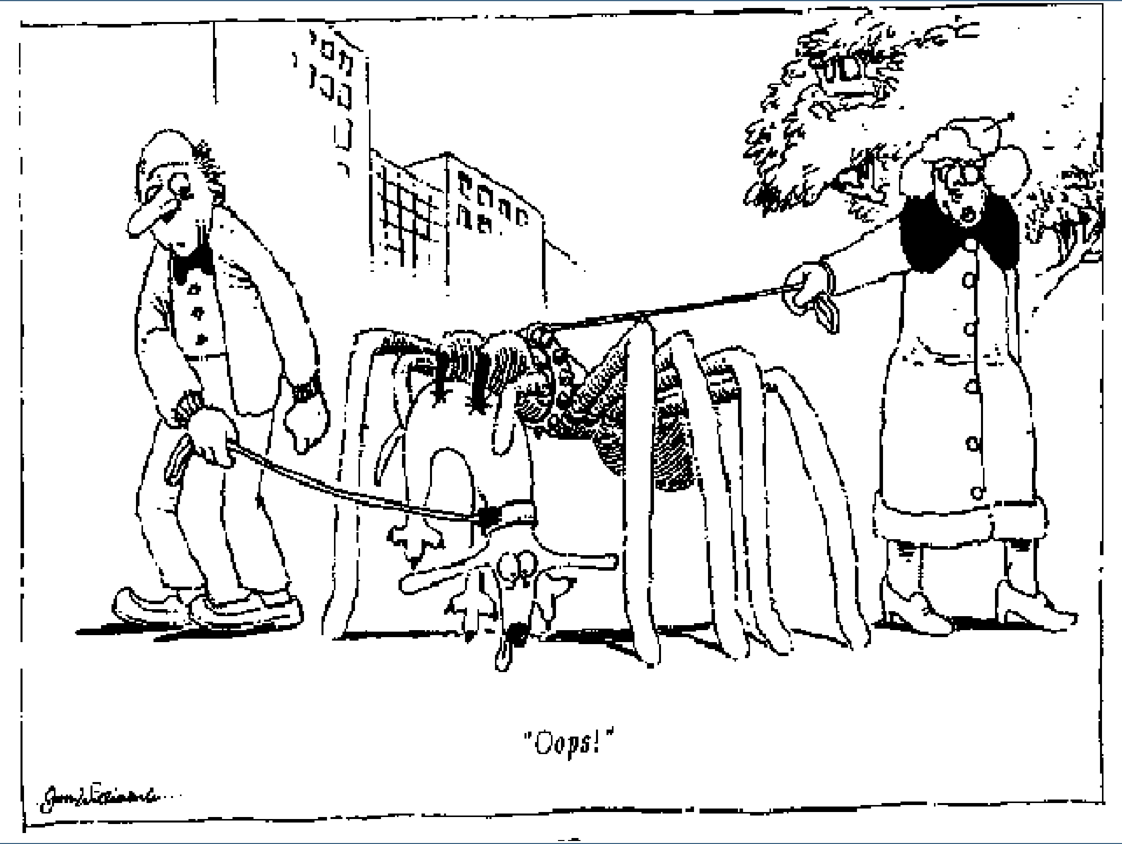


Predation by arachnids

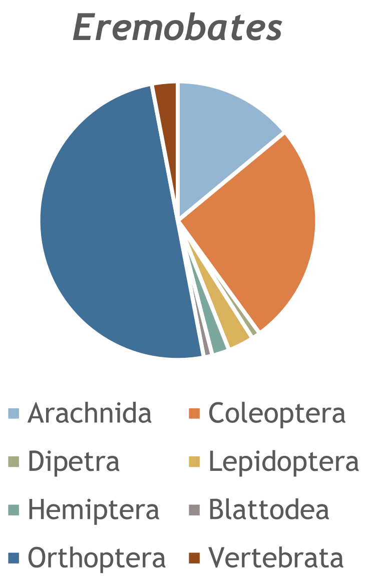
Stano Pekár

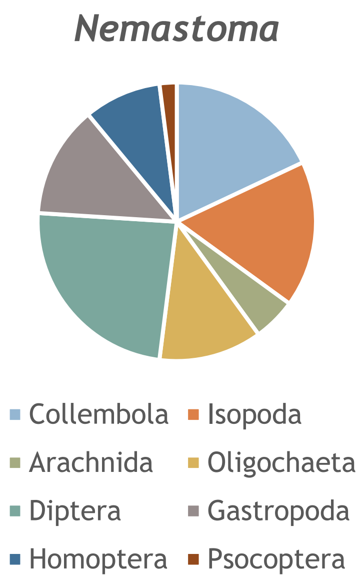
Trophic categories

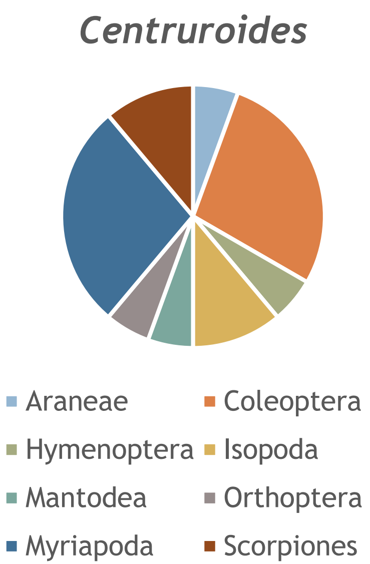
- **True predators** - catch and kill several animals throughout their life (Araneae, Scorpiones, Solifuges, Thelyphonida, Amblypygi, Schizomida, Ricinulei, Pseudoscorpiones, Opiliones, Palpigradi, Gamasida)
- **Scavengers** – feed on prey remnants or dead animals (Opiliones, Holothyrida, Opilioacaridae)
- **Parasites** - live in close association with a host (Sarcoptiformes, Ixodida, Gamasida, Actinedida)
- **Herbivores** - feed on plants (Sarcoptiformes, Actinedida, Opiliones)

Diet breadth

- majority arachnids are euryphagous
- Araneae, Scorpiones, Solifuges, Thelyphonida, Amblypygi, Schizomida, Ricinulei, Pseudoscorpiones, Opiliones, Palpigradi, Gamasida



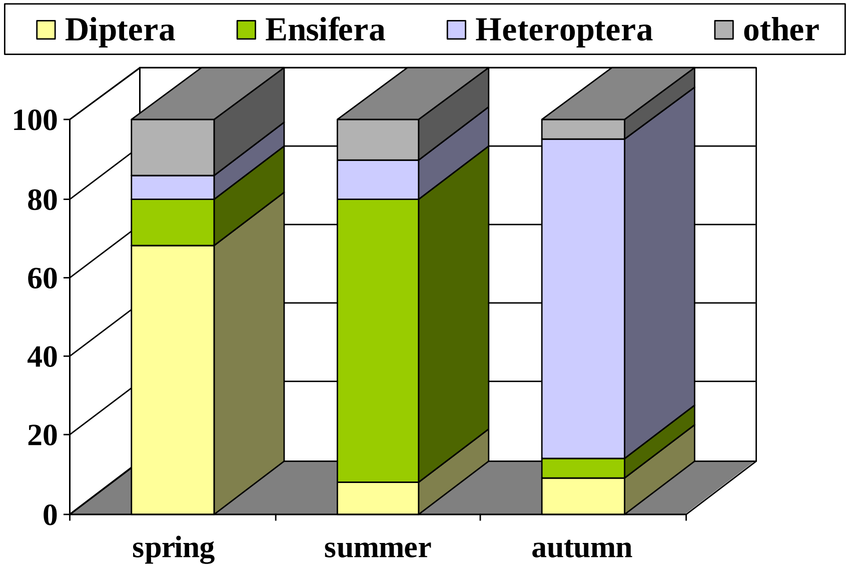




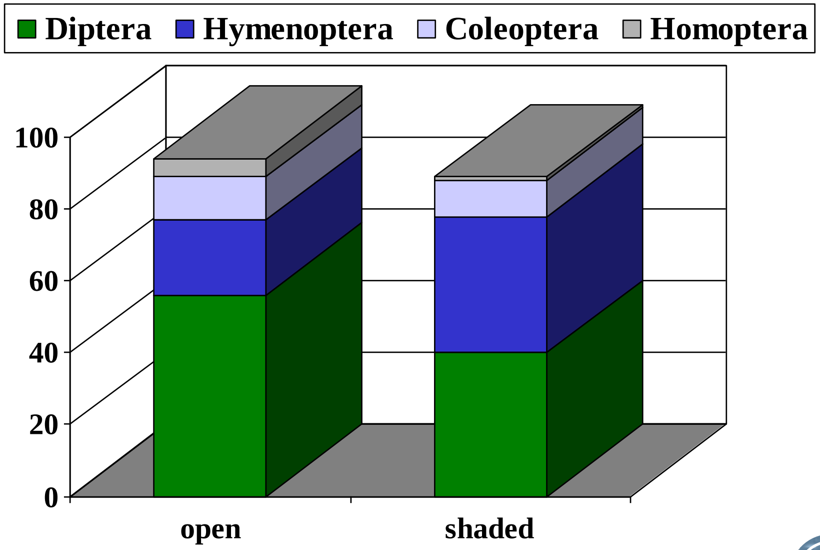
Prey availability

- prey availability vary with season and habitat
- polyphagous predators switch to more common prey or prefer certain prey

Diet of *Pardosa* during season

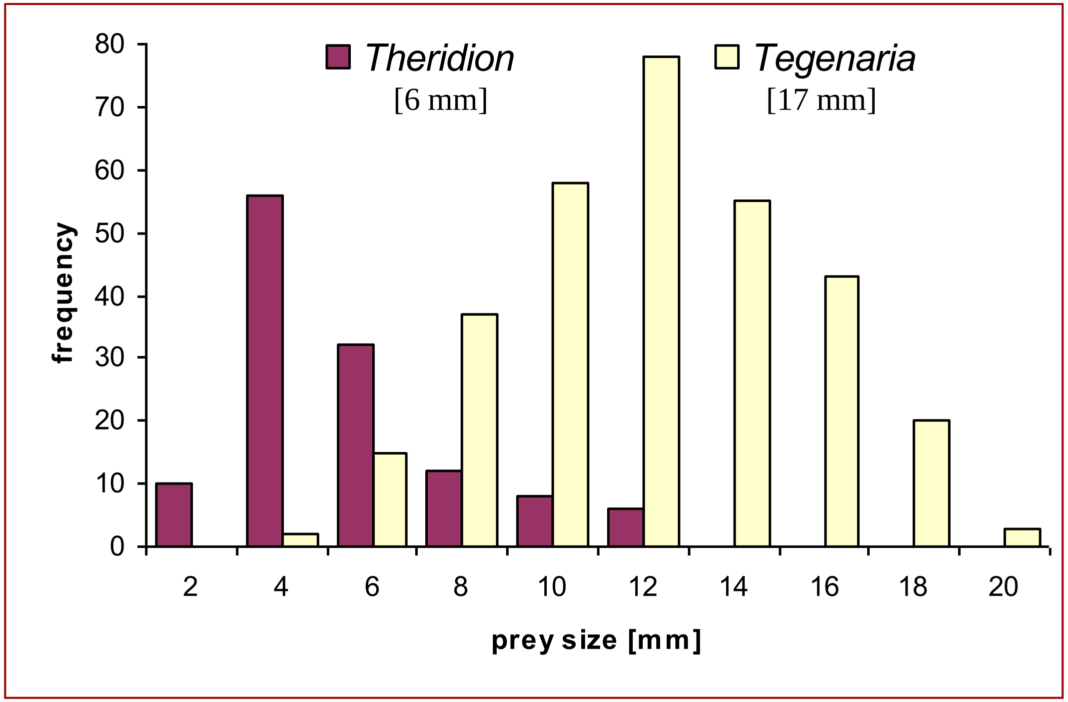


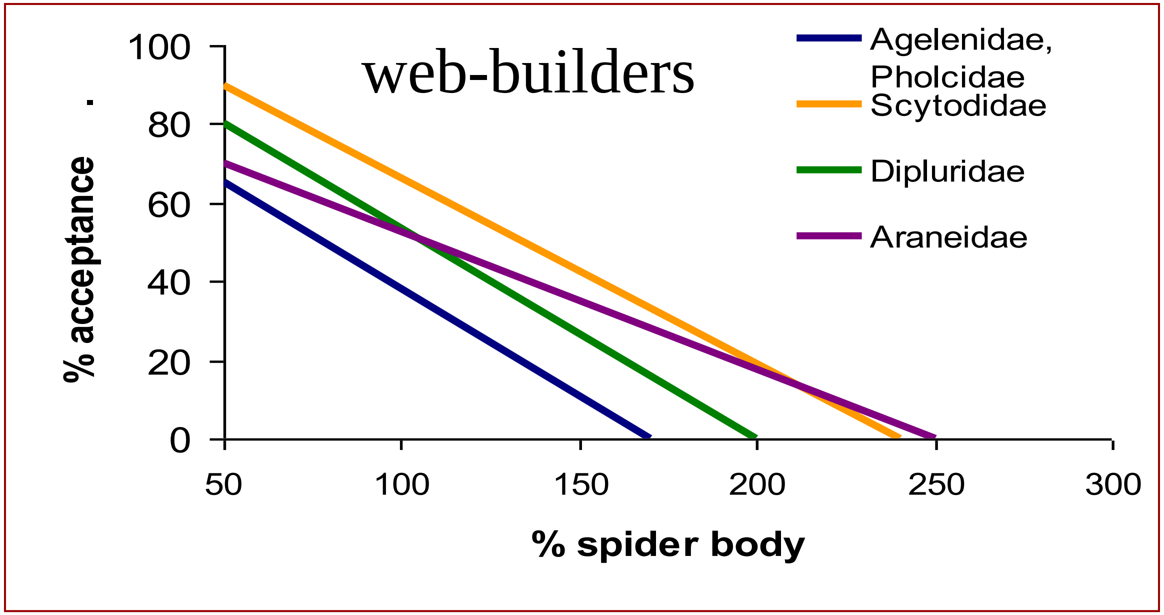
Diet of *Micrathena* in two habitats

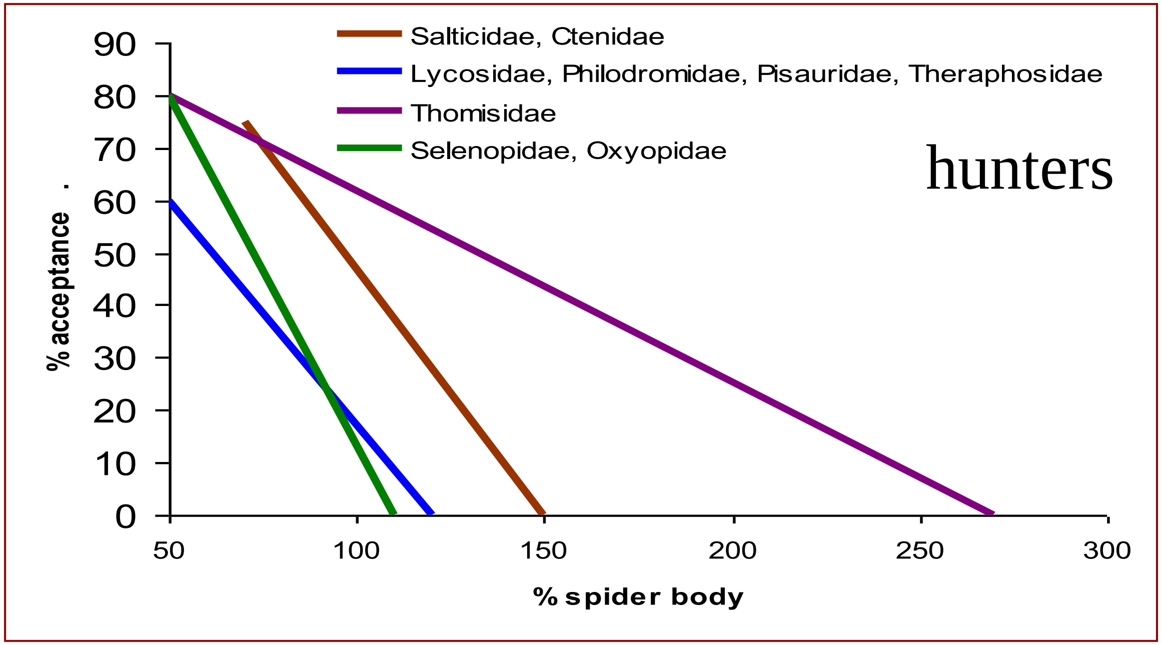


Prey size

- prey size corresponds to spider’s size
- polyphagous species take small prey – smaller than prosoma





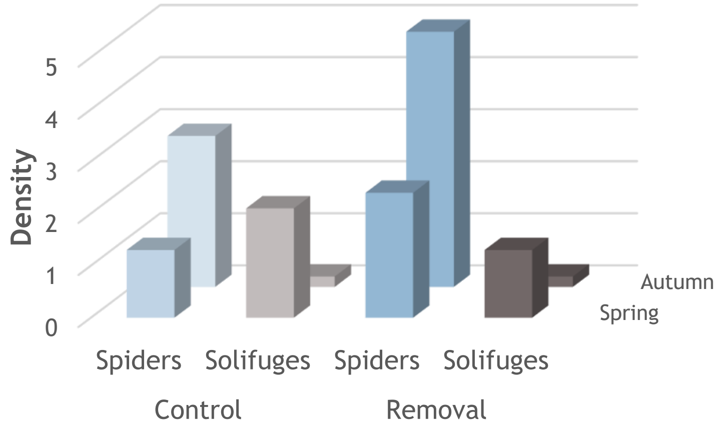


- web builders generally capture larger prey than equally sized hunting spiders

Intraguild predation

- predation among guild members as a result of competition
- cannibalism (sexual, filial)
- Scorpions/spiders/solifuges in the desert (Polis & McCormick 1986) – removal experiment
- Scorpiones feed on spiders (8%) and solifuges (14%)
- Scorpions reduced density of spiders, not solifuges

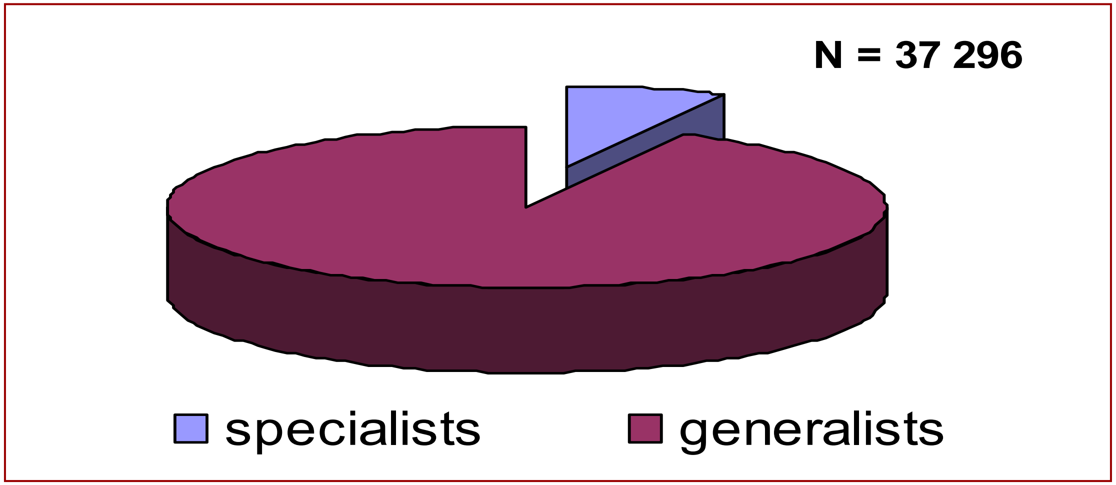
Pauroctonus



Trophic Specialisation

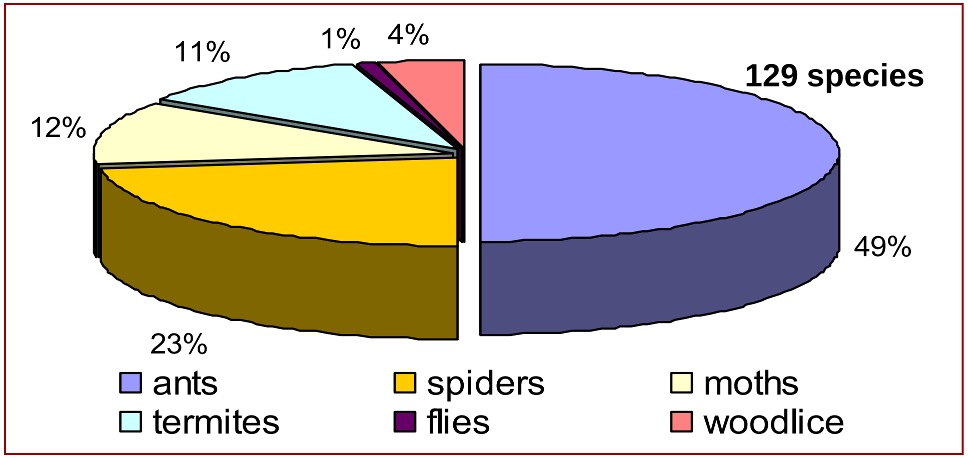
- evolved on dangerous, difficult, and abundant prey
- specialists are able to obtain all required nutrients from a single prey type
- specialisation improves the efficiency of the prey capture and may free the predator from the interspecific competition

Araneae



- Araneophagous – Mimetidae, Palpimanidae
- Lepidopterophagous – some Araneidae
- Termitophagous – Ammoxenidae
- Crustaceophagous – Dysderidae
- Myrmecophagous – Zodariidae, some Theridiidae

Araneae



Mimetidae

Ammoxenidae

Archaeidae

- Ecological (short-term/local) – effect of time and habitat
- Evolutionary (long-term) – evolution of adaptations (psychological, morphological, behavioural, physiological, venomic)

Ecological dimension

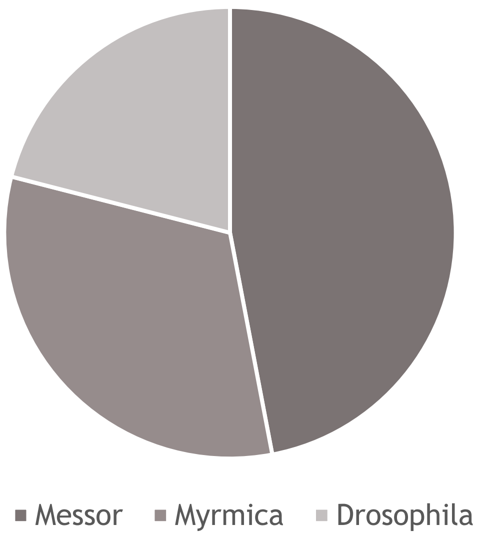
Euryphagous generalist	**Stenophagous generalist**	Evolutionary dimension
Euryphagous specialist	**Stenophagous specialist**	

Pekár & Toft (2015)

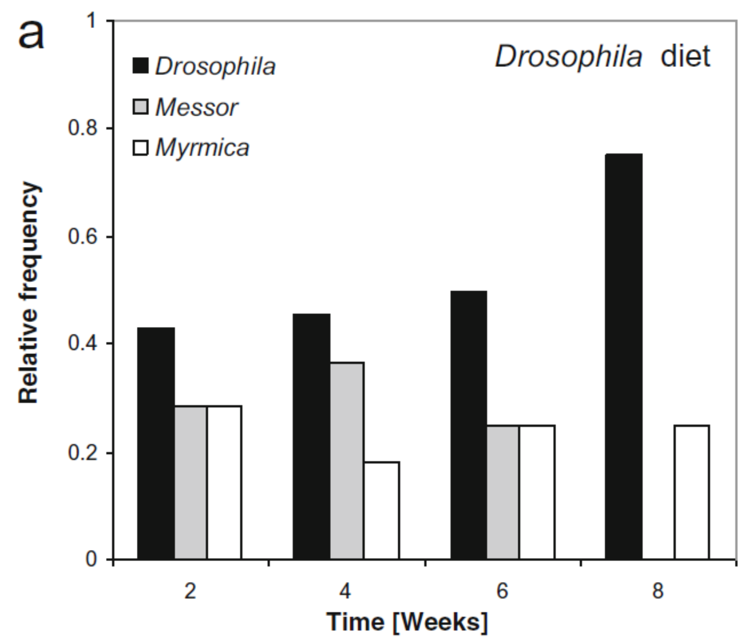
Psychological

- innate olfactory preference in *Euryopis* spiders
- naïve spiderlings preferred cues from *Messor* ants
- older spiderlings on *Drosophila* diet switched their preference

Preference of naïve spiders



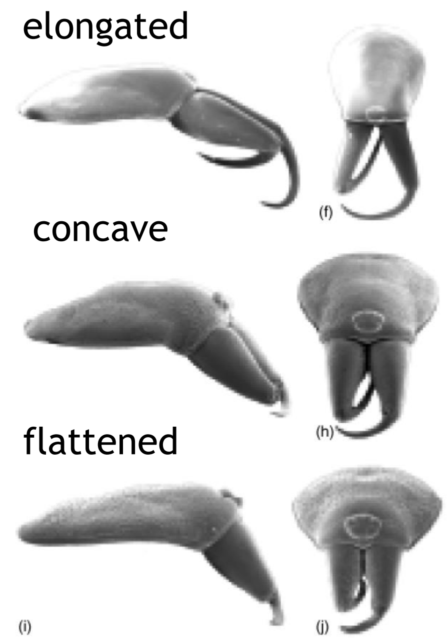
Preference of older spiders



Pekár & Cárdenas (2015)

Morphological

- Different chelicera shape in *Dysdera*
- used to catch woodlice
- Species with elongated chelicera used pincer strategy
- Species with flattened fangs used key strategy
- Species with concave chelicera used fork strategy

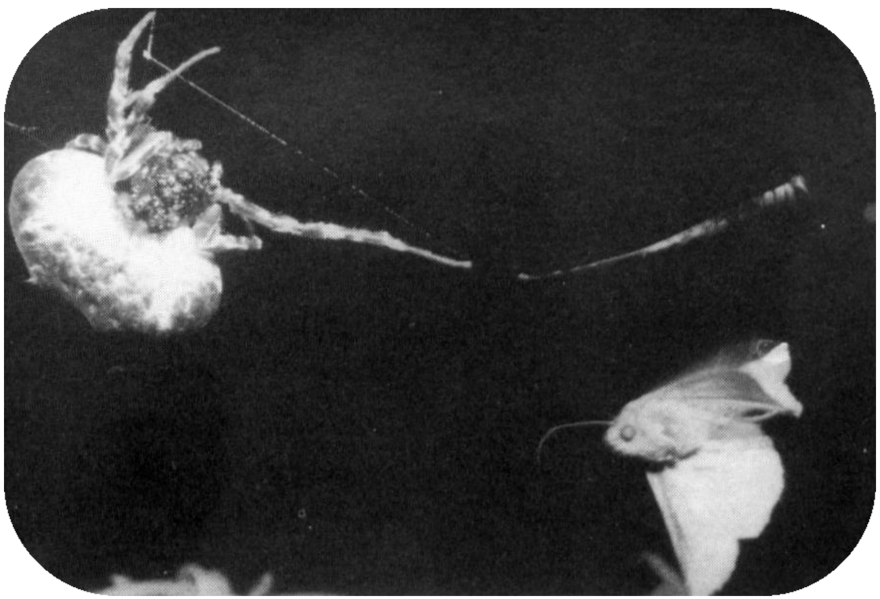


Dysdera

Řezáč *et al*. (2008)

Behavioural

- bolaso swinging in *Mastophora* to catch flying moths
- *M. hutchinsoni* captures predominanty two noctuid moth species: *Trichoplusia mynesalis* and *Lacinipolia renigera*
- females produces allomone imitating the sexual pheromone of moths to attract moth males

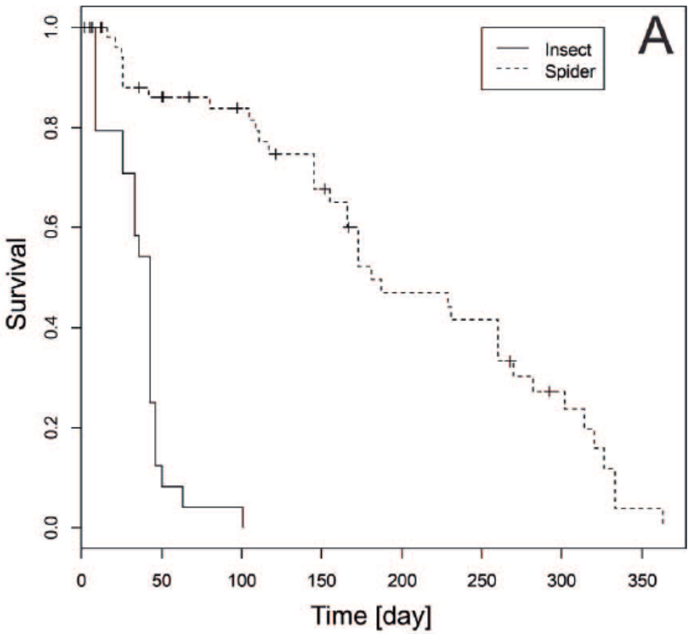


Eberhard (1980)

Physiological

- prey processing in *Palpimanus*
- extracts all nutrients from spiders
- high performance on spider prey but poor on insect prey

Survival on two diets

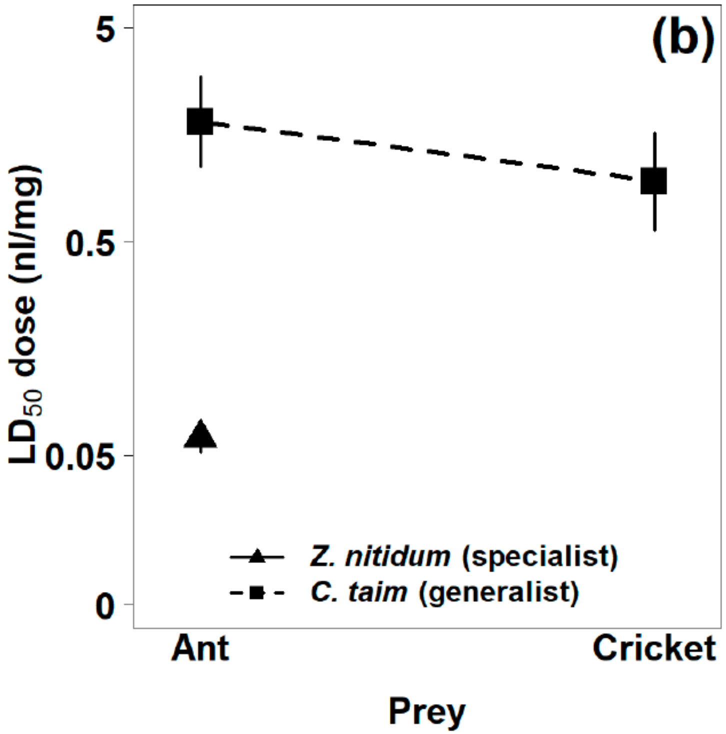


Palpimanus

Pekár & Líznarová (2023)

Venomic

- potent venom of *Zodarion* is used to catch prey
- venom of euryphagous *Cybaeodamus* is similarly effective on various prey
- Venom of *Zodarion* is only potent for ants, not on the alternative prey

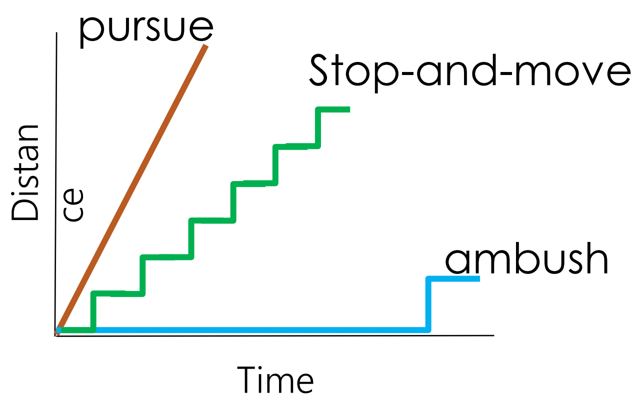


Zodarion

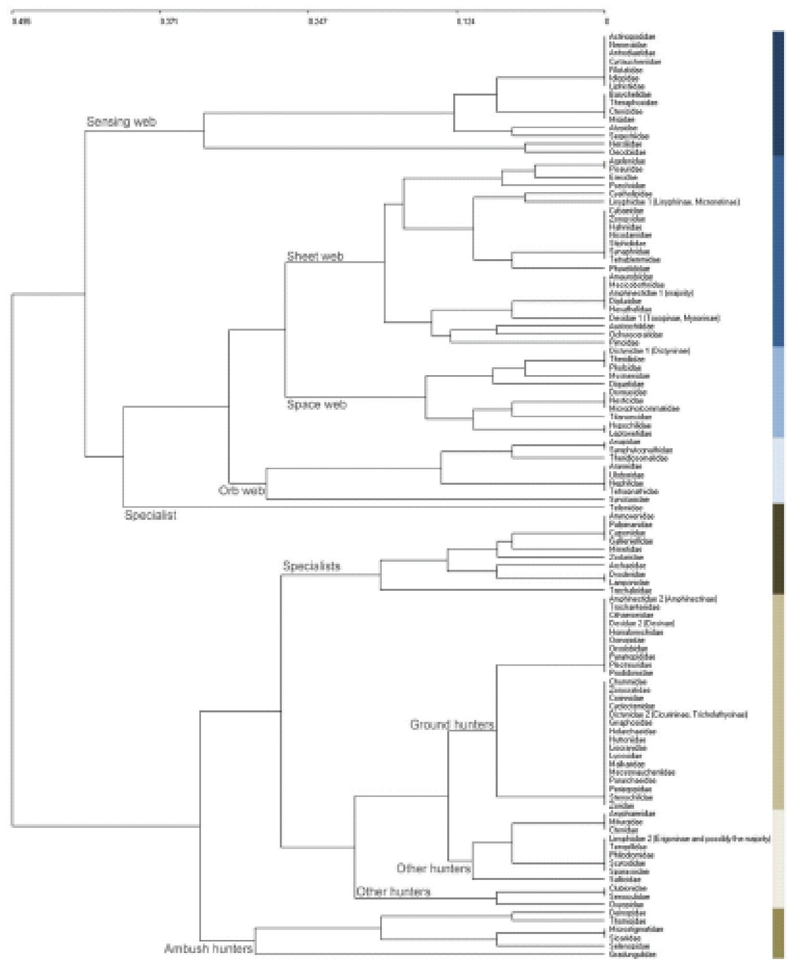
Michálek et al. (2019)

Predatory guilds

- group of species (often closely related) exploiting the same resources in a similar way
- Main classes: passive (sit-and-wait/ambush), intermediate (stop-and-move), active (pursue)
- Passive: Pseudoscorpiones, Ricinulei
- Intermediate: Amblypygi, Thelyphonida, Schizomida, Palpigradi, Scorpiones
- Active: Araneae, Opiliones, Solifuges, Gamasida

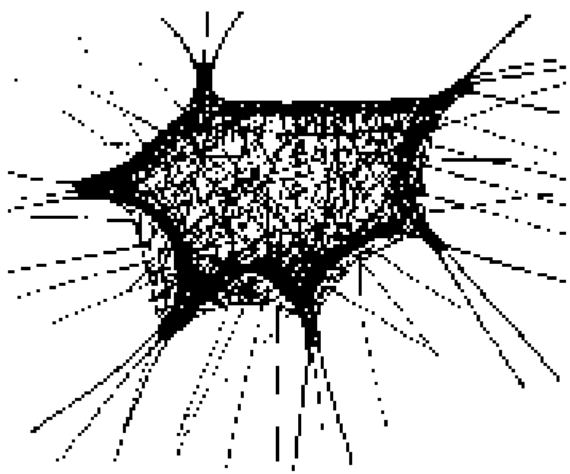


- using data on foraging strategy, prey range, vertical stratification, and circadian activity (Cardoso et al. 2011)
- 111 spider families classified into 8 guilds

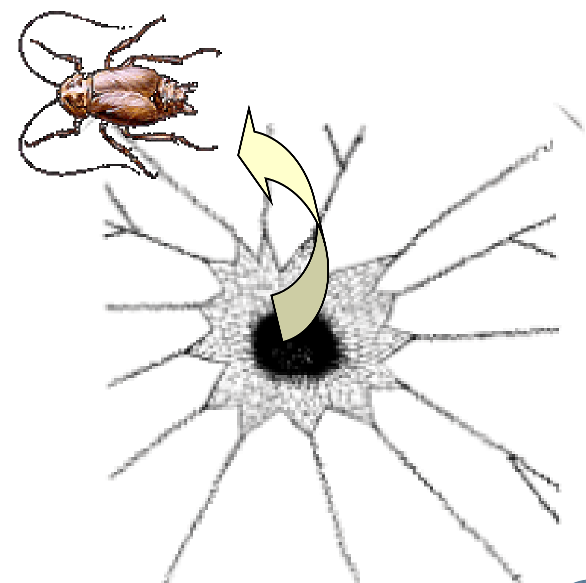


Sensing web

- retreat with signal threads, not used for prey capture but to signal presence of a prey
- on the ground, under stones, on walls, in crevices
- when prey (crawling invertebrates) touches a thread, spider darts forth to seize it
- Oecobiidae, Segestriidae, Filistatidae, Ctenizidae



Oecobiidae

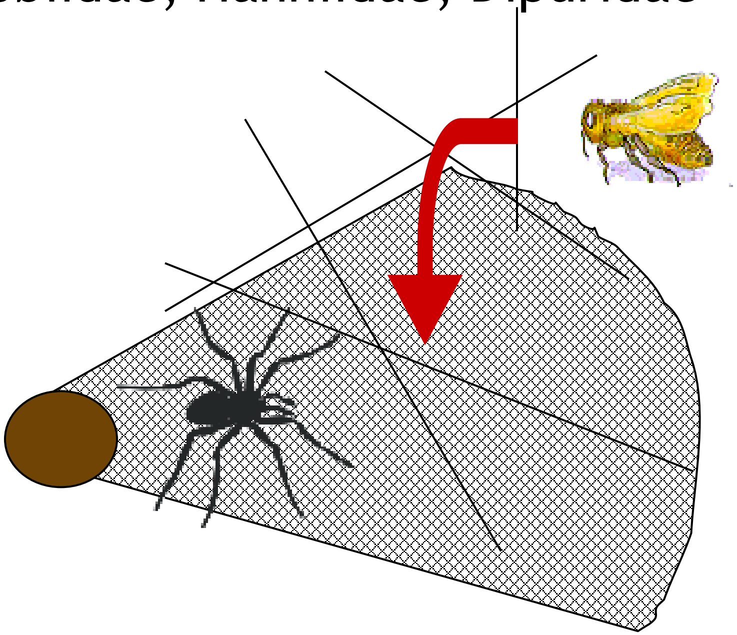


Segestriidae

Sheet web

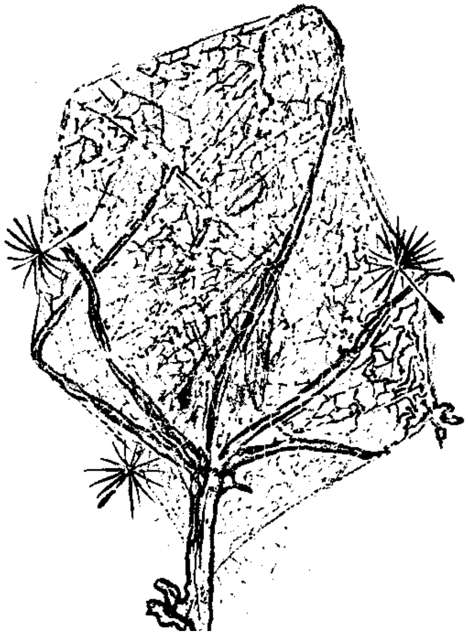
- web with a tubular retreat at one end, and irregular threads above
- built in vegetation
- spider runs on the upper surface of the web
- spider rests in the retreat, when prey stumbles over the threads and falls into the sheet spider rushes out
- Linyphiidae, Agelenidae, Ammaurobiidae, Hahniidae, Dipuridae

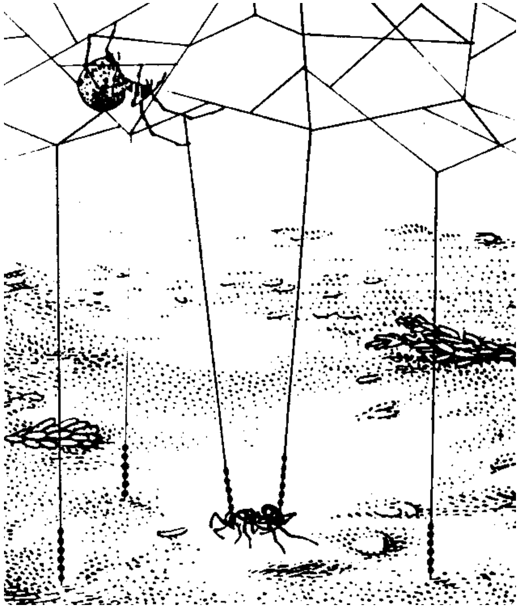
Linyphia



Space web

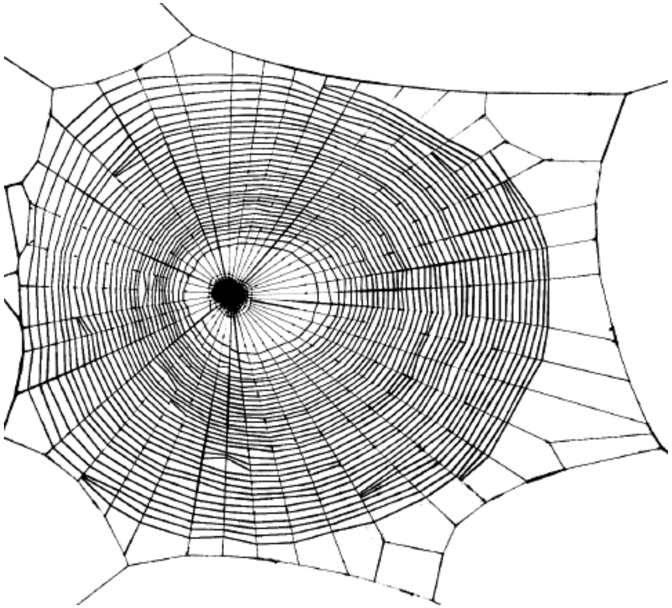
- 3D web, hundreds of short zig-zag threads, some of them are with gluey drops or cribellate silk
- capture prey crawling on ground or vegetation - prey gets stuck, spider may throw more silk on the prey
- Dictynidae, Pholcidae, Nesticidae, Theridiidae

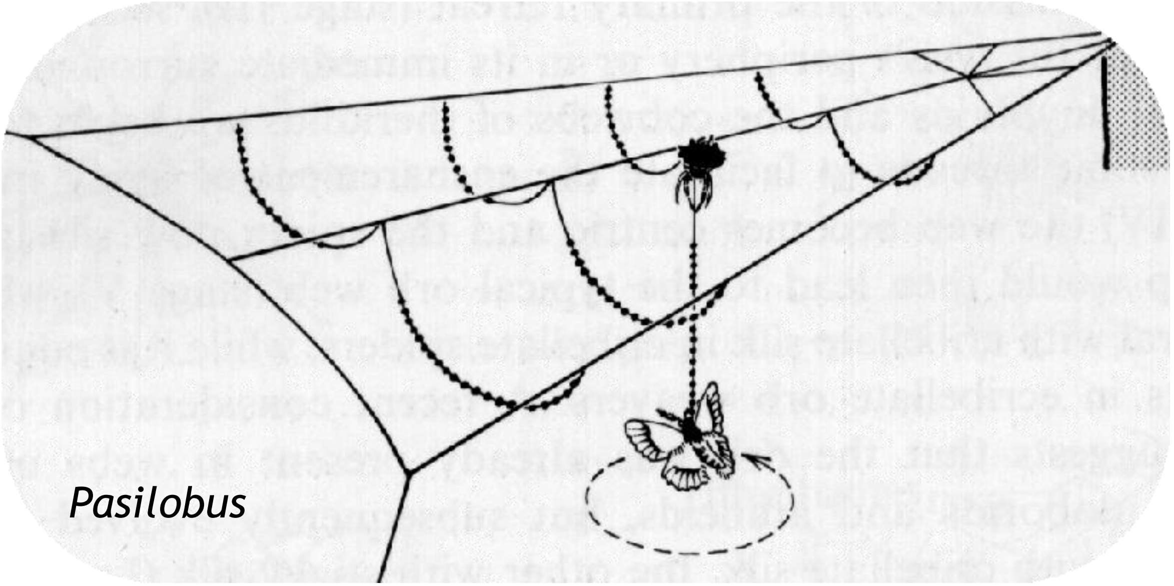




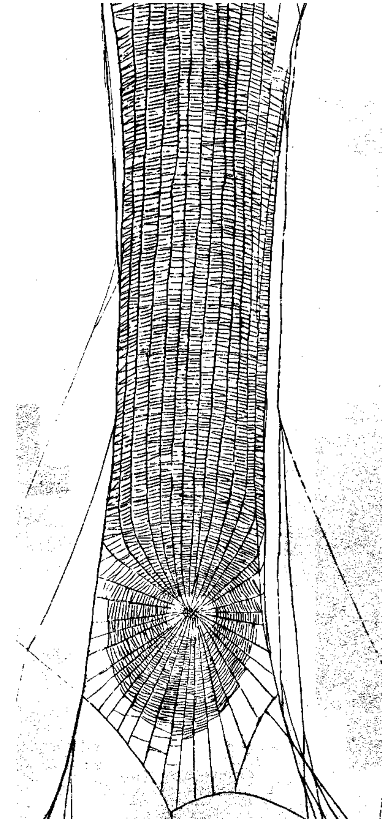
Orb web

- horizontal or vertical 2D web catching flying prey mainly in the night
- Uloboridae put cribellate silk, Araneidae & Tetragnathidae put glue on the catching spiral
- entangled prey is quickly immobilised by wrapping or biting
- Araneidae, Tetragnathidae, Uloboridae

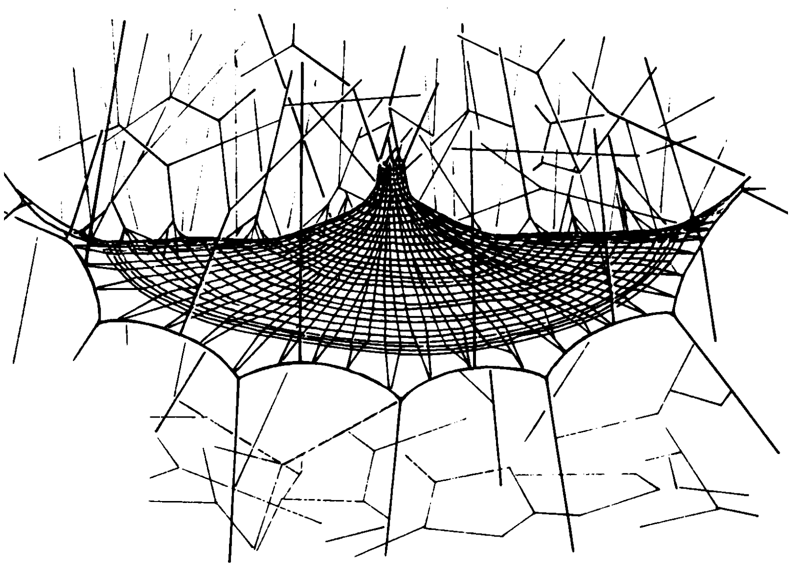




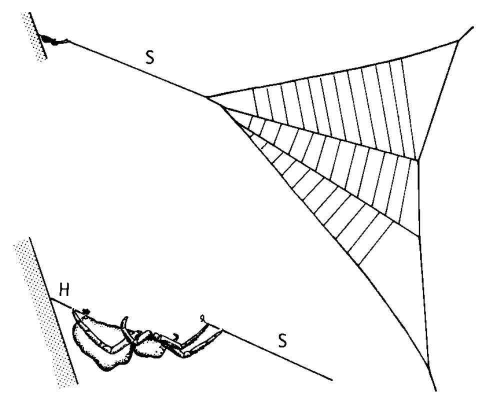
Pasilobus



Scoloderus



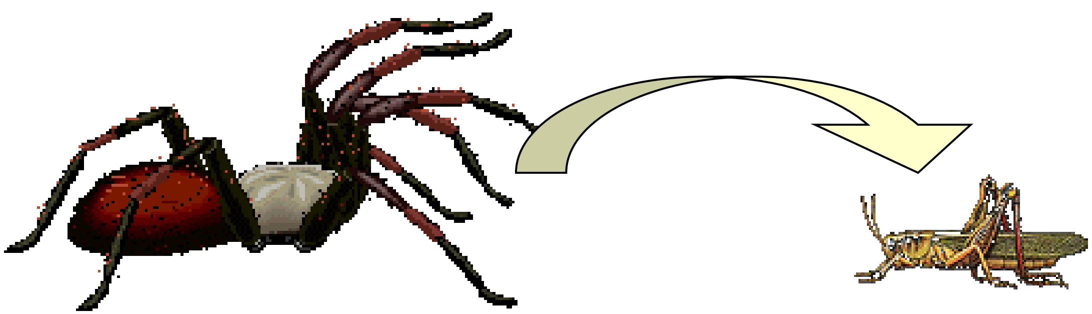
Cyrtophora



Hyptiotes

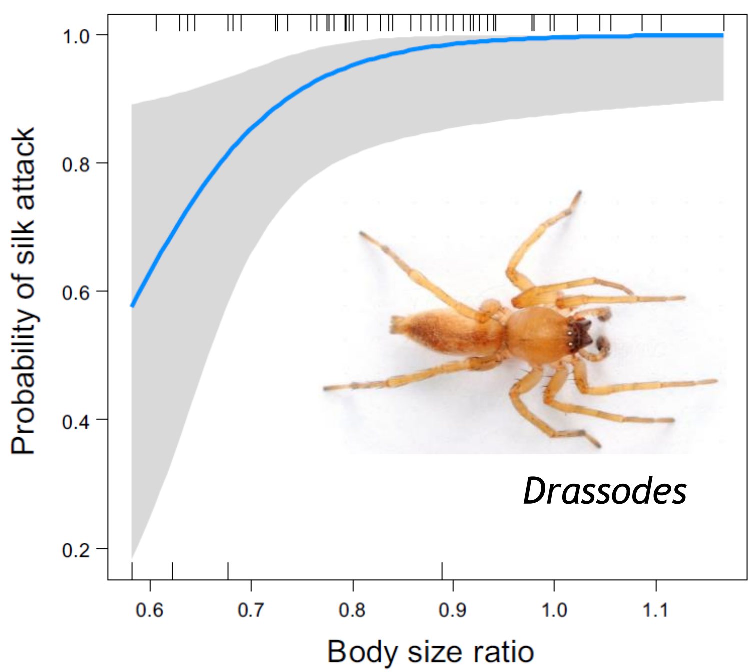
Ground hunters

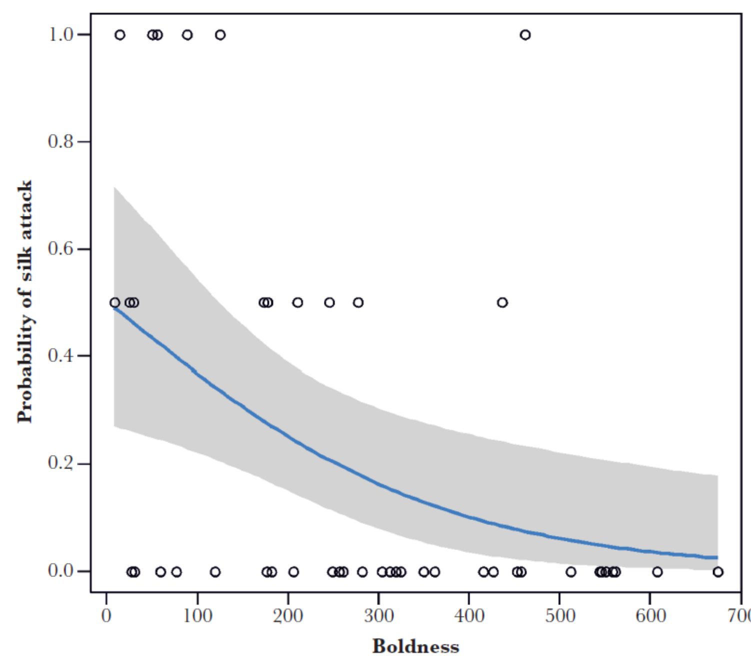
- actively hunt prey on the ground or water
- agile hunters during the day or night
- overpower prey with legs or strands of silk
- Gnaphosidae, Clubionidae, Liocranidae, Lycosidae, Oxyopidae



Conditional strategy

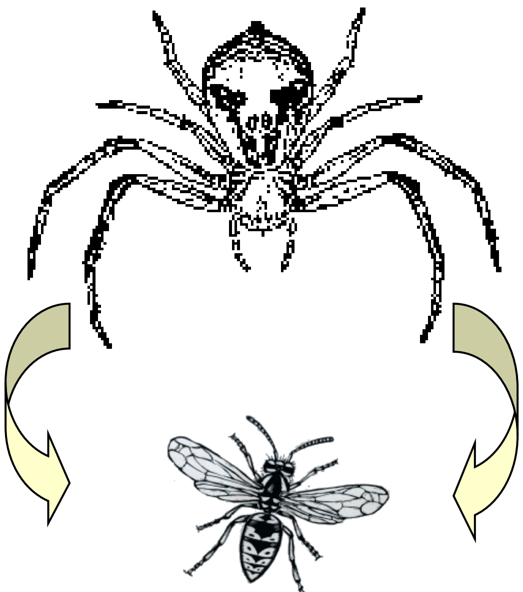
- Prey is immobilised by venom or silk (Beydizada & Pekár 2023)
- Dangerous (large) prey is immobilised by silk
- Bolder individuals use more frequently venom than silk

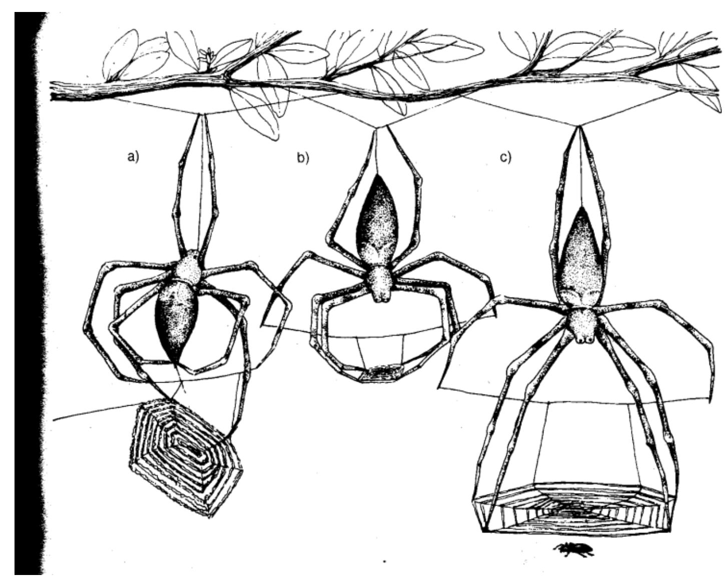




Ambush hunters

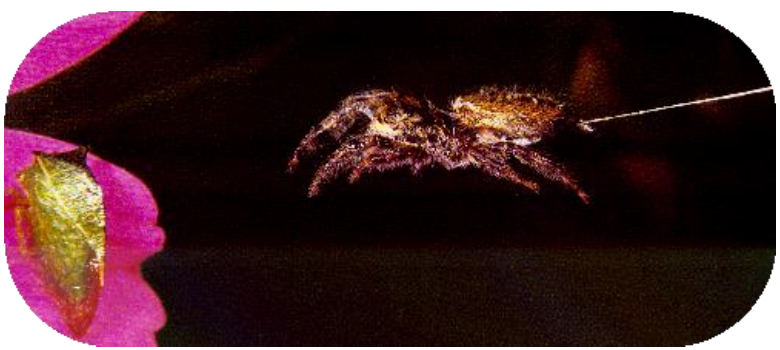
- capture prey on vegetation or ground
- prey is sized by outstretched forelegs that are stout and elongated or small web that is held in forelegs
- Deiniopidae, Thomisidae, Sparassidae, Philodromidae





Other hunters

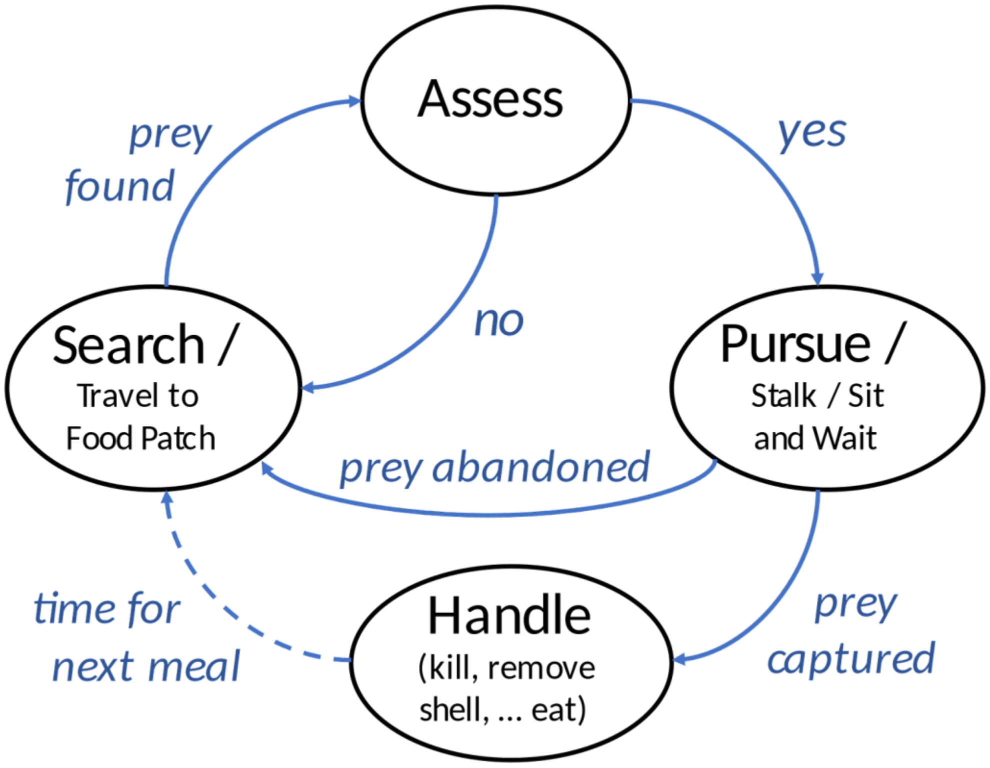
- actively search for prey on a flat surface during day
- orient towards prey, approach within a striking distance and leap on it
- feed on flying or crawling insects
- Salticidae, Scytodidae



Predatory behaviour

Prey capture

- Ethogram of prey capture

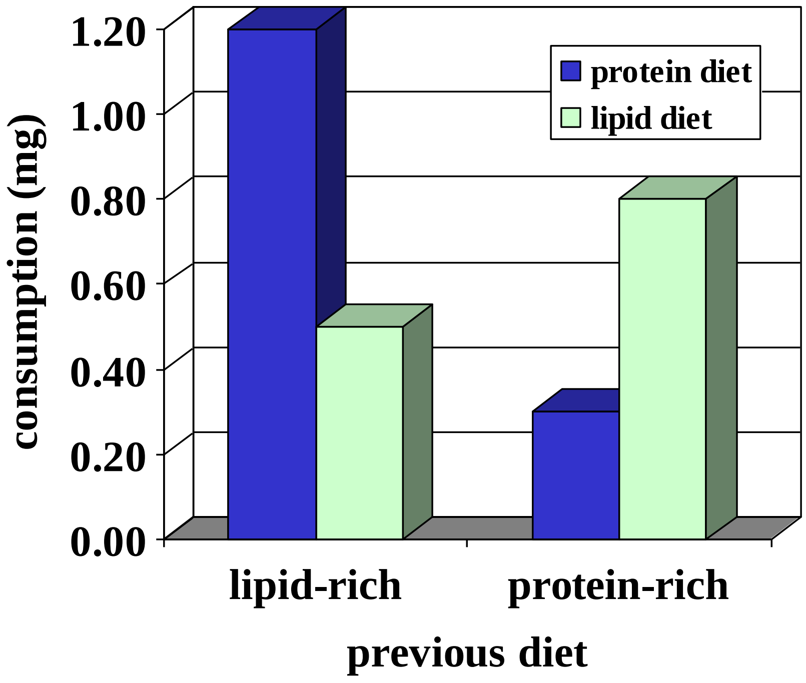


Effect on predator

- spiders adjust their food selection to regulate intake of nutrients (Mayntz et al. 2005)
- consume their prey based on their previous diet
- they either eat more of prey that is rich in nutrients they require or extract specific nutrients from a single prey

Pardosa

Consumption of different types of diet



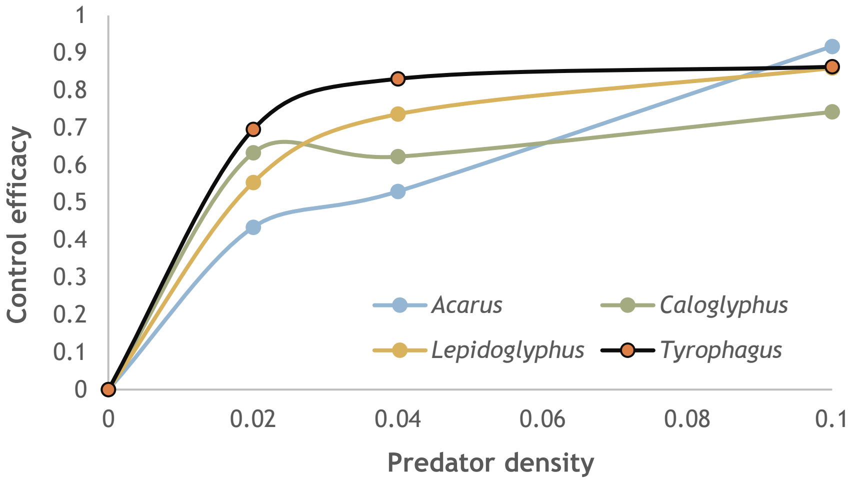
Lethal effect on prey

- Most arachnids have limited biocontrol abilities:

- limited functional and numerical responses, present intraguild predation

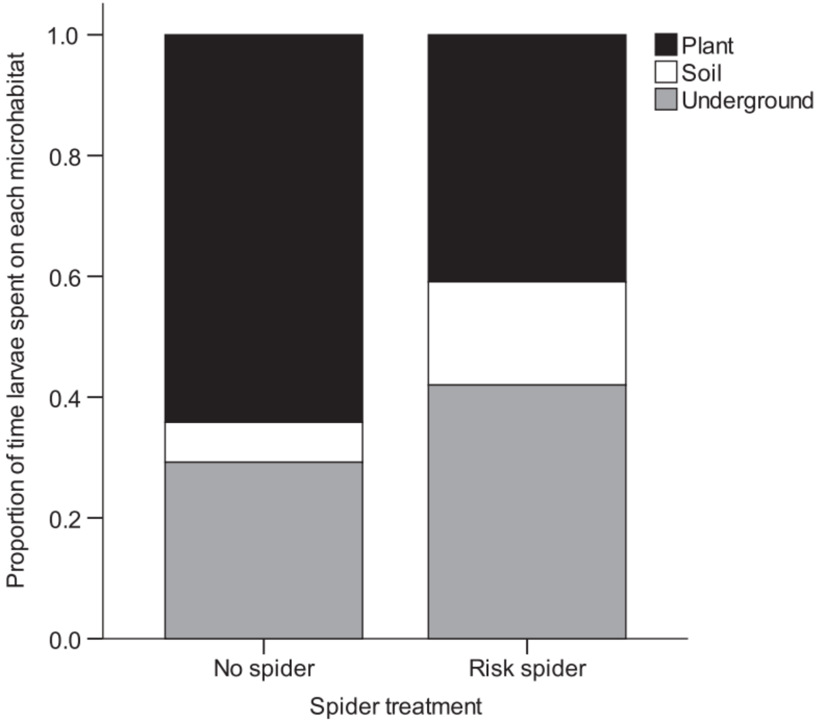
- Mites (*Phytoseiulus*, *Neoseiulus*, *Amblyseius*) are used as efficient biocontrol agents
- *Cheyletus* is used to control mite pests on stored grain (Cebolla et al. 2009)
- it feeds on variety of mite pest species

Cheyletus

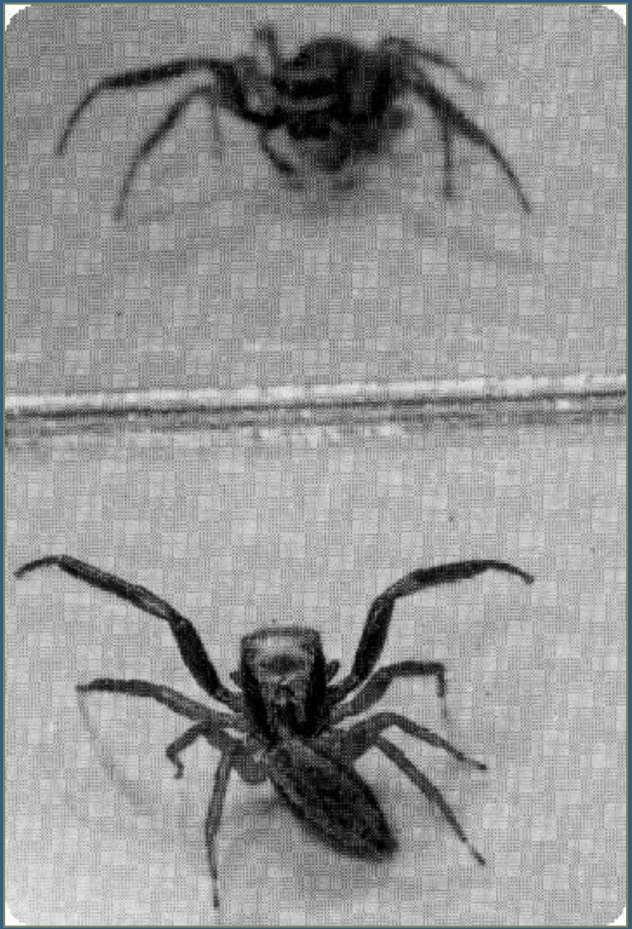


Non-lethal effect

- arachnids can also have non-consumptive effect on their prey
- presence of *Tasmanicosa* (glued chelicera) affected behaviour of *Helicoverpa* - catterpilars spend less time on cotton leaves (Rendon et al. 2016)



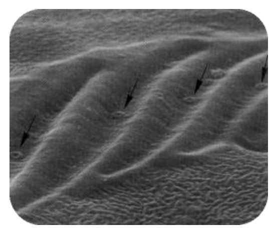
Senses used



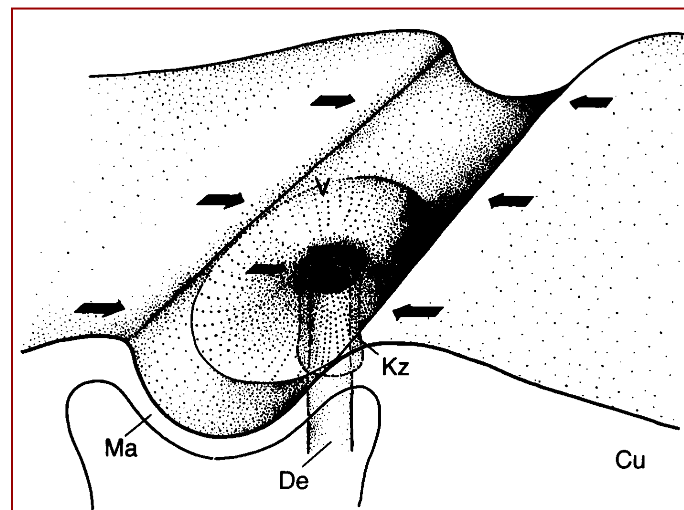
Seismic

- vibrations are perceived through slit sensillae that form lyriform organs (on legs)
- primary sense in all arachnids, mainly primitive hunters, tube builders, signal-web builders and weavers
- web-builders have more slits than hunters
- sensitivity of slits increase with its length

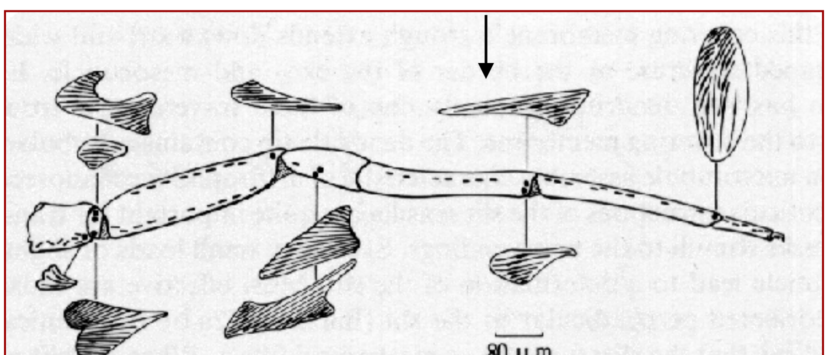
20-120 µm long



A single slit

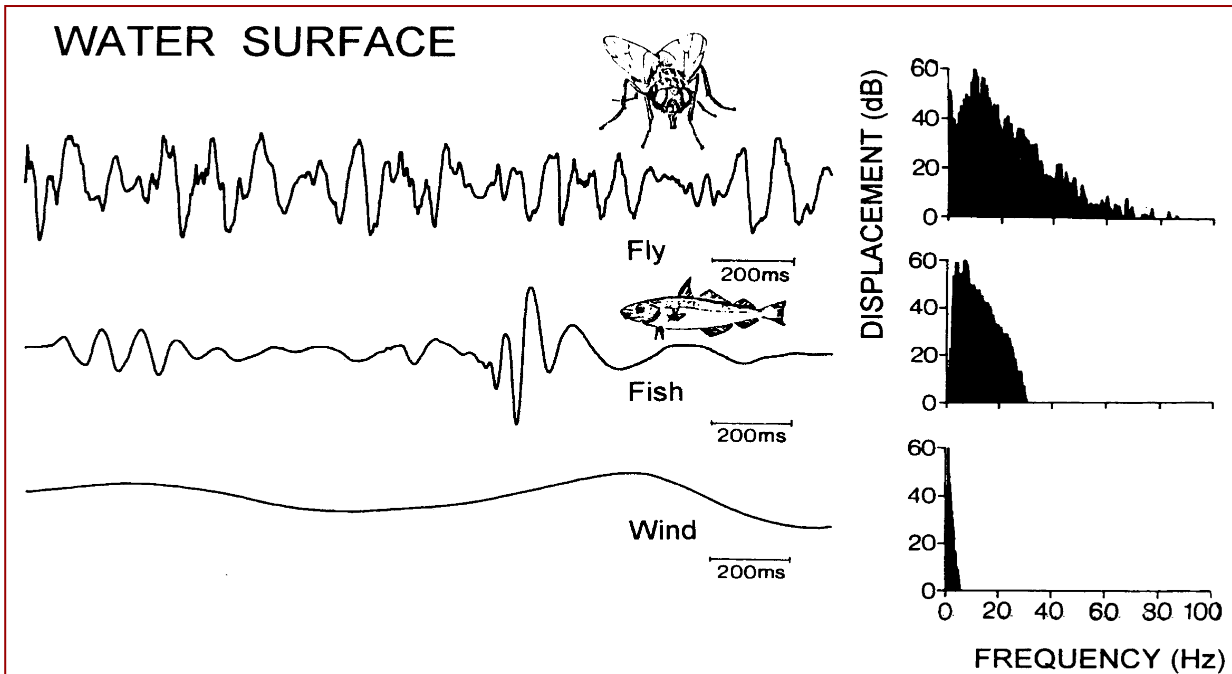


Lyriform organs on a leg



- slits detect the tiniest deformations of the skeleton, sensitive to substrate-born vibrations (10-100 Hz)
- vibrations are not blocked by obstacles (visual or acoustic) or blown away by wind
- spiders discriminate among types of vibrations: noisy irregular signal are more effective than sinusoidal vibrations

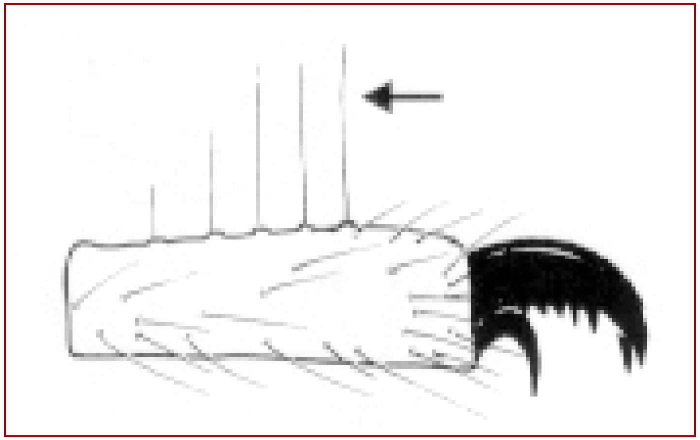
Oscillograms and frequency spectra of vibrations on water

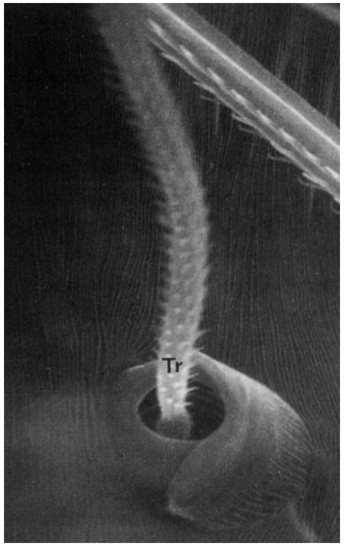


Acoustic

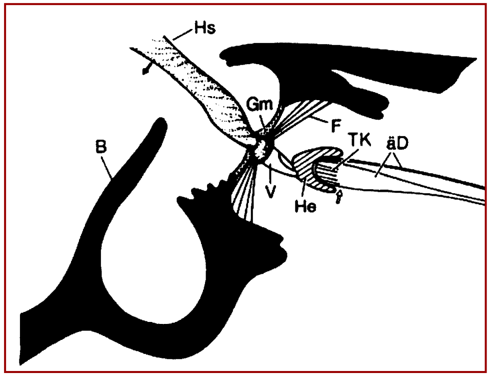
- acoustic signals are perceived by trichobothria on the dorsal side of legs
- trichobothria are sensitive to air-born vibrations (50-150Hz)
- used mainly by hunters, net-casters, funnel weavers
- hunters have more trichobothria than web-builders (< 10/leg)
- trichobothria are feathery - increase the drag force and sensitivity
- maximal distance eliciting predatory behaviour is 25 cm

Trichobothria on Ta

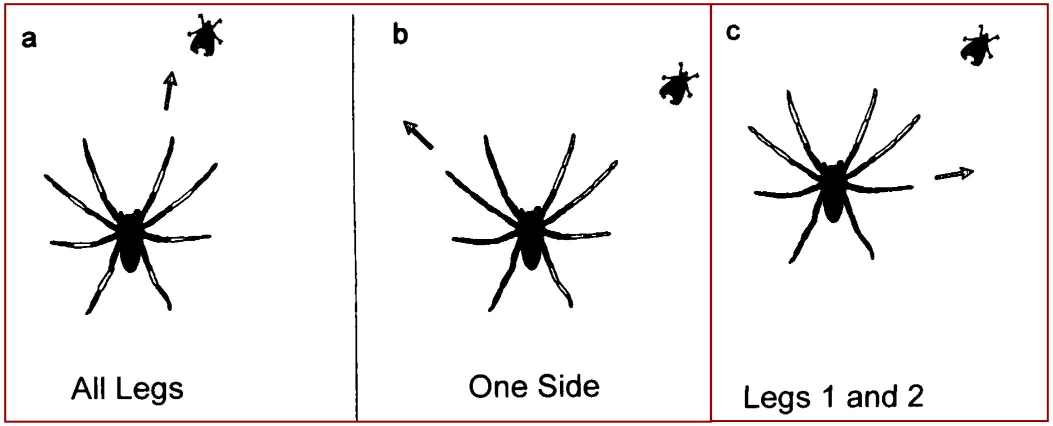




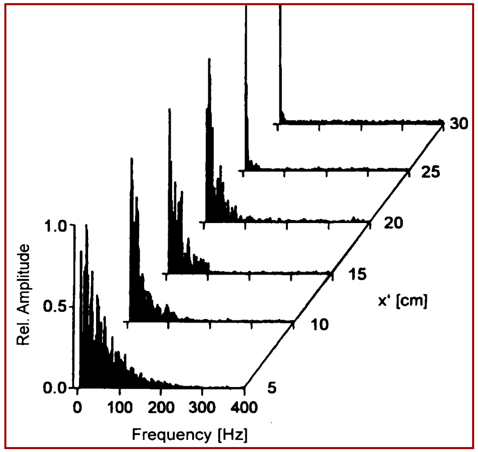
Anatomy of trichobothria



- interplay of trichobothria - *Cupiennius* turned toward the leg stimulated earliest
- removal of 50% trichobothria from all legs → no behavioural change
- removal of trichobothria on one side only → spiders turned at correct angle but to other direction
- removal of trichobothria on forelegs → spider turned backwards

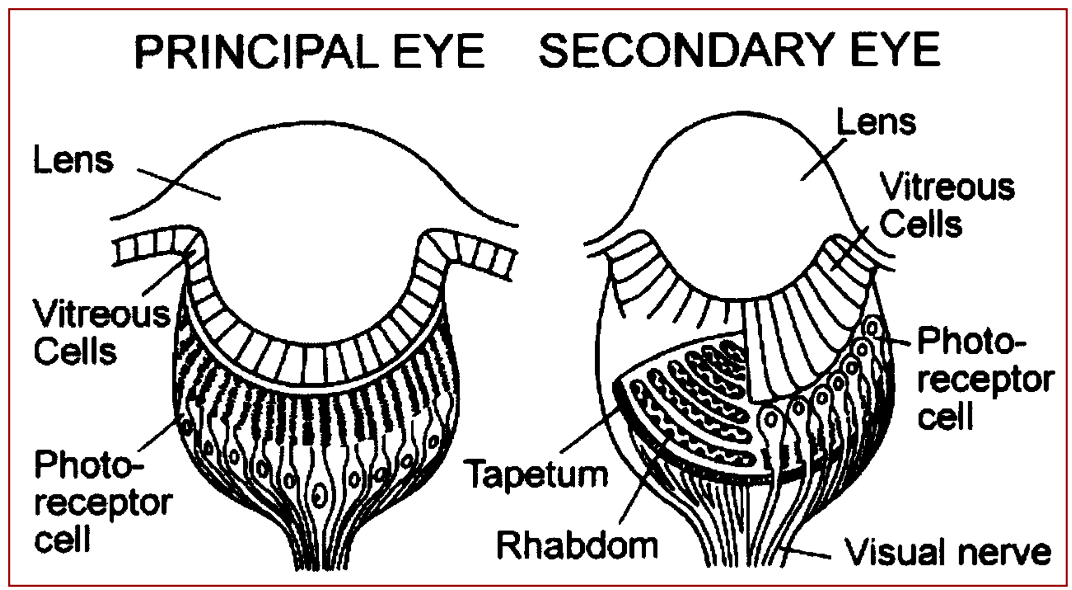


Attenuation of signals in the air



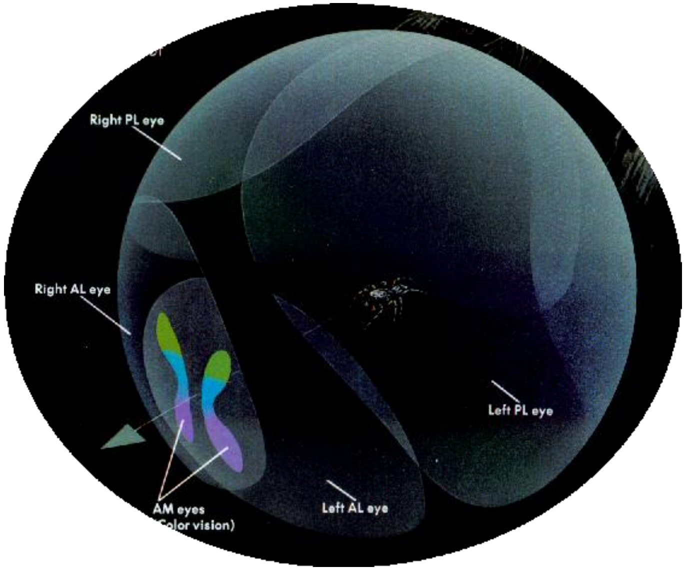
Visual

- visual signals are perceived by eyes (ocelli)
- ME recognise shape and colour, LE are movement detectors
- prey is first detected by wide-angle lenses of LE, then fixed with movable retina of ME
- narrow field of view is compensated for mobile eye tube of ME
- used by Salticidae, Lycosidae, Deinopidae, Sparassidae, Thomisidae

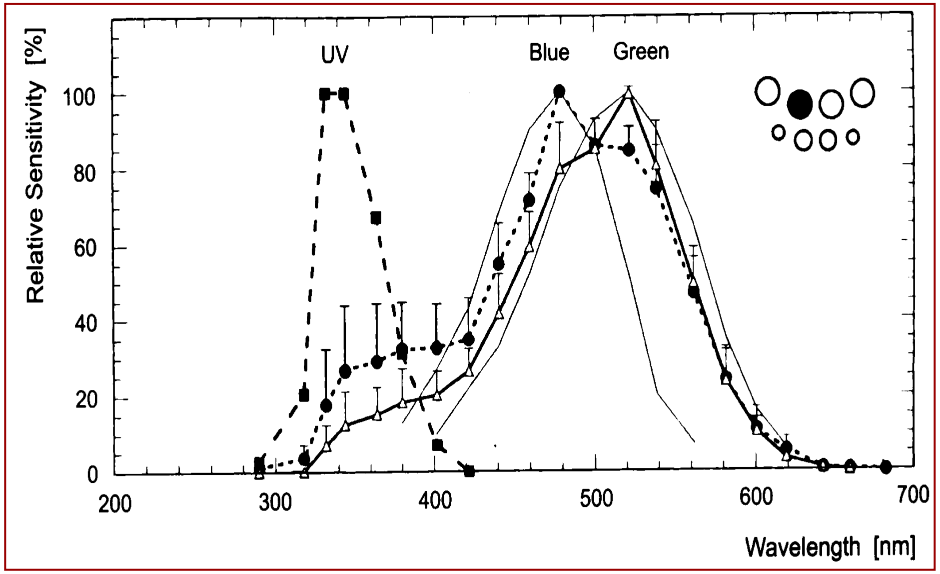


- *Cupiennius* spiders has trichromatic colour vision (UV+green+blue)
- spatial resolution of *Portia* AME is 6x worse than in human and 10x better than in dragonfly
- light sensitivity in *Deinopis* is equal to F=0.58 - better than any camera lens
- *Cupiennius* eyes are sensitive enough even under moonlight

Salticid field of view

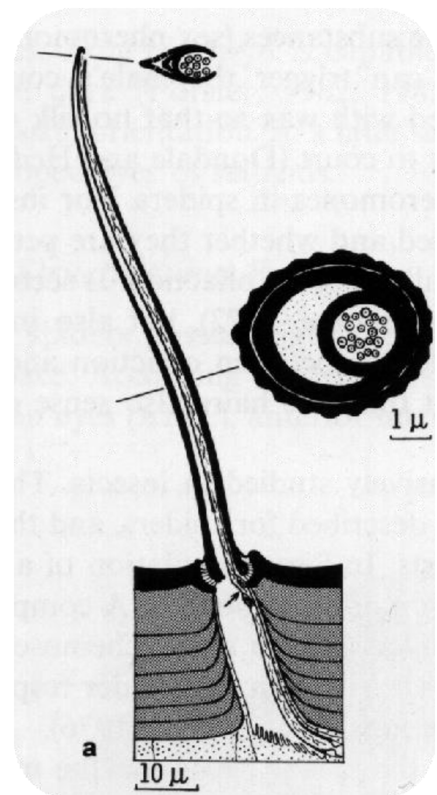


Spectral sensitivity of the *Cupiennius* median eye



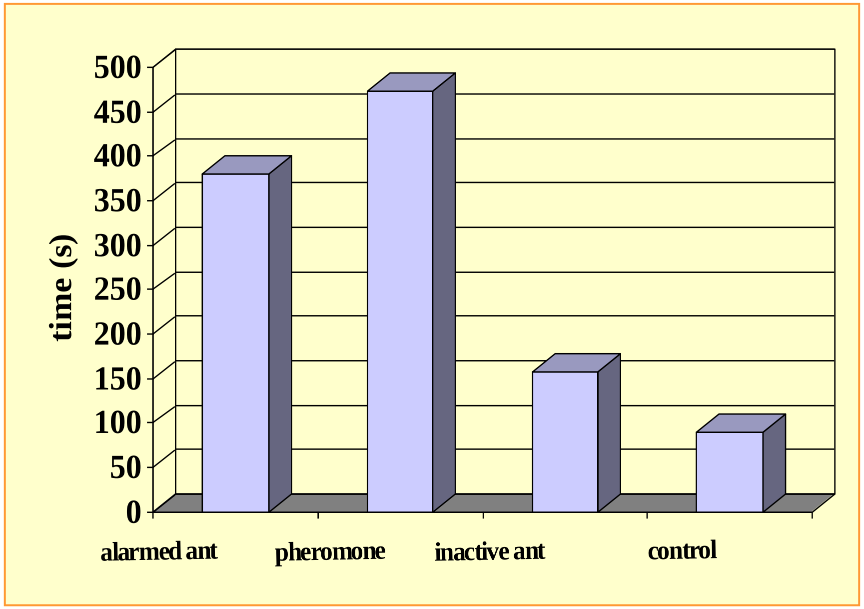
Chemical

- chemical signals are perceived by chemoreceptors on distal tips of tarsi
- chemoreceptors are inervated by 21 sensory cells
- little is known about chemoreception

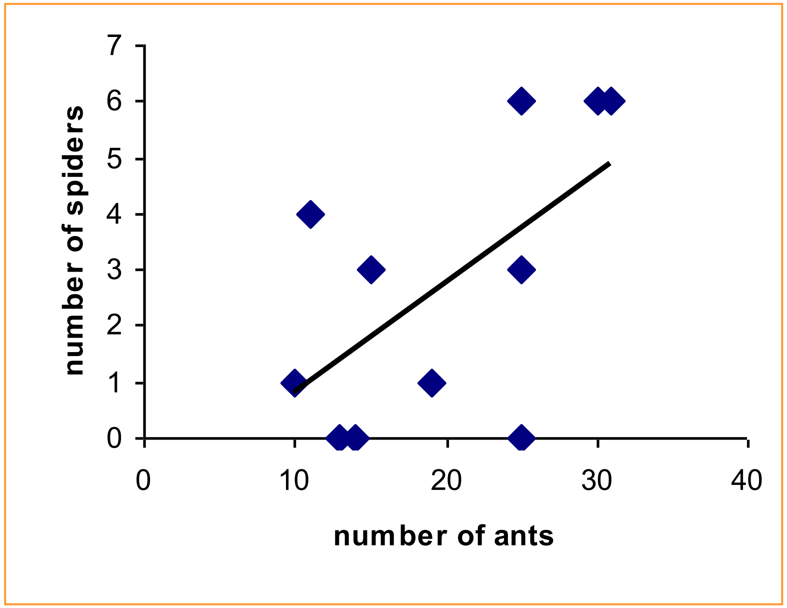


- zodariid *Habronestes bradleyi* feeds on *Iridomyrmex* ants
- is able to identify alarm pheromone of the ants
- spiders locate patches where ant workers are engaged in agonistic interactions

Time spend by spiders in Y-maze arm with different attractors



Relationship between the number of spiders and ants engaged in agonistic interactions



Aggressive mimicry

- predator imitates its prey (using intra- or interspecific signals) in order to approach the prey and thus increase efficiency of capture

Visual signals

- UV is produced by sun - silk reflecting UV imitates open space
- primitive spiders (Mygalomorphs, Uloboridae) produce silk that reflects UV light
- derived spiders (Araneidae) produce silk that exhibits low UV reflectivity
- web decorations (stabilimentum) are highly reflective
- webs without stabilimentum captured 40% less prey than those with stabilimentum

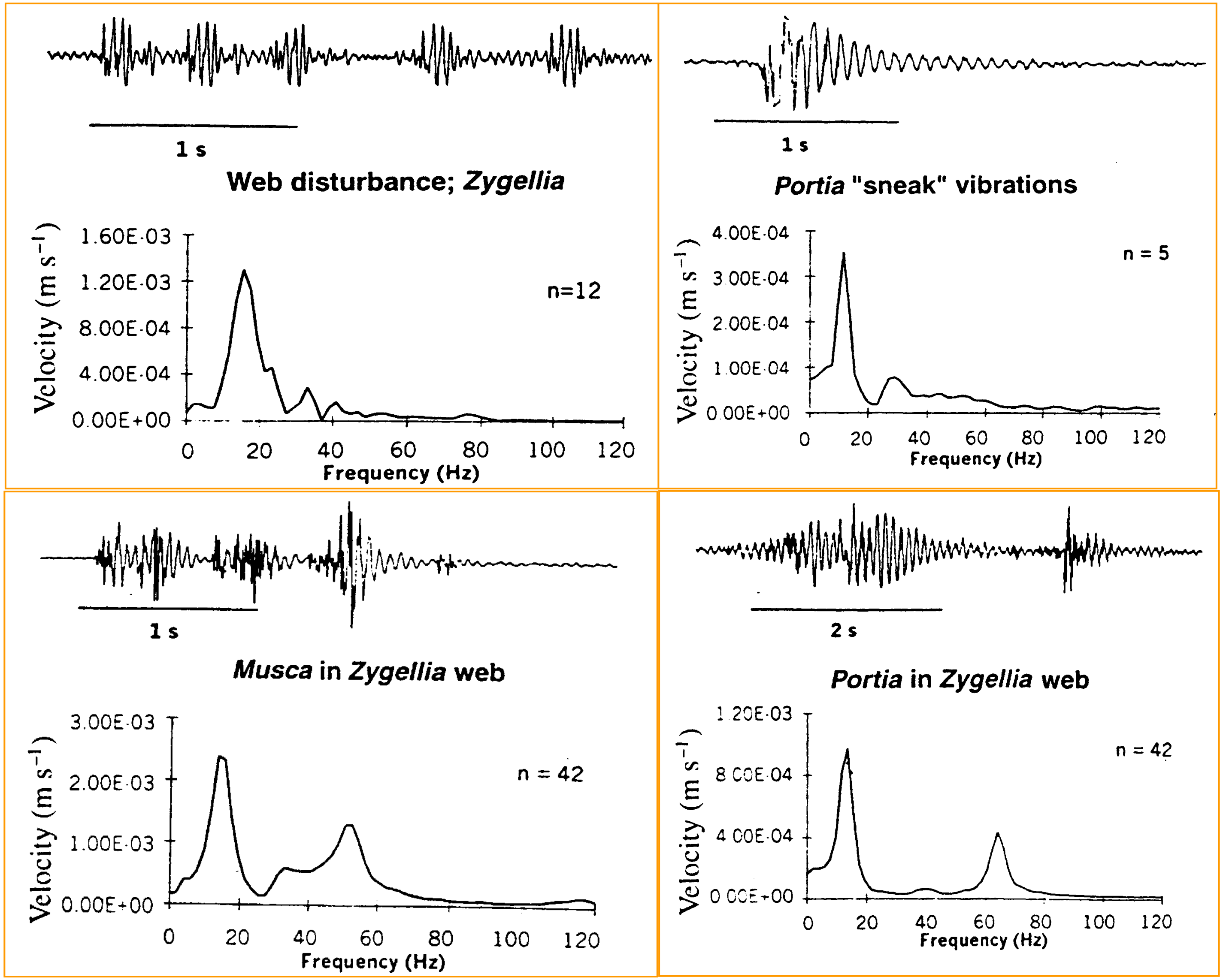
Cyclosa

Seismic signals

- imitation of prey ensnared in the web
- *Portia* invades webs of other spiders
- after entering a web *Portia* vibrates with forelegs to produce:
  - strong vibrations (imitation of ensnared insect)
  - faint manipulation (prey contacting periphery)
  - brief strong rocking (natural disturbance)
- after approaching the resident spider, *Portia* makes strong manipulation if resident spider is large, and faint manipulations if resident spider is small

***Portia* captures a theridiid**

Records of simulated and *Portia*-made vibrations on web



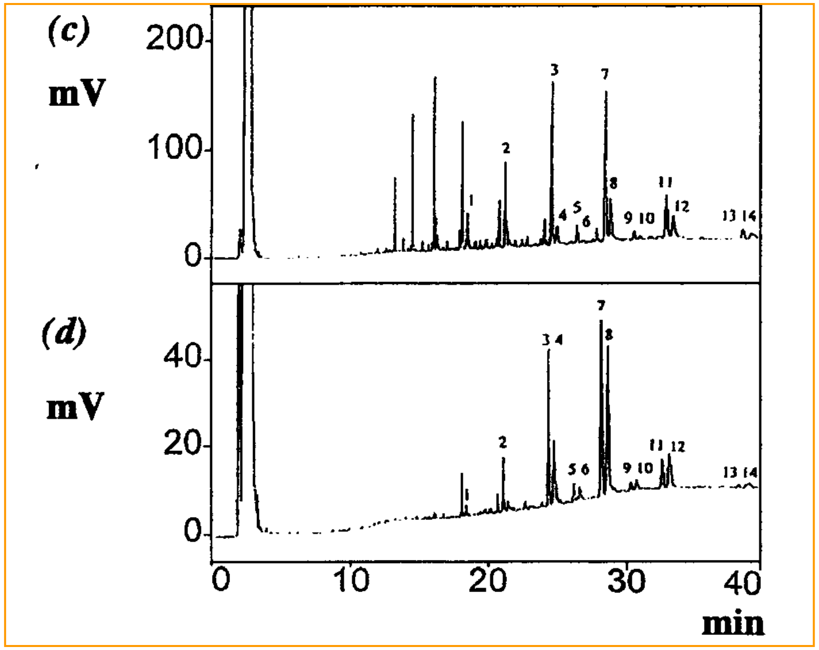
Chemical signals

- *Cosmophasis* spiders live close to and inside nests of *Oecophylla* ants but avoid direct contact with the workers
- feed on the ant larvae not workers and lay eggsacs inside the colony
- spiders steal larvae from an ant that is carrying them

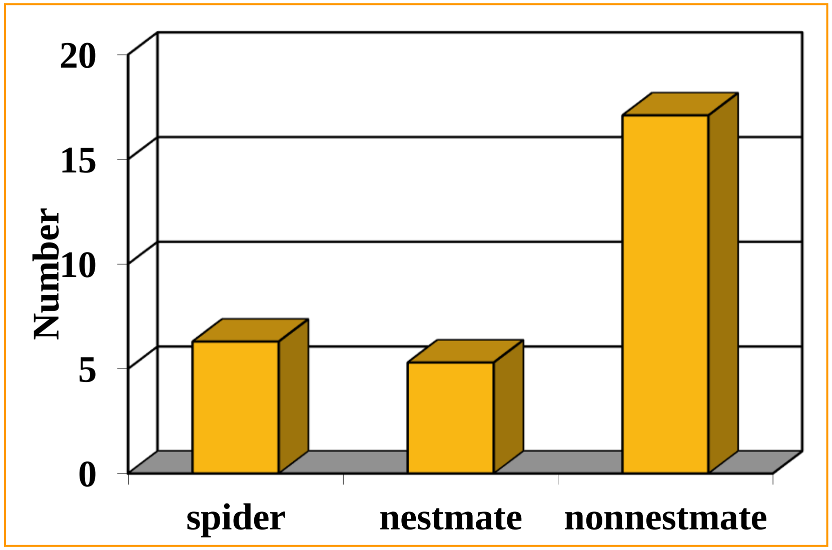
Cosmophasis

- spiders imitate cuticular hydrocarbons (mono- and dimethylalkanes) of ants
- since spiders can penetrate other nests, the mimicking hydrocarbons are rather species than colony specific

Gas chromatogram of ants' and spiders' cuticular hydrocarbons



Number of aggressive behaviours of ants

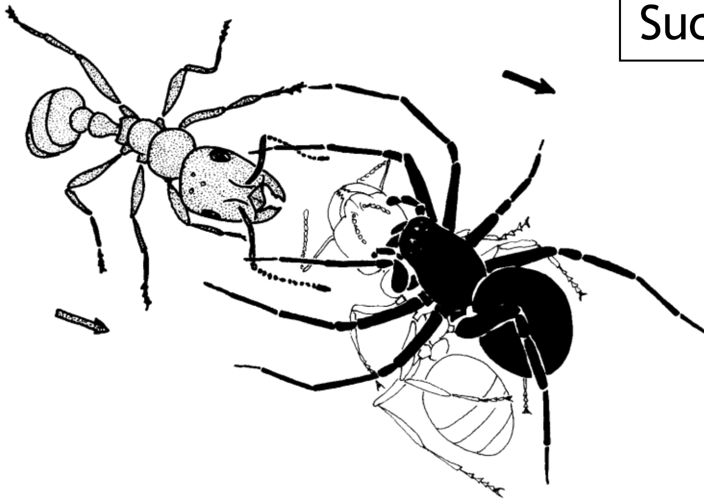


Tactile signals

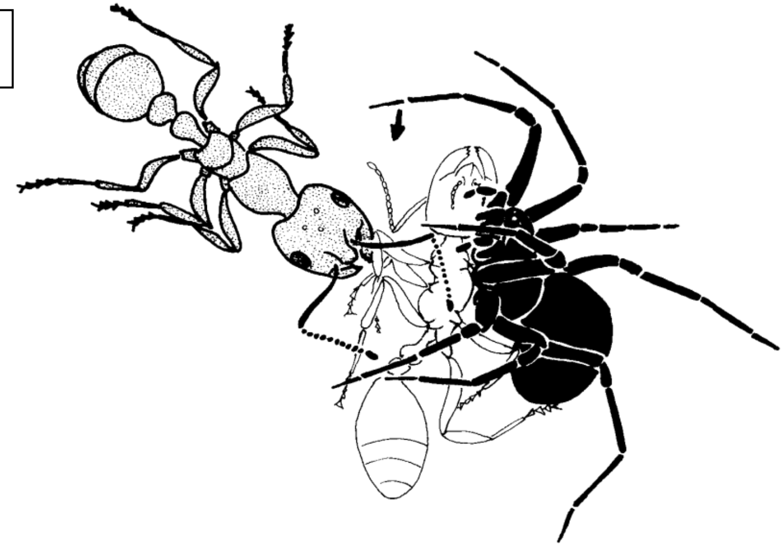
- *Zodarion* hunts ants outside their nests
- after capturing an ant, spider have to carry its prey away from ants
- in order to avoid ants *Zodarion* tries to deceive ants by „prey shielding”

Zodarion

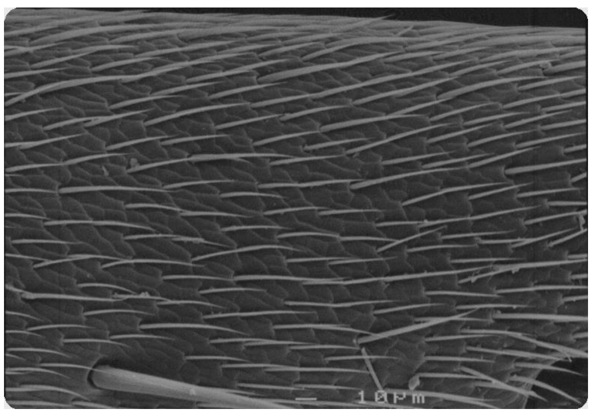
Success: 80%



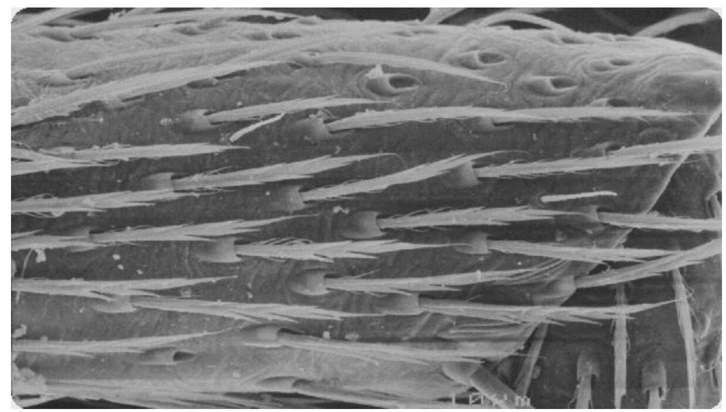
Formica (Ti)



Zodarion (Ti)



38 hairs / 0.01 mm^2



8 hairs but 35 thorns / 0.01 mm^2