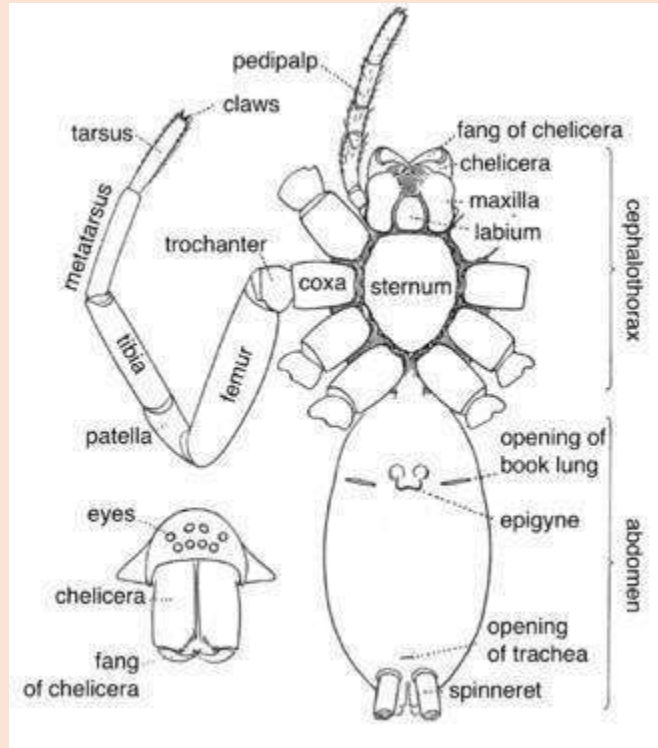


- These are called the **epigastric plates**.

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- Females genital organ is also present on ventral side of the abdomen.
- It is called epigyne.

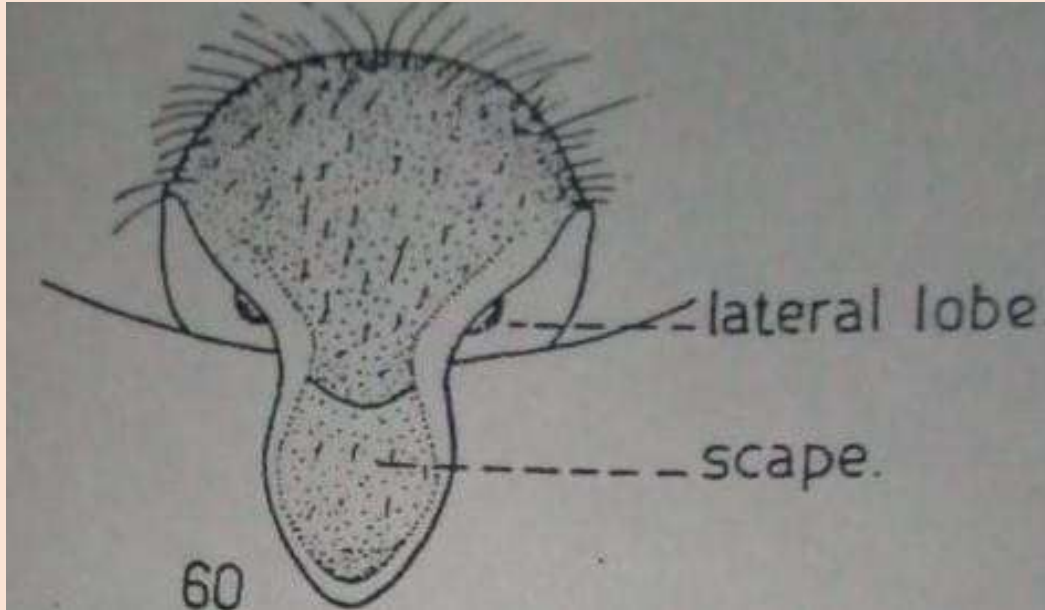
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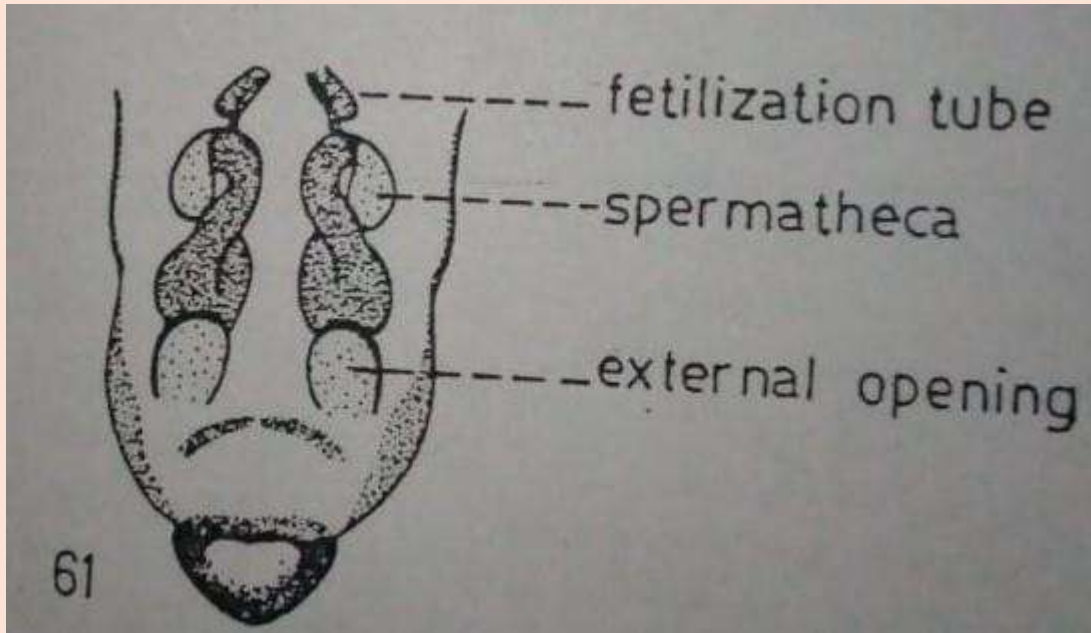
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Morphology of spider's Abdomen



- In many cases epigyne is provided with a tongue like sclerotic projection called scape.
- Scape often have paired lateral lobes as in Neoscona

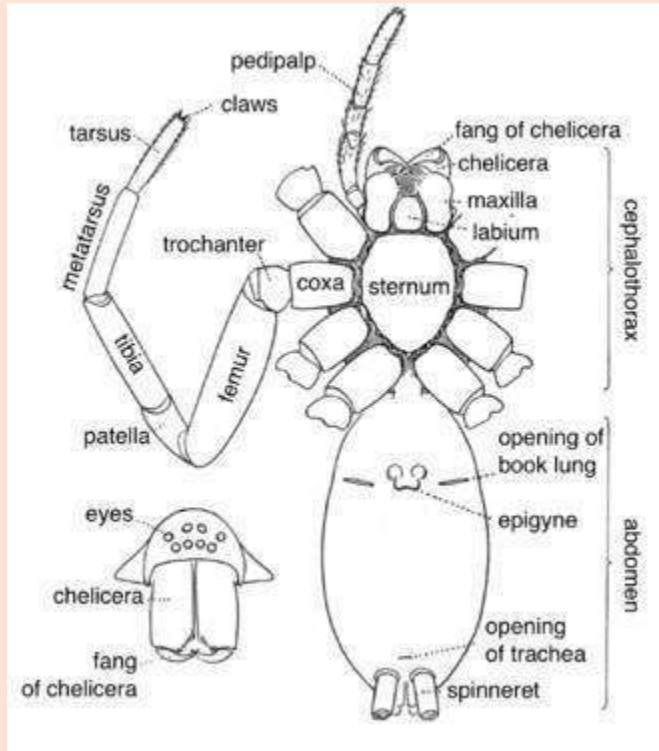
Morphology of spider's Abdomen



Tikadar, 1982. The Funa of India

- Epigine has two external openings which lead to spermathecae inside and paired of narrow curved tubes called fertilization tube
- Scape often have paired lateral lobes as in Neoscon

Morphology of spider's Abdomen



- A fold, known as the epigastric furrow, separates the region of the **book lungs** and **epigyne**.

- In the middle of this furrow is the opening of the oviduct (in females) and at either end are

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the

lung slits.

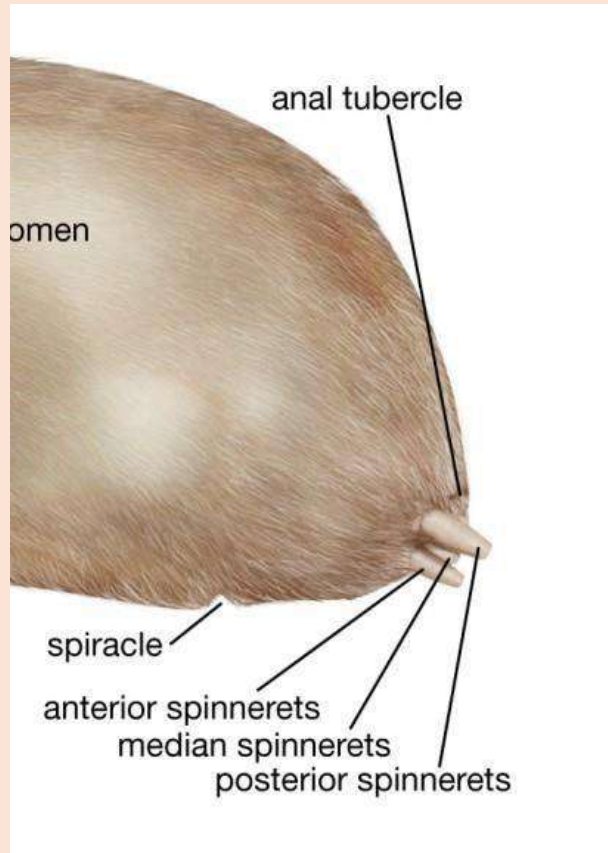
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Morphology of spider's Abdomen

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Morphology of spider's Abdomen

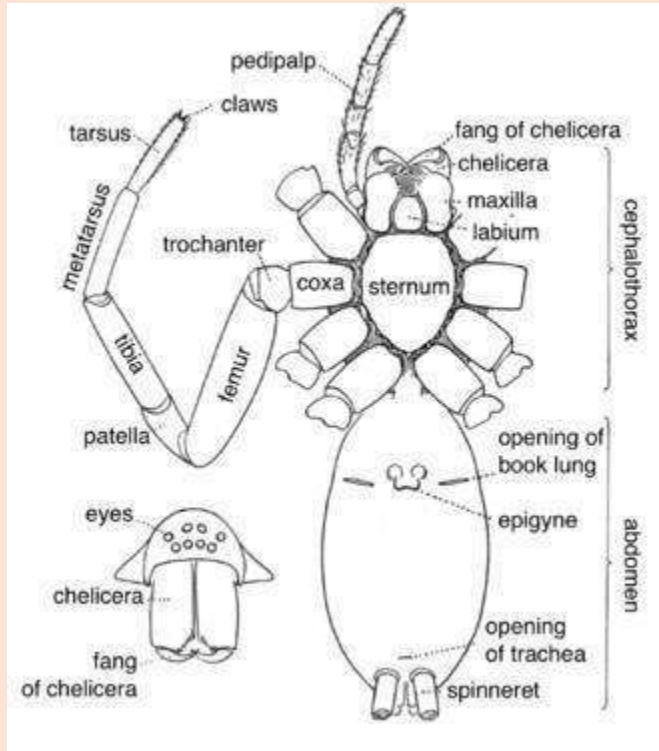


- On posterior side of the abdomen there is conical anal tubercle that bear three pairs of spinnerets ventrally.
- On ventral side there are two pairs of book lungs.

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Morphology of spider's Abdomen



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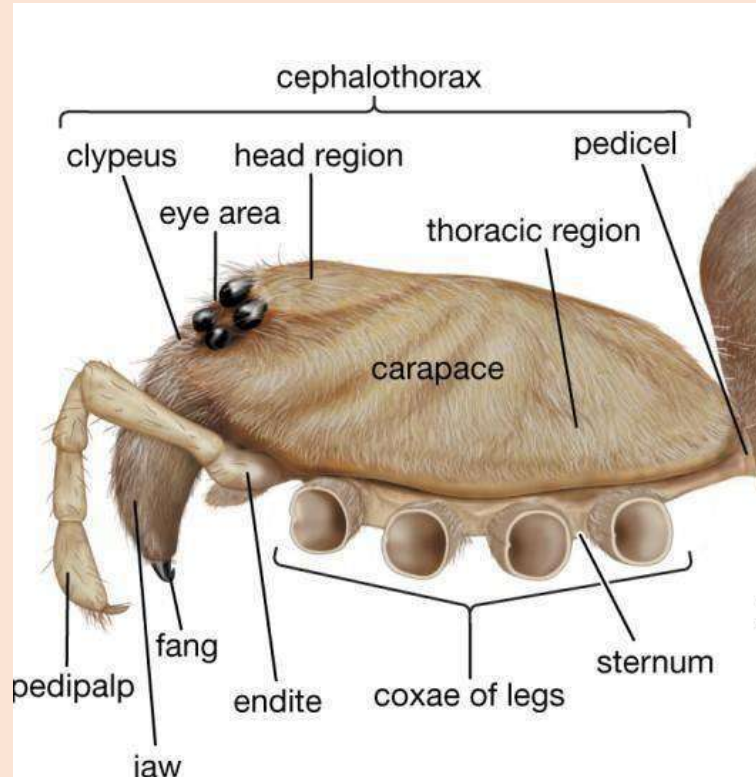
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Morphology of spider's Abdomen

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NM&imgdii=tDDYazdFPMxm0M

Module# 139 Morphology of spider's Cephalothorax



- Cephalic region has 6-8 eyes
- Eyes or black or diurnal
- White or nocturnal
- If only one type of eyes (homogenous)
- If both type of eyes or present

Morphology of spider's Cephalothorax

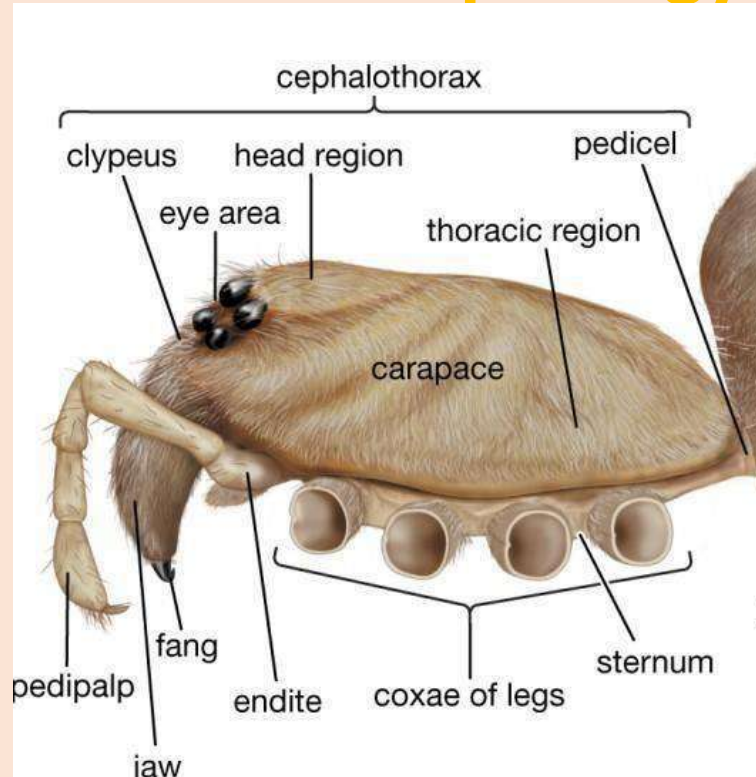
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(heterogeneous)

Usually arranged in

- two rows

Morphology of spider's Cephalothorax



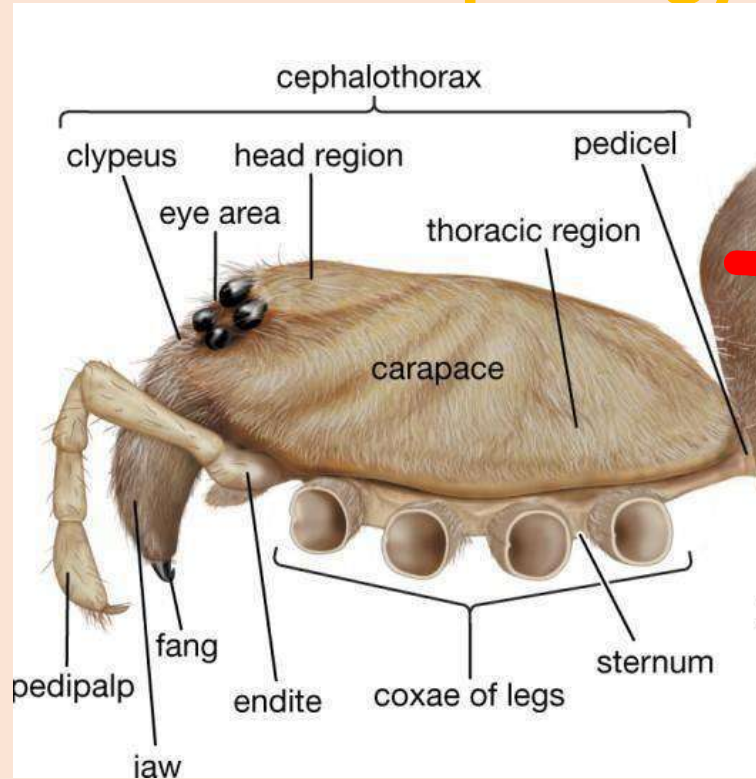
- Each row usually contain 4 eyes.
- Rows of eyes are frequently curved.
- Anterior median/Anterior lateral
- Posterior median/Posterior lateral

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• Cephalic area of eyes is called **ocular area**.

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Morphology of spider's Cephalothorax

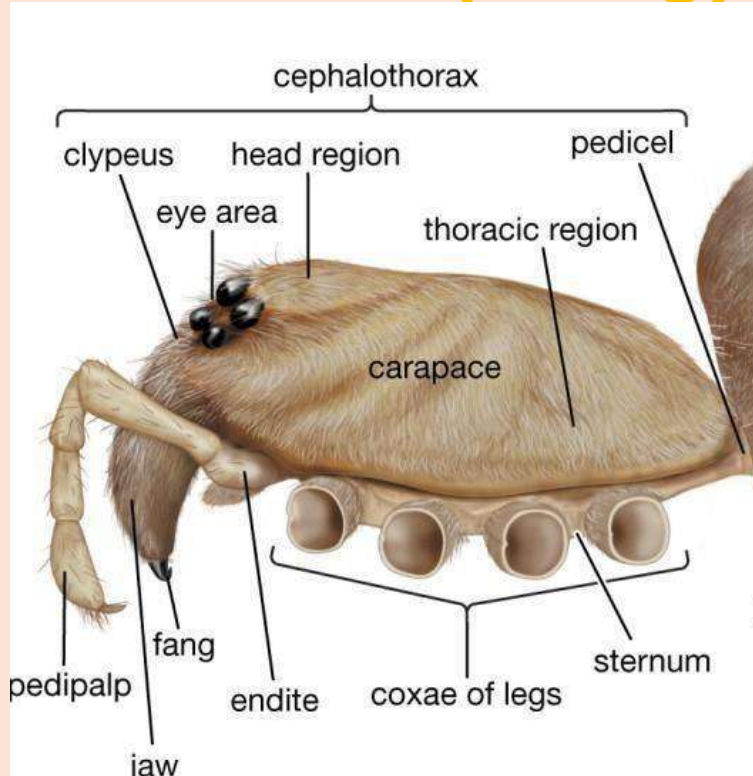


- Area of four median eyes is called ocular quad.
- The area between anterior row of eyes and anterior margin of carapace is clypeus.
- The depression in the middle of

thorax is called **thoracic groove or fovea.**

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Morphology of spider's Cephalothorax



- Appendages
- Chelicerae/Fangs
- Padipalp (2nd pair of appendages)
- Papl has six parts/metatarsus missing.
- In males tarsus/modified

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copulatory organ

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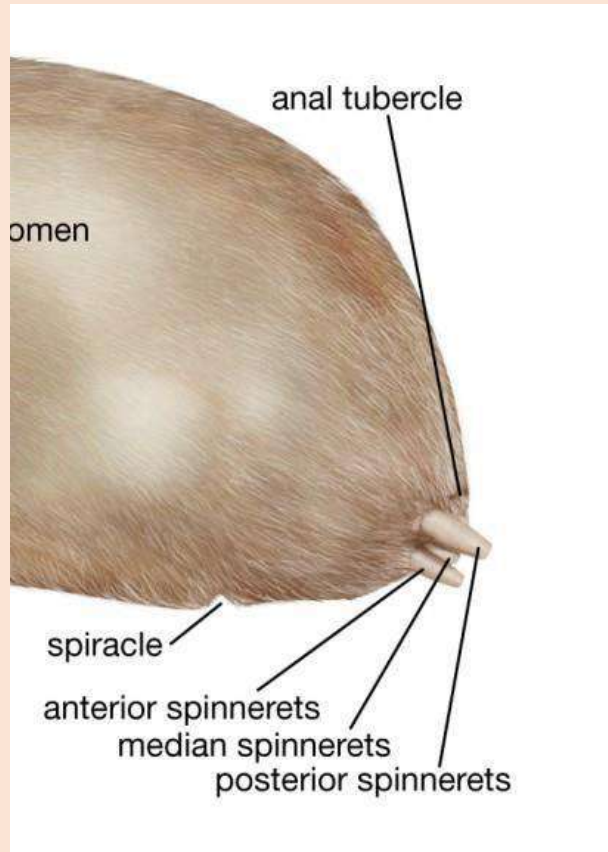
Morphology of spider's Cephalothorax

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- Ventral side is sternum
- Oval/heart shape

Module# 140 Morphology of spider's Spinnerets



- The abdomen of spiders has modified pairs of movable telescoping organs called **spinnerets**, which produce silk.
- The suborder **Mesothelae** is unique in having only two types

Morphology of spider's Spinnerets

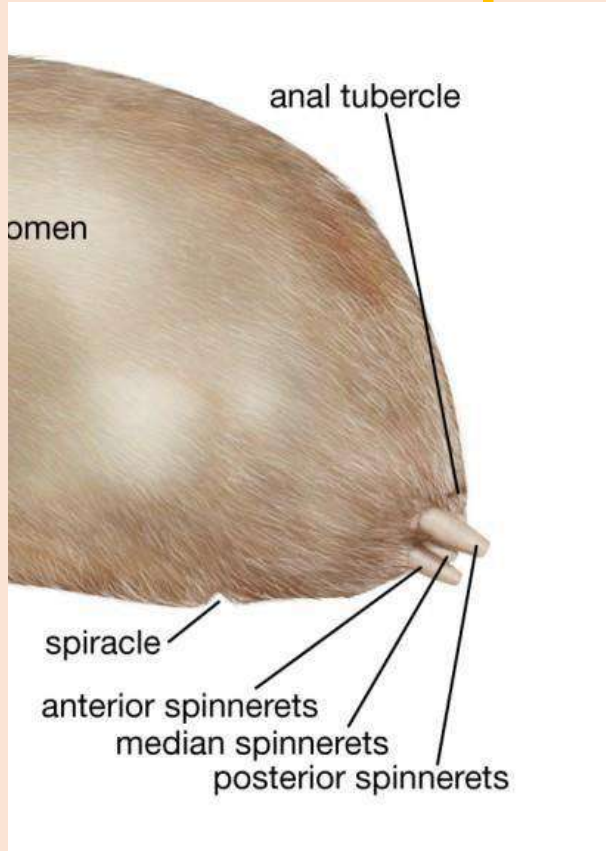
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of silk glands – thought to be
the
ancestral condition.

Morphology of spider's Spinnerets



- Depending on the complexity of the species, spiders will have **two to eight spinnerets**, usually in pairs.

- Behind each spinneret visible on the surface of the spider lies a

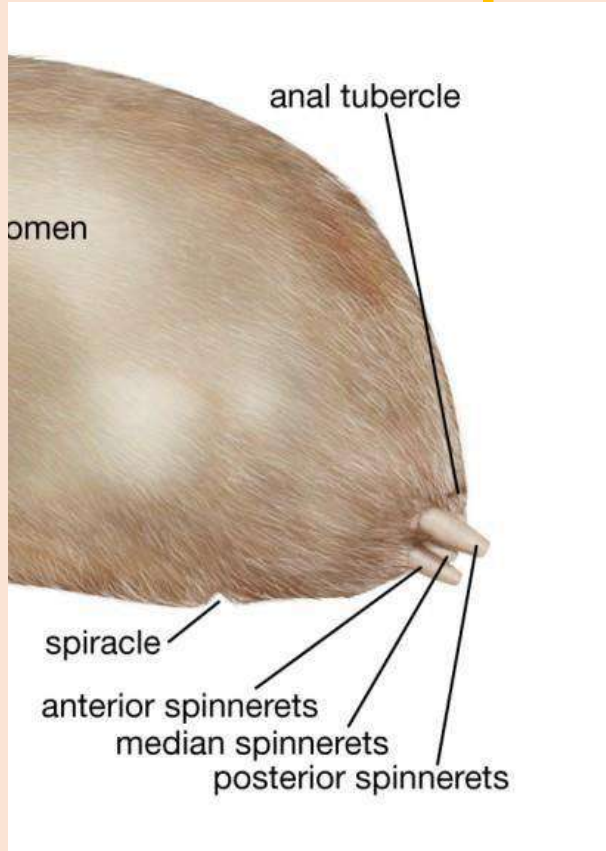
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gland.

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Morphology of spider's Spinnerets



- Each spigot has a valve that controls the thickness and speed of the extruded material. As the spigots pull the fibroin protein molecules out of the ducts and extrude them into the air, the

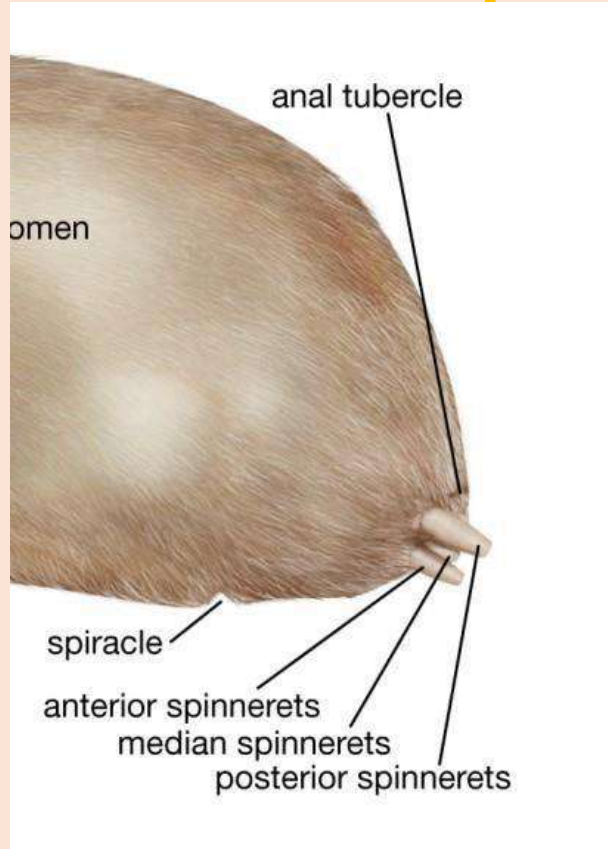
Morphology of spider's Spinnerets

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molecules are stretched out
and
linked together to form long
strands.

Morphology of spider's Spinnerets



for

- The spinnerets wind these strands together to form the sturdy silk fiber.

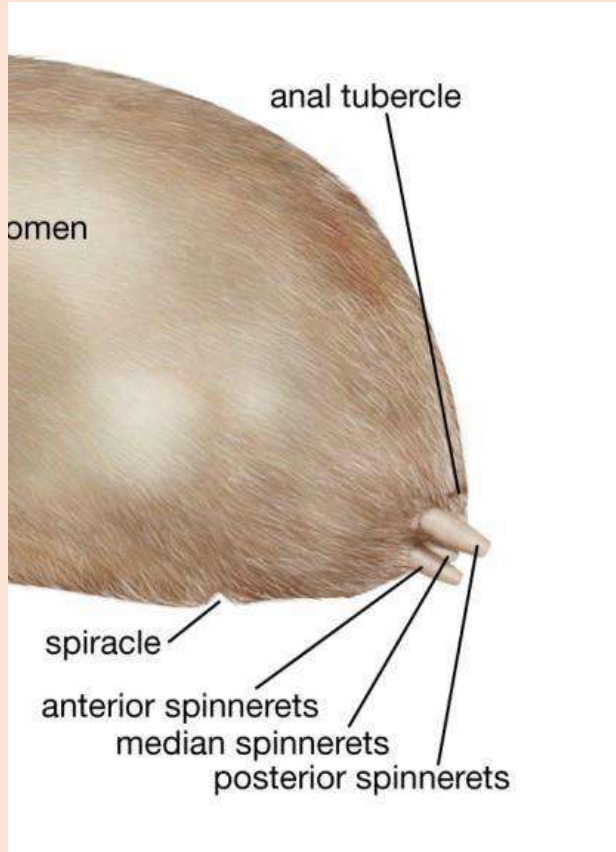
- Most spiders have multiple silk glands, which secrete different types of silk material optimized

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different purposes.

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Morphology of spider's Spinnerets



- Spider silk is incredibly strong and flexible. Five times as strong as an equal mass of steel and twice as strong as an equal mass of Kevlar.
- Elasticity

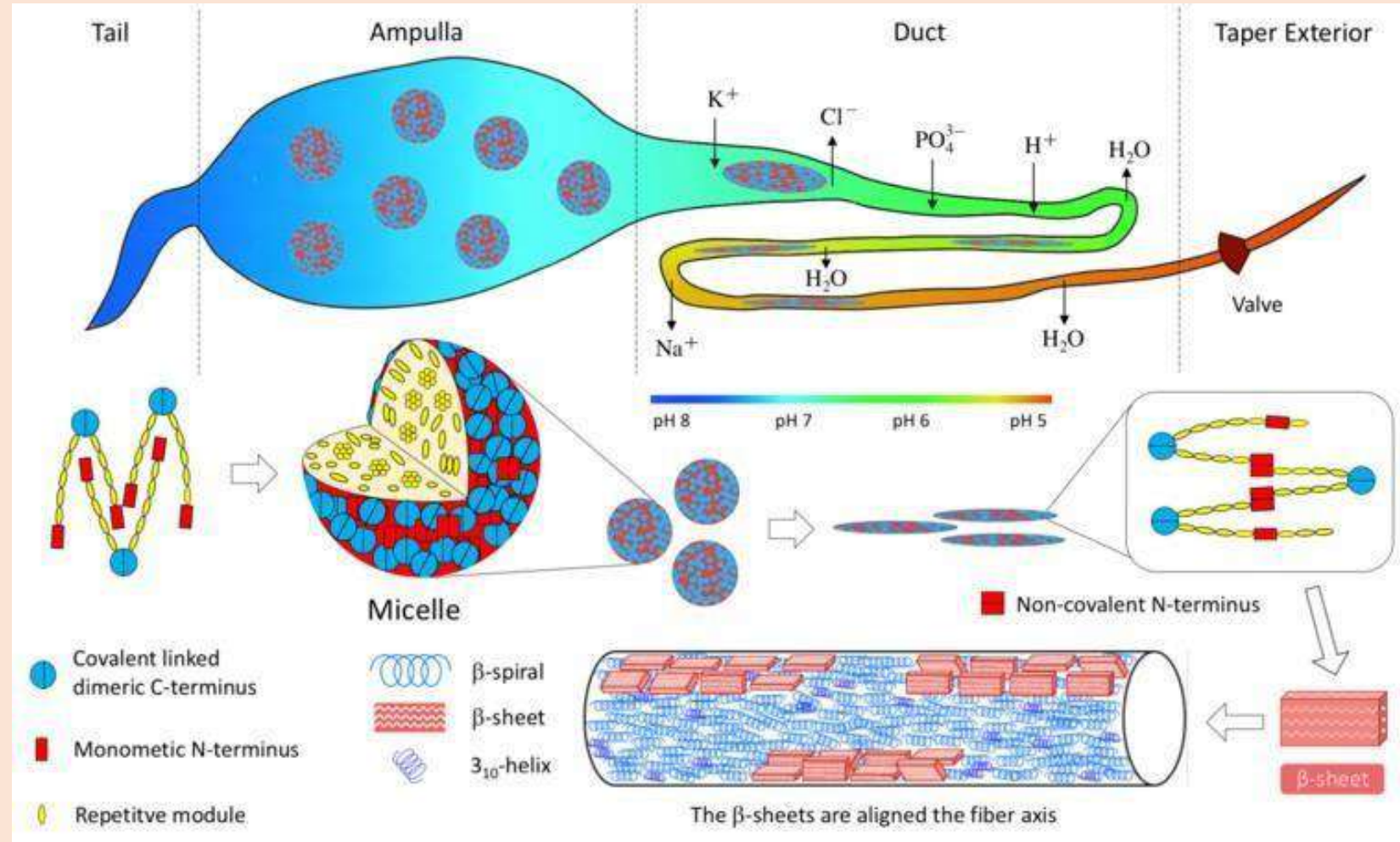
Morphology of spider's Spinnerets

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- Size

- Temperature/PH/uses

Morphology of spider's Spinnerets



Morphology of spider's Spinnerets

https://en.wikipedia.org/wiki/Spider_silk

Module# 141 Introduction to Scorpions



- **Scorpions** are predatory arachnids of the order **Scorpiones**.
- They have eight legs, and are easily recognized by a pair of grasping pincers and a narrow, segmented tail, often carried in a characteristic forward curve over the back and ending with

Introduction to Scorpions



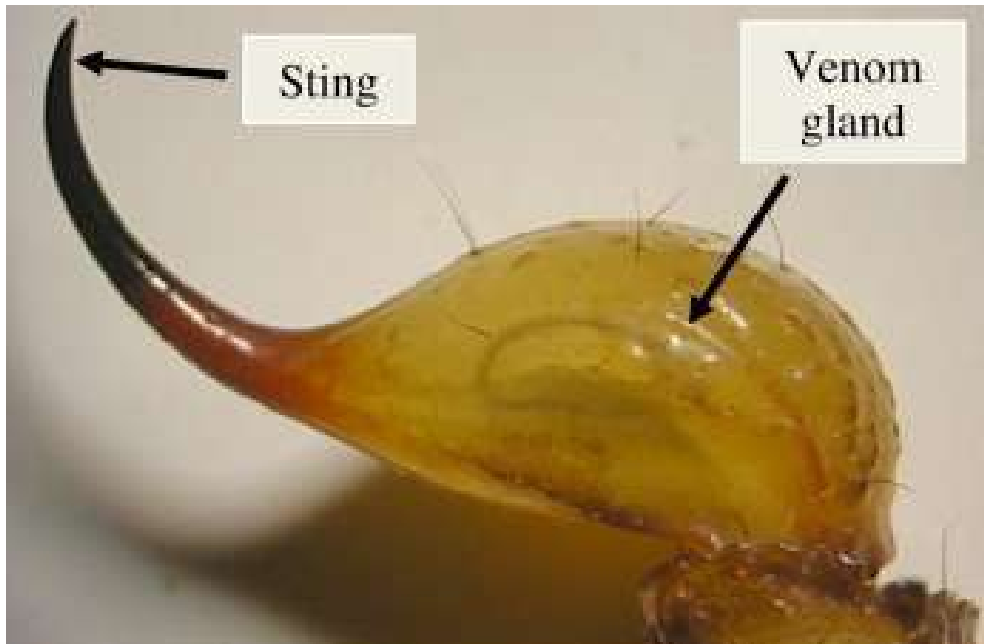
- Scorpions primarily prey on insects and other invertebrates, but some species take vertebrates.
- They use their pincers to restrain and kill prey.

Introduction to Scorpions



- The vast majority of species do not represent a serious threat to humans, and healthy adults usually do not need medical treatment after being stung.
- Poisonous scorpions
- Habitat/desert/Mountains
- Collection/UV/Turning stone/pitfalls

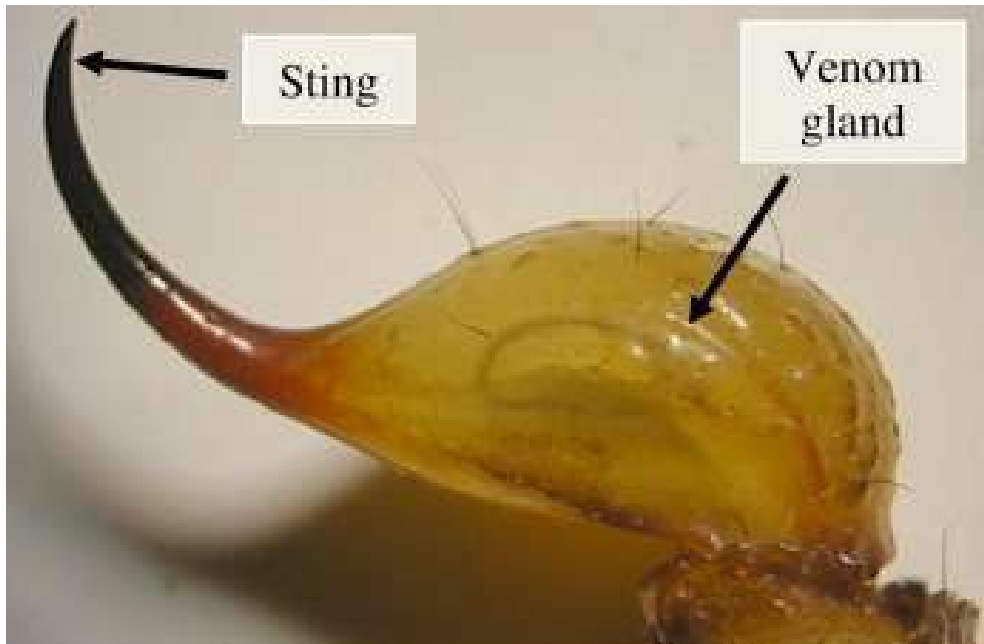
Module# 142 Introduction to Scorpions



- Scorpion bites are highly painful
- Venom peptides
- Type/Long chain/Short chain
- Medical importance/Buthidae
- Treatment of diseases
- Cancer treatment
- Venom price
- Venom collection

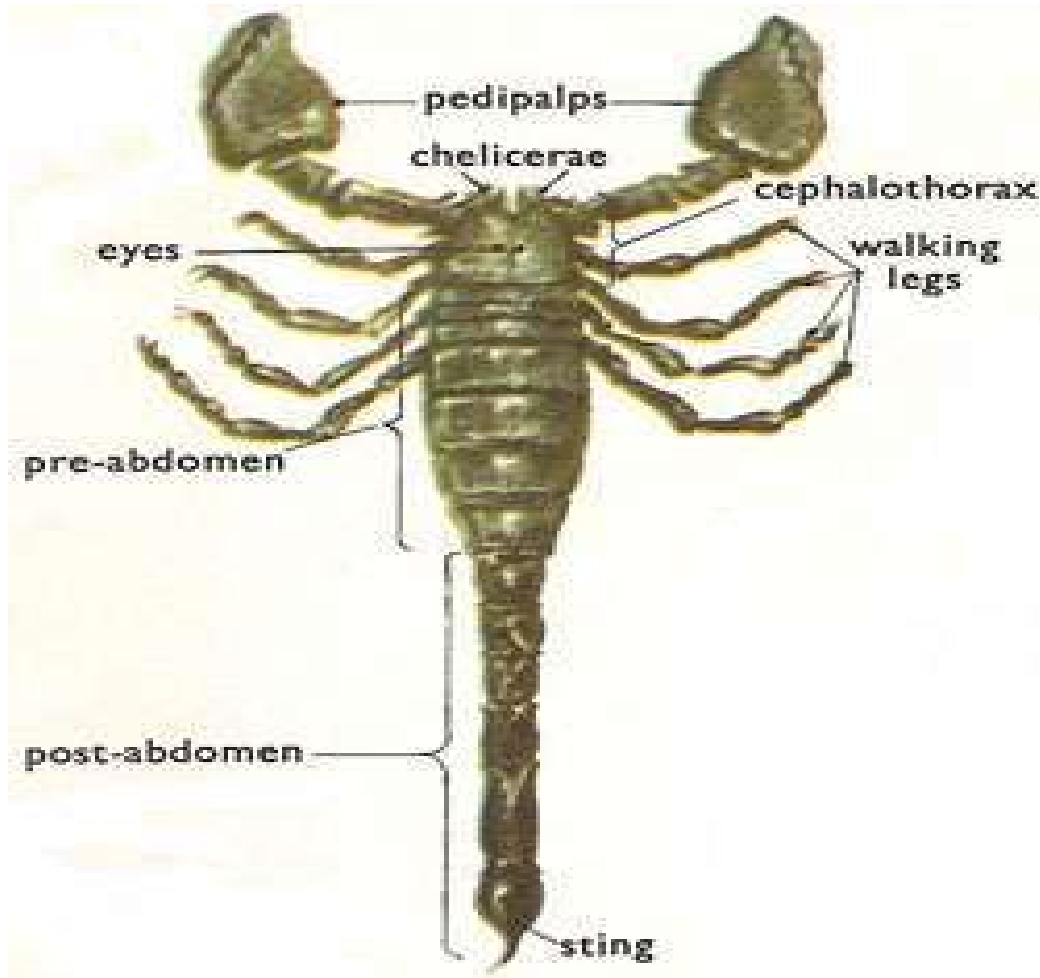
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Introduction to Scorpions



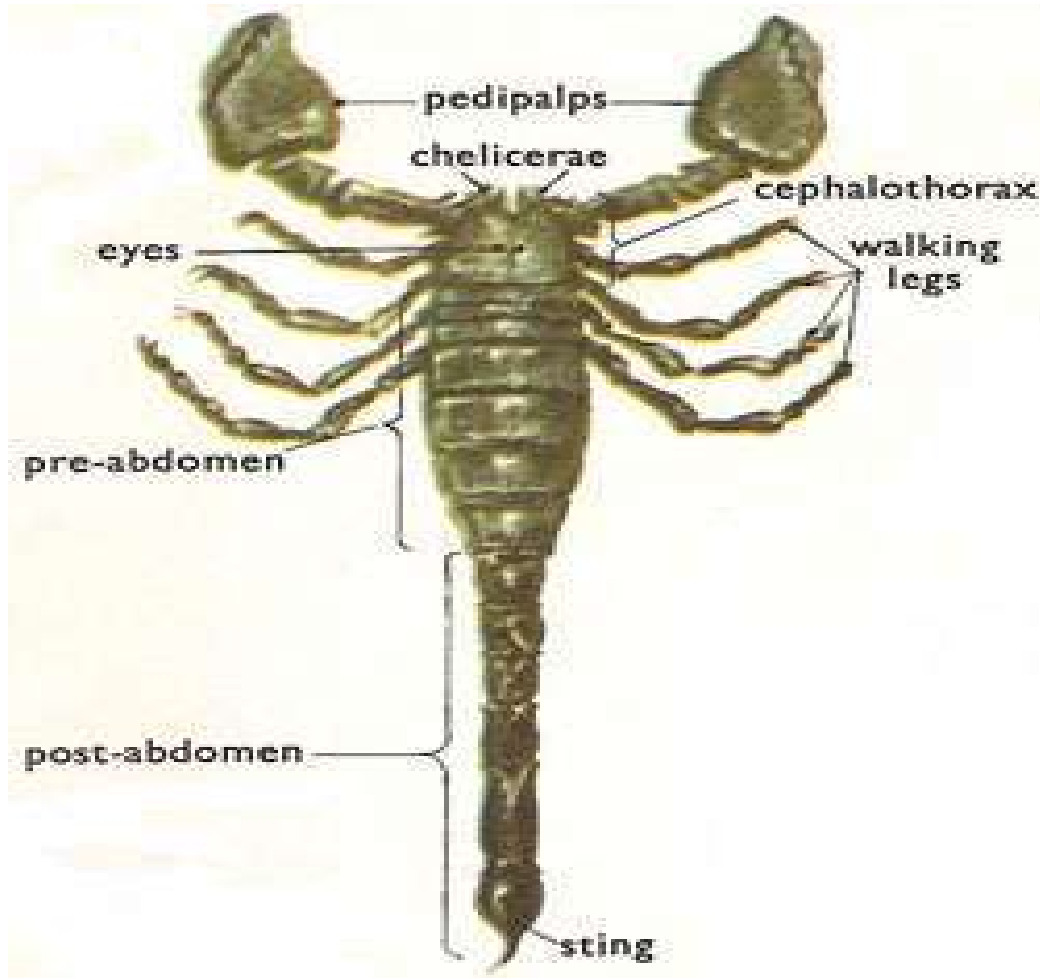
- How to collect venom
- Effect of temperature on venom production
- Amount of venom
- Method of venom collection

Module# 143 Morphology of Scorpions



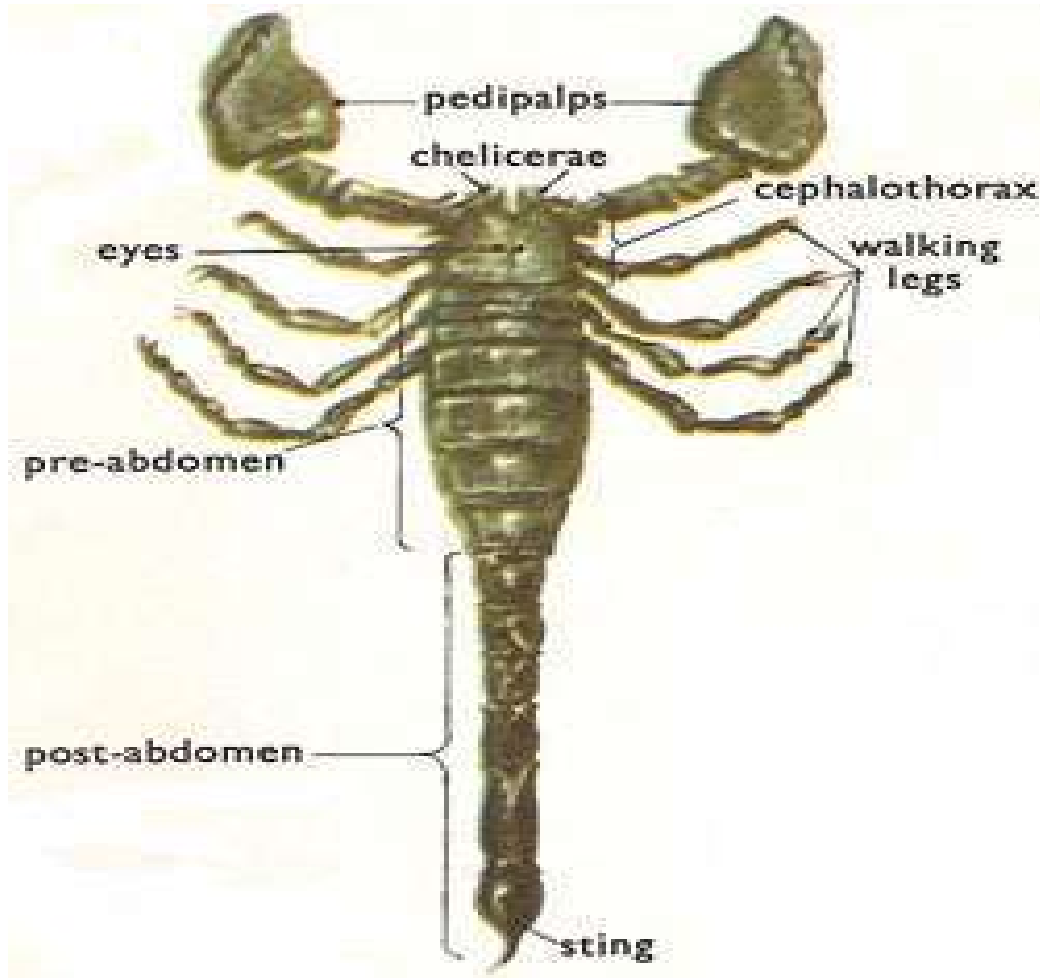
- Cephalothorax
- Padipal
- Chelicera
- Abdomen
- Walking legs
- Sting
- Body is covered with a cuticle consisting of chitin and tanned proteins

Morphology of Scorpions



- 8.5-23mm
- The opisthosoma is subdivided into a broad anterior portion, the mesosoma or pre-abdomen, and a narrow tail-like posterior, the metasoma or post-abdomen.
- Most species are nocturnal.
- Feeding habit/cannibalism

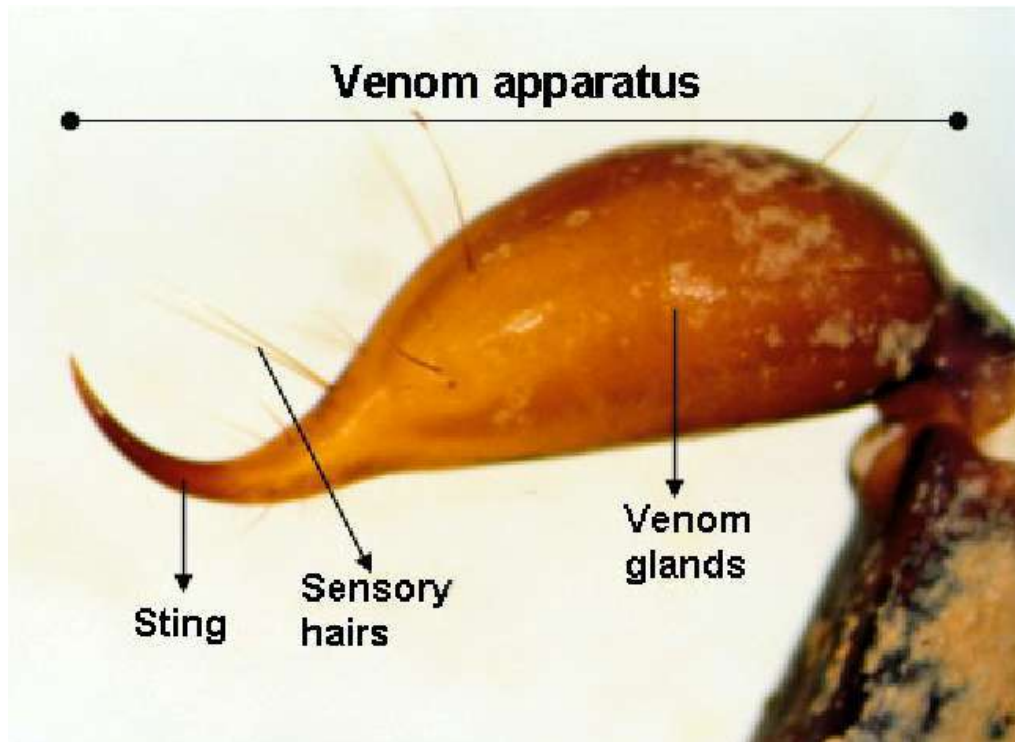
Morphology of Scorpions



<https://en.wikipedia.org/wiki/Scorpion>

- The telson includes the vessicle, which contains a symmetrical pair of venom glands.
- Externally it bears the curved stinger, the hypodermic aculeus, equipped with sensory hairs.
- Abdominal segments These segments have keels, setae and bristles which may be used for

Morphology of Scorpions

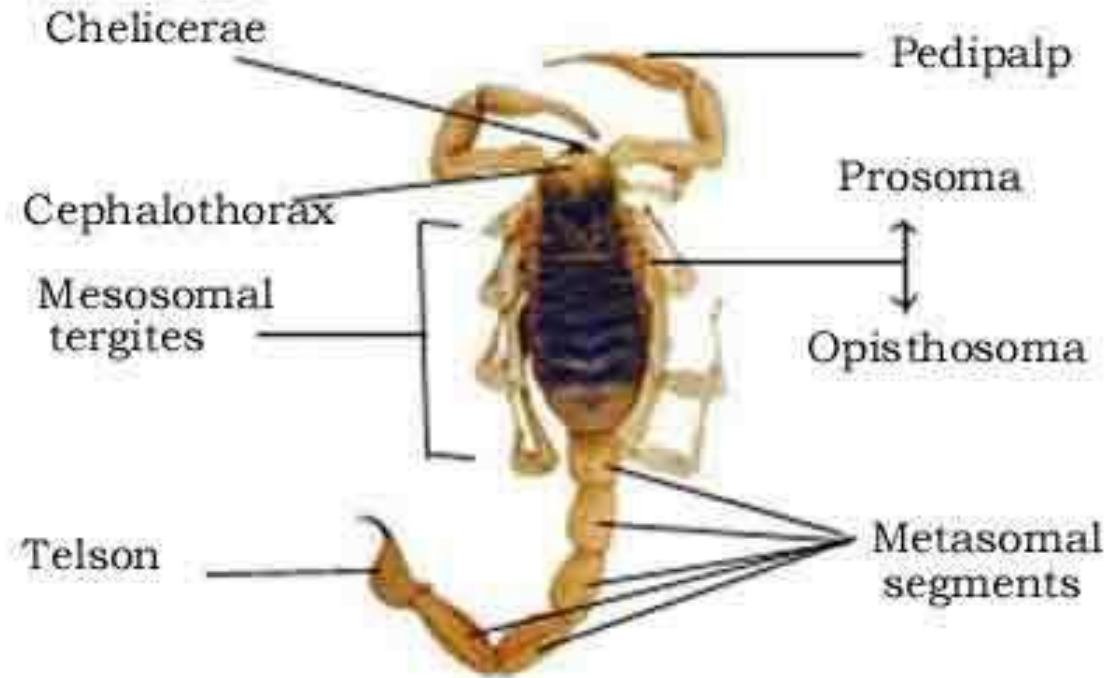


<https://en.wikipedia.org/wiki/Scorpion>

- Each of the venom glands has its own duct to convey its secretion along the aculeus from the bulb of the gland to immediately subterminal of the point of the aculeus.

Morphology of Scorpions

- Parts of scorpion body

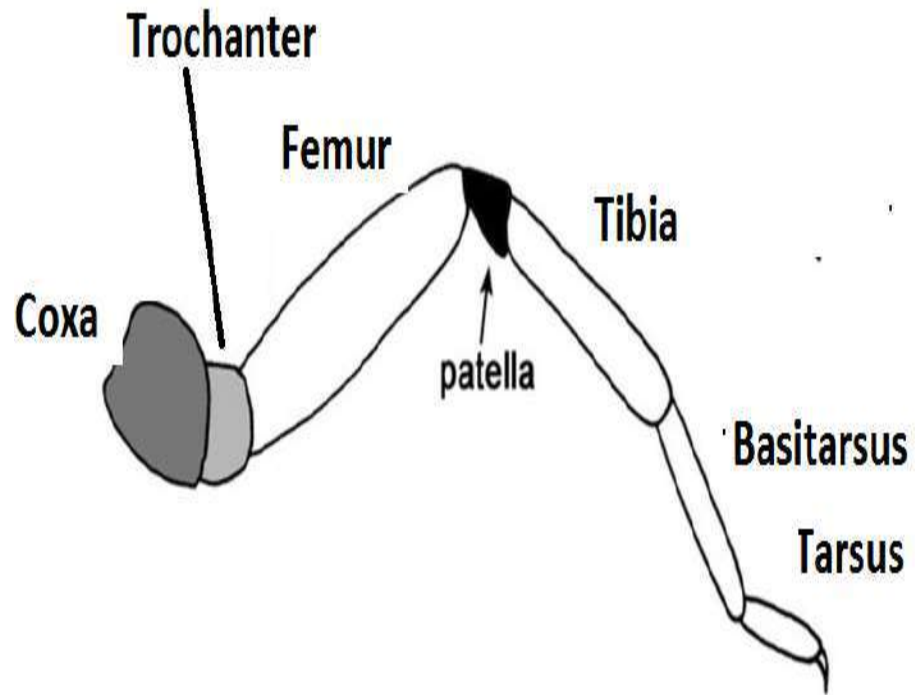


<https://en.wikipedia.org/wiki/Scorpion>

Morphology of Scorpions

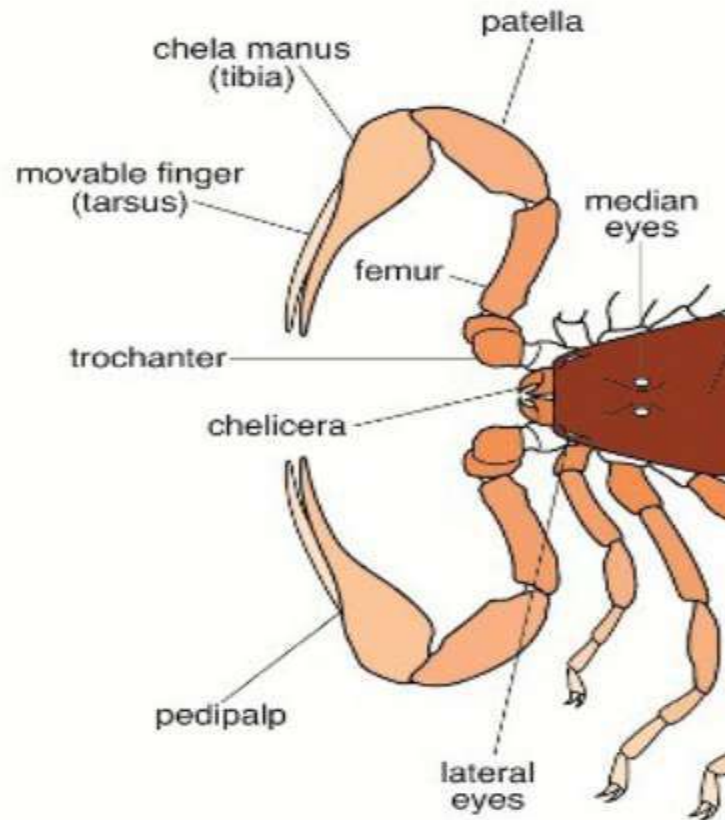
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Module# 144 Morphology of Scorpion Leg



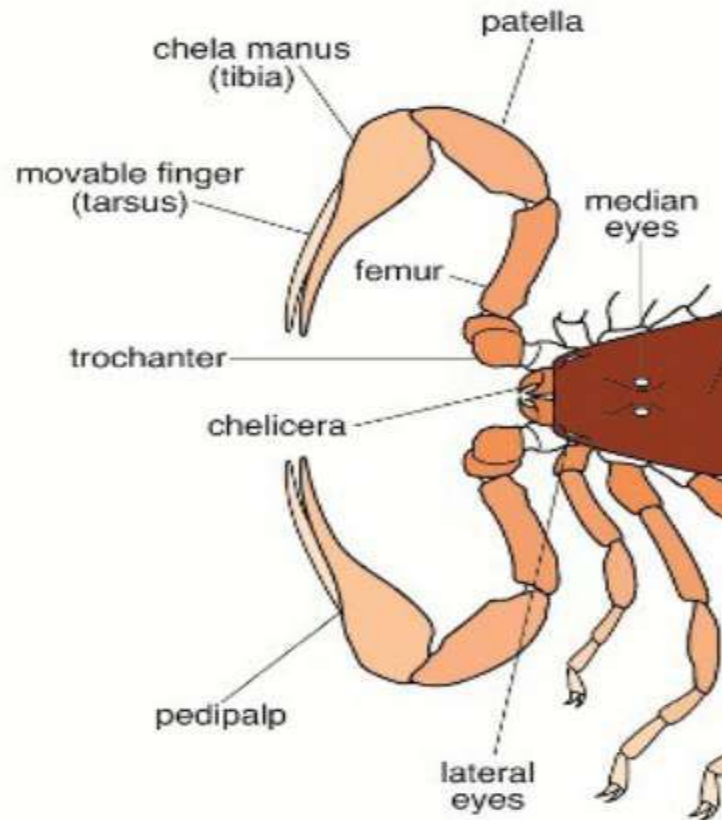
- Four pairs of legs
- Each leg is terminating in a pair of claws.
- A series of trichobothria, the number and positions of which are taxonomically informative, is present on the pedipalp femur, patella, and tibia.

Morphology of Scorpion Leg



- Each chelicera comprises three segments, including a chela manus with fixed finger and a movable finger.
- Each pedipalp comprises a coxa, trochanter, femur, patella, chela manus with fixed finger (tibia), and movable finger (tarsus).

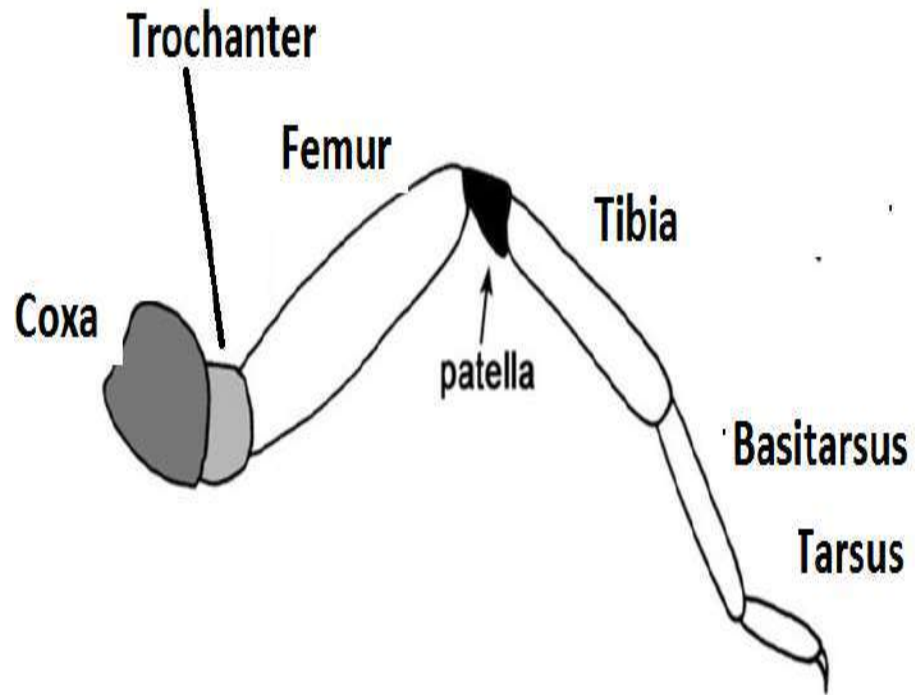
Morphology of Scorpion Leg



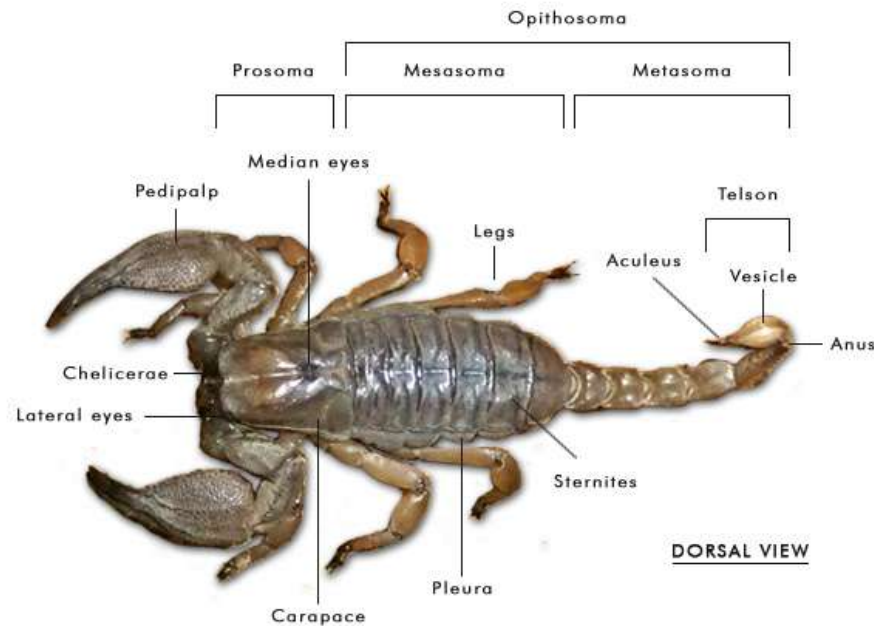
- **Setae** are thick hairs which cover the legs, body, and pedipalps (leg-like mouthparts).
- They are sensitive to the touch.
- Also located on the pedipalps are smaller hairs known as **trichobothria**, which sense air vibrations.

Morphology of Scorpion Leg

- Ground vibrations are sensed by other organs located on the tip of the legs.



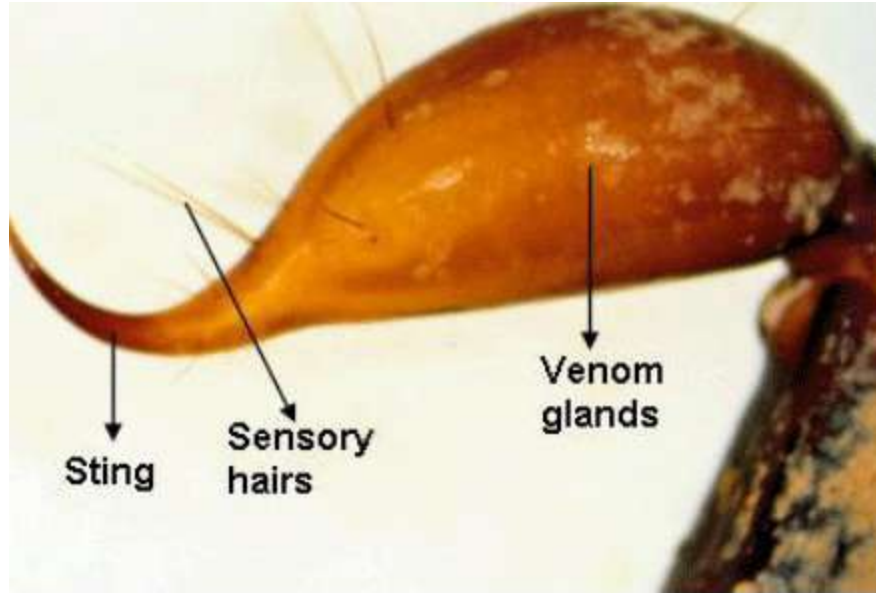
Module# 145 Morphology of Scorpion Telson



https://www.google.com/search?q=morphology+of+scorpion+telson&hl=en&sxsrf=ALeKk00bUZaJahtD8rnr_xX1clbP2SysKw:1609048010091&source=lnms&tbm=isch&sa=X&ved=2ahUKEwiJmcX4u3tAhXmEWMBHYpGCwgQ_AUoAXoECA0QAw&biw=1360&bih=657#imgrc=B-pr-vIW4zl8PM&imgdii=co-WyQk3qjdGRM

- The telson is present in Metasoma.
- Metasoma is also called as post-abdomen.
- The postabdomen includes five metasomal segments, the last of which contains the anus and bears the telson.

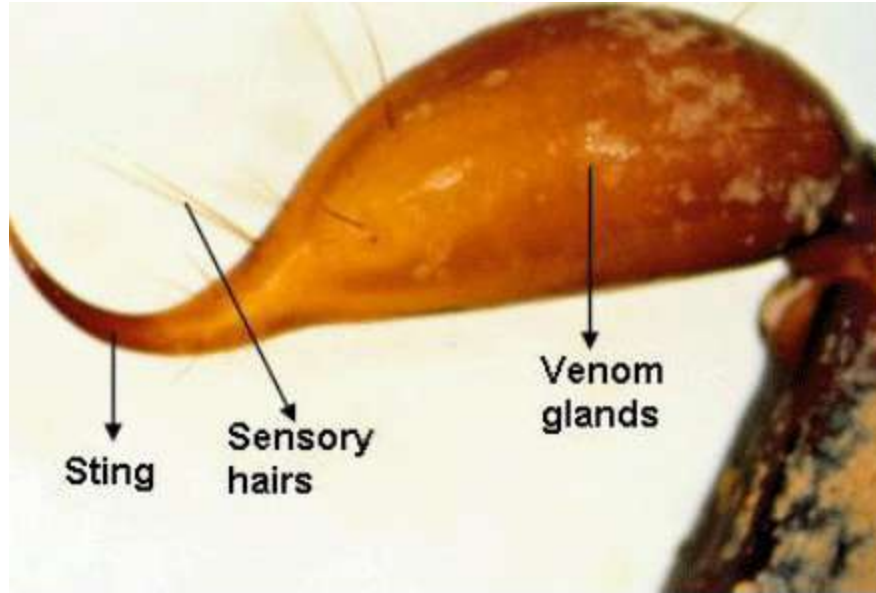
Morphology of Scorpion Telson



- The telson consists of the vesicle, which holds a pair of venom glands, and the hypodermic **aculeus**, the venom-injecting sting.

https://www.google.com/search?q=morphology+of+scorpion+telson&hl=en&sxsrf=ALeKk00bUZaJahtD8rnr_xX1clbP2SysKw:1609048010091&source=lnms&tbm=isch&sa=X&ved=2ahUKEwiJmcX4u3tAhXmEWMBHYpGCwgQ_AUoAXoECA0QAw&biw=1360&bih=657#imgsrc=B-pr-vIW4zl8PM&imgdii=co-WyQk3qjdGRM

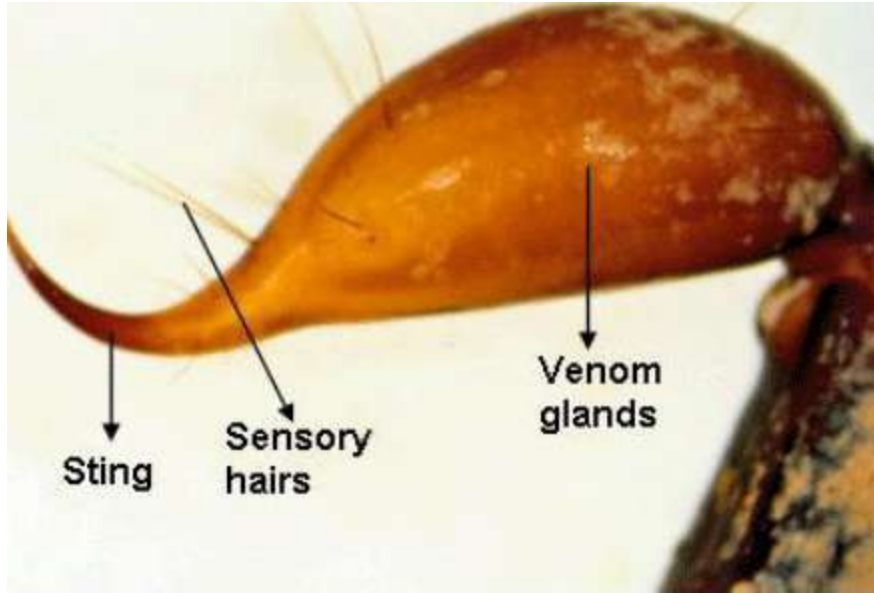
Morphology of Scorpion Telson



https://www.google.com/search?q=morphology+of+scorpion+telson&hl=en&sxsrf=ALeKk00bUZaJahtD8rnr_xX1clbP2SysKw:1609048010091&source=lnms&tbm=isch&sa=X&ved=2ahUKEwiJmcX4u3tAhXmEWMBHYpGCwgQ_AUoAXoECA0QAw&biw=1360&bih=657#imgsrc=B-pr-vIW4zl8PM&imgdii=co-WyQk3qjdGRM

- Each of the venom glands has its own duct to convey its secretion along the aculeus from the bulb of the gland to immediately subterminal of the point of the aculeus, where each of the paired ducts has its own venom pore

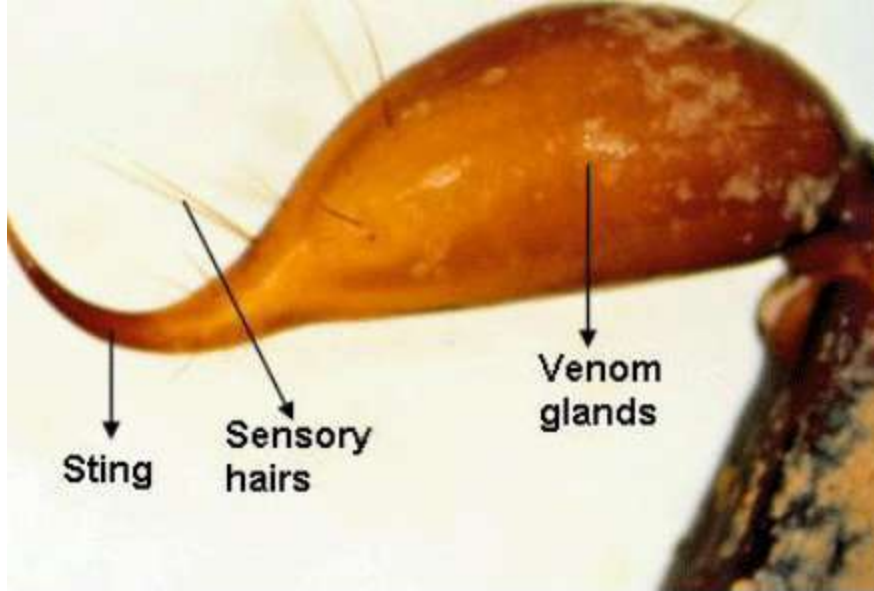
Morphology of Scorpion Telson



https://www.google.com/search?q=morphology+of+scorpion+telson&hl=en&sxsrf=ALeKk00bUZaJahtD8rnr_xX1clbP2SysKw:1609048010091&source=lnms&tbm=isch&sa=X&ved=2ahUKEwiJmcX4u3tAhXmEWMBHYpGCwgQ_AUoAXoECA0QAw&biw=1360&bih=657#imgsrc=B-pr-vIW4zl8PM&imgdii=co-WyQk3qjdGRM

- An **extrinsic muscle system** in the tail moves it forward and propels and penetrates with the aculeus, while an **intrinsic muscle system** attached to the glands pumps venom

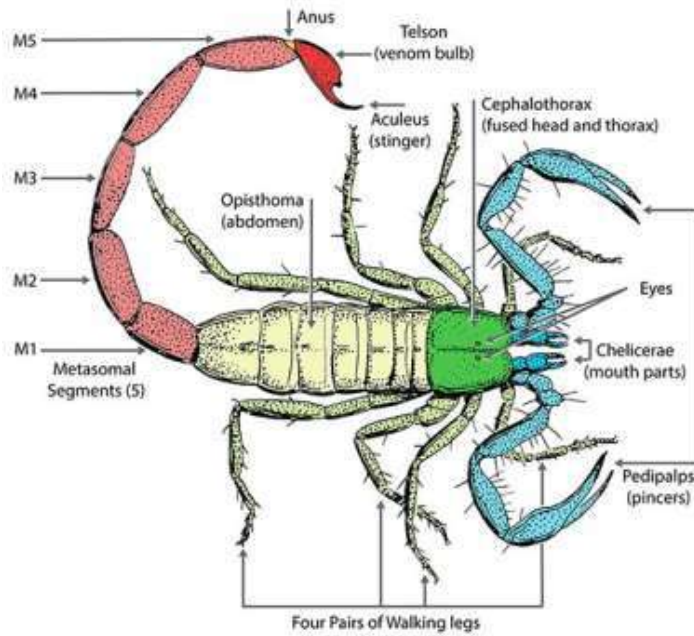
Morphology of Scorpion Telson



- All scorpion species possess venom, which is used to kill or paralyze prey and as a defense against predators.

https://www.google.com/search?q=morphology+of+scorpion+telson&hl=en&sxsrf=ALeKk00bUZaJahtD8rnr_xX1clbP2SysKw:1609048010091&source=lnms&tbm=isch&sa=X&ved=2ahUKEwiJmcX4u3tAhXmEWMBHYpGCwgQ_AUoAXoECA0QAw&biw=1360&bih=657#imgrc=B-pr-vIW4zl8PM&imgdii=co-WyQk3qjdGRM

Module# 146 Morphology of Cheliceræ and Abdomen



https://www.google.com/search?q=cheliceræ+of+scorpion&hl=en&sxsrf=ALeKk038xnnZQit8v9nSosB_7rPe5ABxcQ:1609049933235&source=Inms&tbm=isch&sa=X&ved=2ahUKEwiJxciNwu3tAhXNWxUIHeYLDIUQ_AUoAXoECBoQAw&biw=1360&bih=657#imgsrc=EzHwRyQb55Ah_M

- The cheliceræ of scorpion is present in cephalothorax region.
- They are scorpions jaws.
- Each chelicera comprises three parts a **coxa**, **tibia** which has a fixed finger, and the **tarsus** forming a moveable finger.

Morphology of Chelicerae and Abdomen

https://www.google.com/search?q=chelicerae+of+scorpion&hl=en&sxsrf=ALeKk038xnnZQit8v9nSosB_7rPe5ABxcQ:1609049933235&source=lnms&tbm=isch&sa=X&ved=2ahUKEwiJxcINwu3tAhXNWxUIHeYLDIUQ_AUoAXoECBoQAw&biw=1360&bih=657#imgsrc=ElizabethHwRyQb55Ah_M

Morphology of Chelicerae and Abdomen

- Within the abdomen are the scorpion's respiratory system, which is a set of thin plates called **book lungs**.
- A spiracle leads to each pair of book lungs on each segment.
- The opisthosoma has eight legs arranged into four pairs.

https://www.google.com/search?q=chelicerae+of+scorpion&hl=en&sxsrf=ALeKk038xnnZQit8v9nSosB_7rPe5ABxcQ:1609049933235&source=Inms&tbm=isch&sa=X&ved=2ahUKEwiJxciNwu3tAhXNWxUIHeYLDIUQ_AUoAXoECBoQAw&biw=1360&bih=657#imgrc=EzHwRyQb55Ah_M

Module# 147 Accumulation Curve

Species accumulation curves



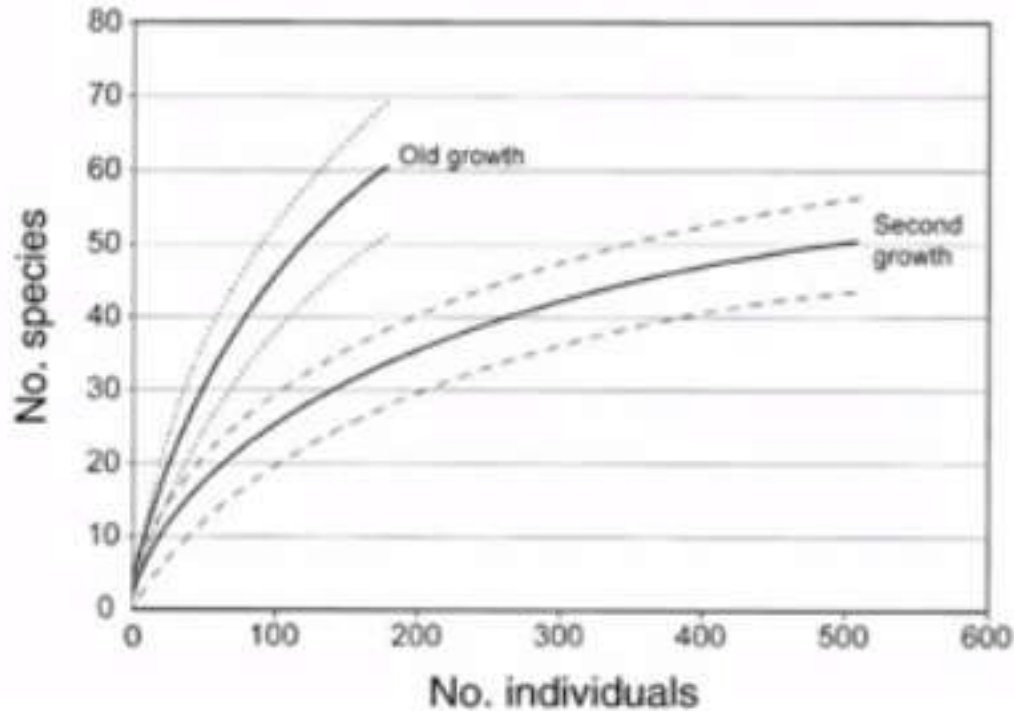
https://www.youtube.com/watch?v=Jj7LYrU_6RA

- The species discovery curve or species accumulation curve is a graph recording the cumulative number of species of living things recorded in a particular environment as a function of the cumulative effort expended searching for them.

Accumulation Curve

<https://besjournals.onlinelibrary.wiley.com/doi/full/10.1046/j.1365-2656.2003.00748.x>

Accumulation Curve



https://www.youtube.com/watch?v=Jj7LYrU_6RA

- Types of accumulation curve
- Importance of accumulation curve
- Accumulation curve vs trapping effort
- Accumulation curve vs trapping method
- Accumulation curve vs biasness

Module# 148 Calculation of Allelic and Genotypic Frequency

$$p + q = 1$$

$$(p + q)^2 = 1$$

$$p^2 + 2pq + q^2 = 1$$

Hardy-Weinberg Equilibrium Model

- P = frequency of Allele A
- q = Frequency of Allele a
- P^2 = Frequency of AA genotype
- $2pq$ = Frequency of Aa genotype
- q^2 = Frequency of aa genotype

Calculation of Allelic and Genotypic Frequency

	AA	Aa	aa	
Individuals	70	80	50	(200)
Genotypic Array	$70/200 = 0.35$	$80/200 = .40$	$50/200 = 0.25$	$= 1$
"A" alleles	140	80	0	$220/400 = 0.55$
'a' alleles	0	80	100	$180/400 = 0.45$

<http://eweb.furman.edu/~wworthen/bio102/evolution219b.htm>

Module# 149 Calculation of Allelic and Genotypic Frequency

Hardy-Weinberg Equilibrium Model

- In a population there are 320AA individuals, 160 heterozygous (Aa) and 20aa individuals.
- Calculate the genotypic and allelic frequencies.

Calculation of Allelic and Genotypic Frequency

Alleles = A, a

Genotypes = AA, Aa, aa

Frequency of allele A: $f(A) = f(AA) + 1/2 f(Aa)$

Frequency of allele a: $f(a) = f(aa) + 1/2 f(Aa)$

Hardy-Weinberg Equilibrium Model

- In a population there are 320AA individuals, 160 heterozygous (Aa) and 20aa individuals.
- Calculate the genotypic and allelic frequencies.

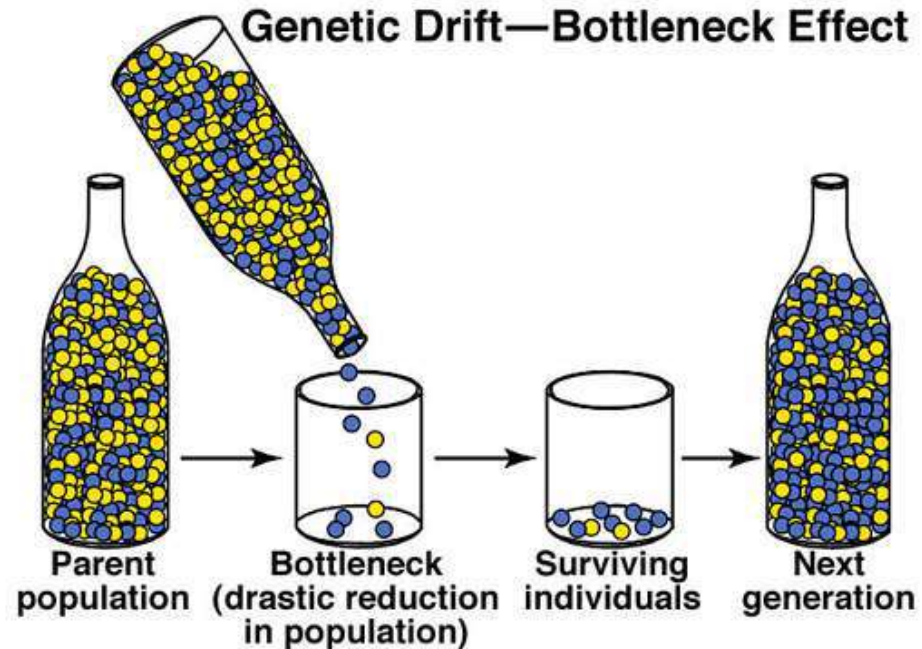
Calculation of Allelic and Genotypic Frequency

Hardy-Weinberg Equilibrium Model

- In a population there are 320AA individuals, 160 heterozygous (Aa) and 20aa individuals.
- Calculate the genotypic and allelic frequencies.

Allelic Frequencies	
A	$320+320+160/1000 = 0.8$
a	$160+40/1000 = 0.2$

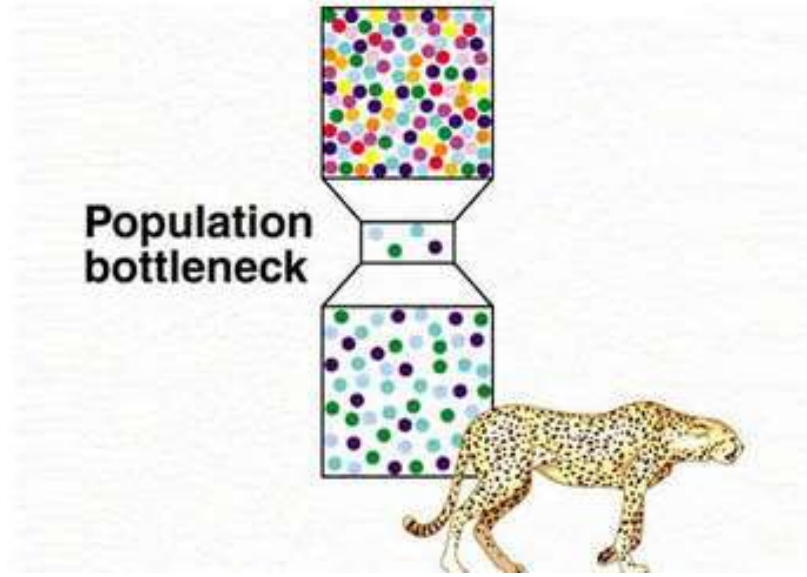
Module# 150 Genetic Drift and its impact on Allele Frequency



https://www.google.com/search?q=genetic+drift&tbm=isch&ved=2ahUKEwjVurHI-evtAhVPw4UKHYbCBvoQ2-cCegQIABAA&oeq=genetic+&gs_lcp=CgNpbWcQARgAMgQIABBDmgQIABBDmgQIABBDmgQIADICCAyAggAMgIADICCAyAggAMgIADoFCAAQsQM6BAgjECc6BwgAELEDEENQ3KsjWNe6I2D6zCNoAHAAeACAAfUDiAGCE5IBCTItNi4wLjEuMZgBAKABAaoBC2d3cy13aXotaW1nwAEB&scient=img&ei=BVXnX5WkA8-GlwSGhZvQDw&bih=657&biw=1360#imgsrc=bg-AkcfJaUxBGM

- Change in allele frequency which occur by chance.
- Loss in alleles
- Loss in genetic diversity
- Lost genes for ever
- Bottle neck effect
- Unique genes
- Examples

Genetic Drift and its impact on Allele Frequency



https://www.google.com/search?q=genetic+drift&tbm=isch&ved=2ahUKEwjVurHI-
evtAhVPw4UKHYbCBvoQ2-
cCegQIABAA&eq=genetic+&gs_lcp=CgNpbWcQARgAMgQIABBDMgQIABBDMgQIABBD
MgIIADICCAyAggAMgIIADICCAyAggAMgIIADoFCAAQsQM6BAgjECc6BwgAELEDEENQ
3KsjWNNe6l2D6zCNoAHAAeACAfUDiAGCE5IBCTItNi4wlJEUmZgBAKABAAoBC2d3cy13ax
otaW1nwAEB&scient=img&ei=BXNnX5WkA8-
GlwSGhZvQDw&bih=657&biw=1360#imgsrc=bg-AkcfJaUxBGM

- Change in allele frequency which occur by chance.
- Loss in alleles
- Loss in genetic diversity
- Lost genes for ever
- Bottle neck effect
- Unique genes
- Examples

Module# 151 Principles of Systematics

Concept of Fitness

Concept of fitness

Genetic Load = Max. fit individual - Ave. fitness of population

Genetic Load = $9 - 6 = 3$

- Survival+ reproductive success
- Relative fitness
- Ideal population
- Maximum value of fitness
- Genetic load/Genetic burden
- Population with high load
- Population with low load
- Variability in fitness

Module# 152 Taxonomic publications

- No taxonomic study is complete until its results are published.
- Advances in any area of science is made through publications.
- Taxonomic publications range from short description of species (may be one page) to monograph or handbook (several volumes)

Taxonomic publications

Kinds of publications

- Short research paper
- Synopsis & Reviews
- Revisions
- Monographs
- Faunal/Floral Work
- Field guide/Manuals
- Catalogues & Check lists

- They are ordinary descriptive papers of new species, subspecies or combined all of these or some.
- May or may not contain key for identification.
- May contain a brief check list.

Taxonomic publications

Kinds of publications

- Short research paper
- Synopsis & Reviews
- Revisions
- Monographs
- Faunal/Floral Work
- Field guide/Manuals
- Catalogues & Check lists

- They are brief summaries of current knowledge of a group.
- Not necessary to include new material or new interpretations.
- Such work bring scattered work together
- Helpful for Revisionary or monographic work.

Module# 153 Taxonomic publications

Kinds of publications

- Short research paper
- Synopsis & Reviews
- Revisions
- Monographs
- Faunal/Floral Work
- Field guide/Manuals
- Catalogues & Check lists

- Revisions are representations of new material or new interpretations that have been integrated with previous knowledge with brief summaries i.e.
- Restudy of complete unit of particular group of Taxa.

Taxonomic publication

Kinds of publications

- Short research paper
- Synopsis & Reviews
- Revisions
- Monographs
- Faunal/Floral Work
- Field guide/Manuals
- Catalogues & Check lists

- Revisions usually include super families, families or part of families.
- It can also deal with genus or species.
- Generic revision
- Species revision

Taxonomic publications

Kinds of publications

- Short research paper
- Synopsis & Reviews
- Revisions
- Monographs
- Faunal/Floral Work
- Field guide/Manuals
- Catalogues & Check lists

- It include re-description or diagnosis of little known taxa, list of synonymy, new names along with keys.

Taxonomic publications

Kinds of publications

- Short research paper
- Synopsis & Reviews
- Revisions
- Monographs
- Faunal/Floral Work
- Field guide/Manuals
- Catalogues & Check lists

- A comprehensive systematic study of a particular taxonomic group.
- Always taxon-based, not geography-based.
- Its preparations require more complete material than other types of publications.

Taxonomic publications

Kinds of publications

- Short research paper
- Synopsis & Reviews
- Revisions
- Monographs
- Faunal/Floral Work
- Field guide/Manuals
- Catalogues & Check lists

- 3-5 years for completion.
- Monographs try to review all the facts about a taxonomic group.
- A **Monograph** is a complete global account of a **taxon** of any rank – family, genus or species at a given time.
- Book format

Taxonomic publications

- They show comprehensive characters of animals in picture form.
- Purpose of atlases are purely taxonomic
- Very helpful taxonomist for identification
- Comparison of species

Module# 154 Taxonomic publications

- It deals with detail description faunal/Floral work of particular region.
- It may include information on geographical distribution.
- Also include quantitative data and ecological comments.
- Only experience specialists.

Taxonomic publications

- Example: Atlas of scale insects of North America
- Some works are done by taxonomists for non-taxonomists to help them identify common animals.
- Include easy and understandable simple key characters.

Taxonomic publications

- Manuals are also written in simple language.
- For students and layman

Taxonomic publications

- A catalogue is an index to taxa arranged in such a way to give a vivid picture of references for both zoological and nomenclature purpose:
- Catalogue contain following information:

Taxonomic publications

- Catalogue contain following information:
- The original description reference
- Later references
- Type locality
- Depository detail
- Type of genus

Taxonomic publications

- Taxa are written alphabetically
- Merits depends on completeness
- Its preparation is tedious job
- Useful to know many species/genera are reported from particular area.

Module# 155 Parts of thesis & Research paper

Thesis

- Abstract/Summary
- Introduction
- Review of literature
- Materials and Methods
- Results
- Discussion
- References

Parts of thesis & Research paper

Research paper

- Abstract
- Introduction
- Materials and Methods
- Results
- Discussion
- Acknowledgements
- References

END

Module# 156 Parts of thesis & Research paper

Parts of references

- Name of authors
- Year of publication
- Title/topic of article
- Name of Journal
- Volume number
- Issue number
- Page number

Parts of thesis & Research paper

Pakistan J. Zool., vol. 41(2), pp. 85-93, 2009.

Effects of Different Management Practices and Field Margins on the Abundance of Ground Spiders in Rice Ecosystems

Hafiz Muhammad Tahir

Department of Zoology University of the Punjab Lahore, Pakistan

Reference in Text

- Spider is carnivorous animal
(Tahir, 2009)
- Spider is carnivorous animal
(Tahir and Butt, 2009)

Parts of thesis & Research paper

Reference in Text

- Spider is carnivorous animal
(Sherawat et al., 2009)
- Spider is carnivorous animal
(Tahir, 2008; Tahir, 2012;
Sherawat et al., 2009)

Parts of thesis & Research paper

Reference in Text

- Spider is carnivorous animal
(Sherawat et al., 2009^a)
- Spider is carnivorous animal
(Sherawat et al., 2009^b)

Module# 157 How to write References

Full reference

- Serawat, S.M., Butt, A. and Tahir, H.M., 2009. Effect of pesticides on agrobiont spiders in laboratory and field. Pakistan Journal of Zoology, 42 (4): 120-129.

How to write references

Full reference

- Butt, A. and Tahir, H.M., 2009.
Effect of pesticides on agrobiont
spiders in laboratory and field.
Pakistan Journal of Zoology, 42
(4): 120-129.

How to write References

Reference

- Tahir, H.M., 2009. Effect of pesticides on agrobiont spiders in laboratory and field. Thesis submitted to University of the Punjab, Lahore, Pakistan.

How to write References

Reference of Thesis

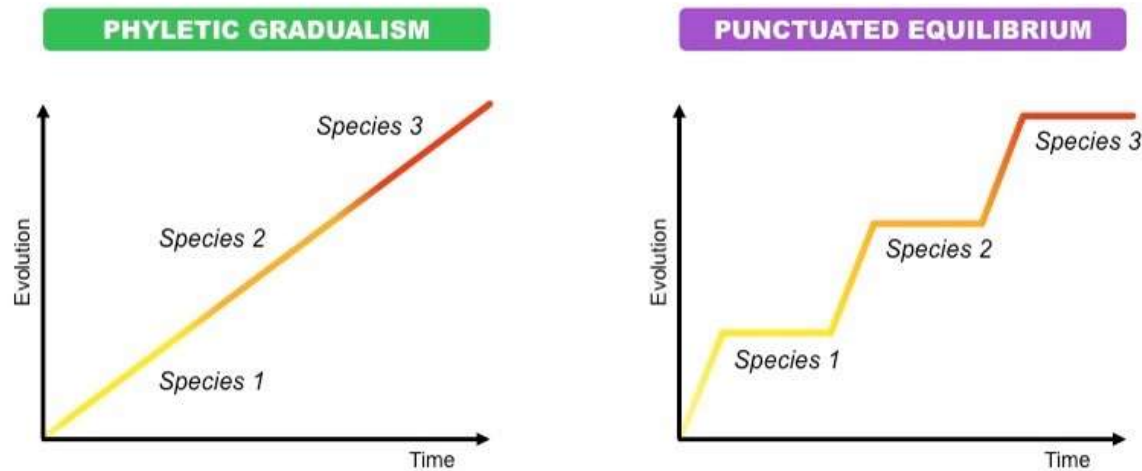
- Tahir, H.M., 2009. Effect of pesticides on agrobiont spiders in laboratory and field. Thesis submitted to University of the Punjab, Lahore, Pakistan.

How to write References

Reference of Book

- Tahir, H.M., 2009. Effect of pesticides on agrobiont spiders in laboratory and field. Oxford University press, England. Pages. 120-129.

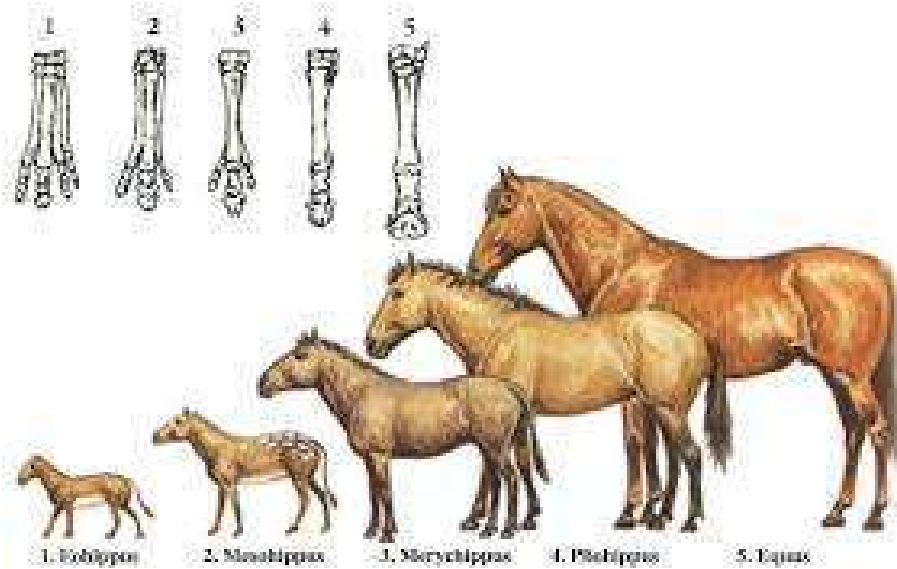
Module# 158 Phyletic Gradualism Vs Punctuated Equilibrium



Phyletic gradualism

- Evolution is a continuous process
- Bring small variation to particular species
- Occurred over a long period of time
- Describe as slow process
- Not proven by fossil record

Phyletic Gradualism Vs Punctuated Equilibrium

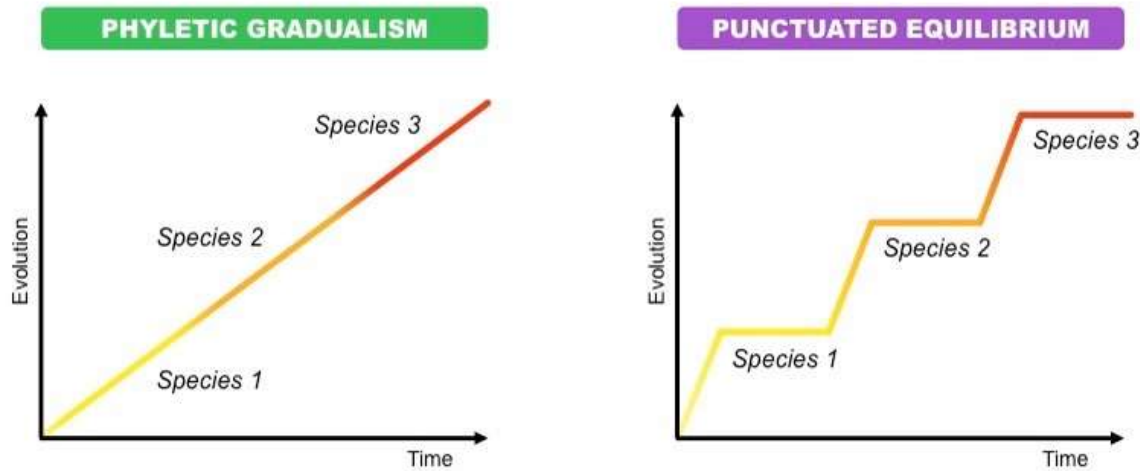


https://www.google.com/search?q=evolution+of+horses&sxsrf=ALeKk02aH8tIJqhmp23ipjOZarZGrJkUhA:1609052837923&source=lnms&tbm=isch&sa=X&ved=2ahUKEwig1tD2zO3tAhV-UxUIHTvEDe4Q_AUoAXoECB4QAw&biw=1360&bih=657

Phyletic gradualism

- It is natural theory of natural selection.
- Small changes are passed from one generation to other generation.
- Horses 50 million years (from small to model day horse)

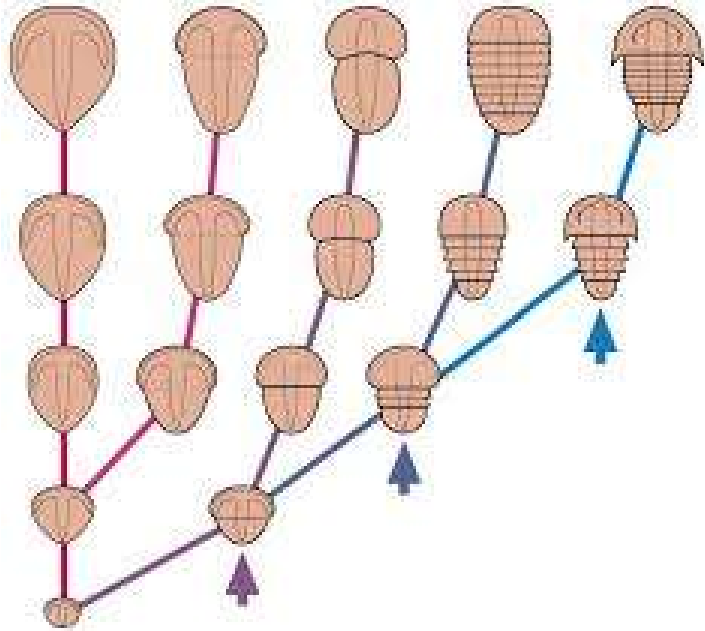
Phyletic Gradualism Vs Punctuated Equilibrium



Punctuated Equilibrium

- Evolution is not a continuous process/fast at one time and slow at other time
- Caused consistent and accumulative changes
- Occurred within short period of time

Phyletic Gradualism Vs Punctuated Equilibrium



Punctuated Equilibrium

- Better model to describe species
- Evolution of Trilobites

https://www.google.com/search?q=evolution+of+trilobites&tbm=isch&ved=2ahUKEwjY7rH5zO3tAhUQ4oUKHUqKCnIQ2-cCegQIABAA&oq=evolution+of+trilobites&gs_lcp=CgNpbWcQAzICCAAyBAGAEBg6BAGjECc6BAGAEENQ_bkFWIzzBWCH9QVoAHAAeACAACQCiAHwK5IBBjltMTkuM5gBAKABAaoBC2d3cy13aXotaW1nwAEB&scient=img&ei=qzLoX5jtKpDElwTKIKqQBw&bih=657&biw=1360

Module# 159 Adaptation

- Adaptation refers to all the structural, functional and behavioral characteristics that enhance the organism's reproductive success in its natural environment.

Adaptation

Examples

- **Frogs:** Have adapted to freezing temperatures by evolving a glycol like substance in their bloodstreams - like antifreeze.
- **Bats:** Have adapted their hearing to hunt at night via sonic response.

Adaptation

- **Butterflies:** non toxic ones have adapted to look like their more poisonous cousins.
- **A behavioral adaptation** in the oceans is the use of loud, low-frequency calls by fin whale to communicate with other whales over great distances.

-

Adaptation

- **One physical adaptation** used in the intertidal zones is a crab's hard shell, which protects it from predators, drying out and being crushed by waves.

Module# 160 Taxonomy and Ecology of spiders

- Spiders are poisonous, predacious and fluid feeding carnivorous animals.
- They are found all over the world.
- Body is divided into two main divisions (Prosoma and Opisthosoma)
- Connected by pedicel

Taxonomy and Ecology of spiders

Phylum **Arthropoda**

Sub-Phylum **Chelicerata**

Class **Arachnida**

- Prosoma is dorsally covered by carapace
- Ventrally covered by two chitinous plates (small labium and large sternum)
- Prosoma bears eyes and six pair of appendages
- Chelicerae are provided with poisonous gland
- Four walking legs having 7 segments

Taxonomy and Ecology of spiders

Phylum **Arthropoda**

Sub-Phylum **Chelicerata**

Class **Arachnida**

- Opisthosoma contains spinnerets, Female genital organ, book lungs
- May be nocturnal or diurnal
- Wolf spiders chase their prey
- Sit and wait predators
- Jumping spiders has largest eyes and keenest vision
- Crab spiders lurk among flower petals and fallen flowers, in wait of prey

Taxonomy and Ecology of spiders

Phylum **Arthropoda**

Sub-Phylum **Chelicerata**

Class **Arachnida**

- Mostly feed on insects
- Survive without food for many months
- Only few species are dangerous to man (i.e. Latrodectus)
- Power of regeneration (leg)
- Sexual dimorphism (male smaller)

Taxonomy and Ecology of spiders



- Female suck body sap of male after mating
- Some species carry cocoon on the back of abdomen

Module# 161 Taxonomy and Ecology of Lady beetle

- Ladybugs, also called lady beetles or ladybird beetles, are a very beneficial group.
- They are natural enemies of many insects, especially aphids and other sap feeders.
- A single lady beetle may eat as many as 5,000 aphids in its lifetime.

Taxonomy and Ecology of Lady beetle



<https://entomology.ca.uky.edu/ef105>

- Adult lady beetles have very characteristic convex, hemispherical to oval shaped bodies that can be yellow, pink, orange, red, or black, and usually are marked with distinct spots.
- This is a type of **warning coloration** to discourage other animals that may try to eat them.

Taxonomy and Ecology of Lady beetle



<https://entomology.ca.uky.edu/ef105>

- Like many other brightly-colored insects, they are protected by an odorous, **noxious fluid that seeps out of their joints** when the insects are disturbed.

Taxonomy and Ecology of Lady beetle



<https://entomology.ca.uky.edu/ef105>

- Adult females usually lay clusters of eggs on plants close to aphid, scale, or mealybug colonies.
- The alligator-like larvae are also predators.

Taxonomy and Ecology of Lady beetle



<https://entomology.ca.uky.edu/ef105>

- The alligator-like larvae are also predators.
- They are spiny and black with bright spots.
- Although they look dangerous, lady beetle larvae are quite harmless to humans.
- After feeding on insect prey for several weeks, the larva pupates on a leaf.

Taxonomy and Ecology of Lady beetle



<https://entomology.ca.uky.edu/ef105>

- Some lady beetle species have several generations each year while others have only one.
- During the summer months, all stages often can be found at the same time.
- Adults of some species spend the winter clustered together in large groups under leaf litter, rocks, or other debris.

Taxonomy and Ecology of Lady beetle



<https://entomology.ca.uky.edu/ef105>

- Important biological control agents
- Should be conserved
- Learn to recognize the different stages of these beneficial insects.
- Make insecticide applications only when necessary and use selective insecticides or limited treatments to avoid killing lady

Taxonomy and Ecology of Lady beetle



<https://entomology.ca.uky.edu/ef105>

- Important biological control agents
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Taxonomy and Ecology of Lady beetle



<https://entomology.ca.uky.edu/ef105>

- Birds are ladybugs' main predators, but they also fall victim to frogs, wasps, spiders, and dragonflies.
- Ladybugs are happy in many different habitats, including grassland, forests, cities, suburbs, and along rivers.

Taxonomy and Ecology of Lady beetle



<https://entomology.ca.uky.edu/ef105>

- Highly susceptible to pesticides
- Ladybugs are most active from spring until fall. When the weather turns cold, they look for a warm, secluded place to hibernate, such as in rotting logs, under rocks, or even inside houses. These hibernating colonies can contain thousands of ladybugs.
- 5000 species/different consumption rate

Module# 162 Taxonomy and Ecology of Green lacewing

- Green lacewings are an often under-appreciated group of beneficial insects.
- As with lady beetles, these natural enemies are important predators of many types of soft bodied insects and insect eggs.

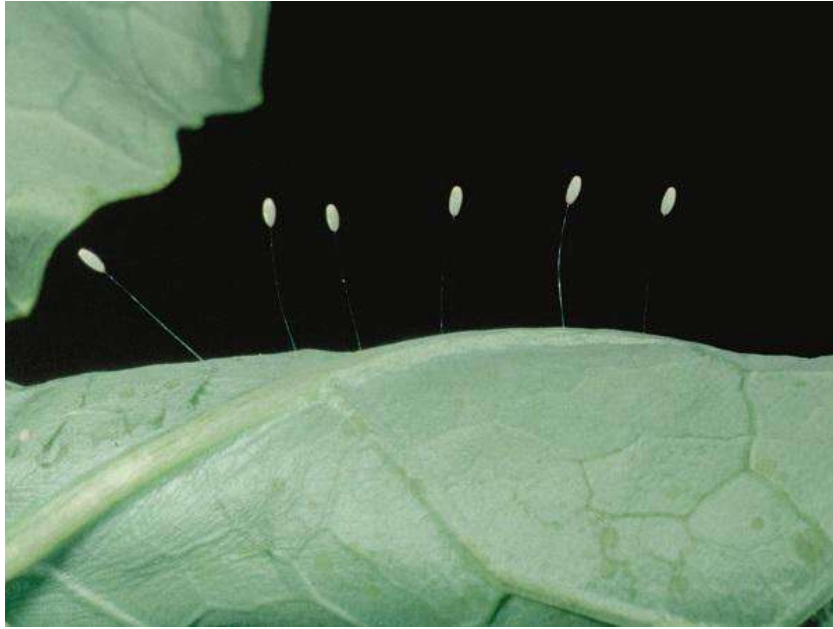
Taxonomy and Ecology of Green lacewing



<https://entomology.ca.uky.edu/ef105>

- The adult green lacewing is about 3/4 inch long, light green and has a delicate appearance with lacy wings.
- One unusual characteristic are its eyes, they look like two golden hemispheres.
- They are weak fliers and are commonly found near aphid colonies.

Taxonomy and Ecology of Green lacewing



<https://entomology.ca.uky.edu/ef105>

- The **adults feed** mostly on nectar, pollen, and honeydew but with some species the adults will feed on insects.
- The eggs are either laid singly or in small groups. Each is always found perched on the tip of a hairlike stalk that is about 1/2 inch long.
- This helps to reduce cannibalism of the eggs by sibling larvae.

Taxonomy and Ecology of Green lacewing



<https://entomology.ca.uky.edu/ef105>

- Females will usually deposit the egg close a food source for the larvae.
- The larvae are brown and white and may grow up to about 1/2 inch in length.
- Larvae are called aphidlions, because they feed on other soft-bodied insects as well as aphids.
- They are voracious feeders, attacking with large, curved, hollow mandibles.

Module# 163 Taxonomy and Ecology of Stink bug



- **Pentatomidae** is a family of insects belonging to the order Hemiptera, generally called **shield bugs** or **stink bugs**.
- Pentatomidae has over 4700 species
- Have piercing sucking mouthparts
- Most are phytophagous, severe pests on agricultural crops.

Taxonomy and Ecology of Stink bug

- However, some species, particularly in the subfamily Asopinae, are predatory and may be considered beneficial.
- They have ability to release a pungent defensive spray when threatened, disturbed, or crushed.
- The composition of this spray may vary between species, and even by sex or age

Taxonomy and Ecology of Stink bug



<https://www.uky.edu/Ag/CritterFiles/casefile/insects/bugs/stinkbugs/stinkbugs.htm>

- but generally includes aldehyde and alkanes.
- Moderate to large size, ranging in length from 7 to 25 mm, and are broadly elliptical in shape.
- The subfamily Asopinae belongs to the family Pentatomidae of the suborder Heteroptera (true bugs).
- About 300 species in 69 genera have been described worldwide.

Taxonomy and Ecology of Green lacewing



<https://www.uky.edu/Ag/CritterFiles/casefile/insects/bugs/stinkbugs/stinkbugs.htm>

- Adult stink bugs are strong fliers and typically migrate into cotton from alternate hosts outside the field, including adjacent fields of maturing corn and soybean.
- Stink bugs are difficult to scout.
- Adults tend to aggregate, and the distribution of stink bugs within a field may be highly concentrated, particularly along borders.

Taxonomy and Ecology of Stink bug



<https://www.uky.edu/Ag/CritterFiles/casefile/insects/bugs/stinkbugs/stinkbugs.htm>

- Despite being relatively large insects, they can be difficult to see.
- Stink bugs can be scouted for visually, but most thresholds are based on drop cloth samples or the occurrence of internal symptoms of feeding damage to bolls.

Taxonomy and Ecology of Stink bug



<https://www.uky.edu/Ag/CritterFiles/casefile/insects/bugs/stinkbugs/stinkbugs.htm>

- Predatory stink bugs are a gardener's friend, feeding on more than 100 species of insect pests.
- Both nymphs and adults attack insects larger than themselves, and suck the body fluids from their prey with a needle-like beak.

Taxonomy and Ecology of Green lacewing



<https://www.uky.edu/Ag/CritterFiles/casefile/insects/bugs/stinkbugs/stinkbugs.htm>

- Predatory stink bugs tend to have a shorter, stouter beak than the long, thin beak of plant-feeding stink bugs.
- Adults overwinter in sheltered locations and leaf litter, emerging in early spring to stalk and devour their prey.

Taxonomy and Ecology of Stink bug



<https://www.uky.edu/Ag/CritterFiles/casefile/insects/bugs/stinkbugs/stinkbugs.htm>

- **Life stage(s) that feed on pests:** Nymphs and adults.
- **Insect(s) fed on:** Spined soldier bugs prefer larger insects such as grubs and the larvae of various beetles and moths, and are especially fond of caterpillars. Two-spotted stink bugs often eat the eggs and larvae of Colorado potato beetle, and smaller caterpillars and larvae.

Taxonomy and Ecology of Stink bug



<https://www.uky.edu/Ag/CritterFiles/casefile/insects/bugs/stinkbugs/stinkbugs.htm>

- 1st instar nymphs of two-spotted stink bugs feed on plant sap, as will adults in early spring before prey are available, but do no significant damage to plants.
- **Where to find:** Generally throughout the garden, particularly on apples, asparagus, beans, cole crops, cucurbits, eggplant, potatoes, onions, sweet corn and tomatoes.

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Taxonomy and Ecology of Stink bug



<https://www.uky.edu/Ag/CritterFiles/casefile/insects/bugs/stinkbugs/stinkbugs.htm>

- **How to attract and conserve:** Pheromones have been used to attract spined soldier bugs to the garden. Year-round ground cover in garden will provide overwintering sites and shelter, as well as plant sap to feed on early in the season. Avoid or reduce use of broad-spectrum insecticides.

Module# 164 Taxonomy and Ecology of parasitoid wasp



- Wasps, a very large evolutionary group of hymenopteran insects,
- *Tamarixia radiata* is a species specific ectoparasitoid of the Asian citrus psyllid (ACP) *Diaphorina citri*.
- *Diaphorina citri* is an economically important pest of citrus in many citrus growing regions of the world (Halbert and Manjunath, 2004).

Taxonomy and Ecology of parasitoid wasp



<https://biocontrol.entomology.cornell.edu/parasitoids/Tamarixia.php>

- The psyllid vectors the phloem limited gram-negative bacterium *Candidatus Liberibacter asiaticus*, one of the causal organisms of the devastating citrus disease “**huanglongbing**” (HLB) or **citrus greening disease**. HLB is responsible for the decline of most trees seen in disease affected regions of the world

Taxonomy and Ecology of parasitiod wasp



<https://biocontrol.entomology.cornell.edu/parasitoids/Tamarixia.php>

- *Tamarixia radiata* was first imported to Florida from Taiwan and south Vietnam and limited numbers were released soon after psyllid was discovered in the state (Hoy et al., 1999).
- Successfully managed the pest
- Saved citrus industry of Florida
- *Tamarixia radiata* was first described from northwestern India (Punjab) which is now part of Pakistan.

Taxonomy and Ecology of parasitoid wasp



<https://biocontrol.entomology.cornell.edu/parasitoids/Tamarixia.php>

- *Tamarixia radiata* is not yet available commercially.
- The female usually deposits one and very rarely two eggs on the ventral side of the *D. citri* nymph, mostly in the groove between thorax and abdomen and close to the point of attachment of hind coxae.

Taxonomy and Ecology of parasitoid wasp



<https://biocontrol.entomology.cornell.edu/parasitoids/Tamarixia.php>

- The neonate larva sucks fluid from the site of attachment
- The parasitized nymph remain indistinguishable from unparasitized nymph for couple of days until almost all body contents of the parasitized nymph are consumed and only wing buds and dorsal covering are left.

Taxonomy and Ecology of parasitoid wasp



<https://biocontrol.entomology.cornell.edu/parasitoids/Tamarixia.php>

- At that point, the larva is mature and attaches itself to the leaf or shoot surface with a network of fine anchoring silken threads
- Pupation takes place underneath the mummified nymph and the adult emerges by chewing a circular exit hole in the integument of the thoracic region.

Taxonomy and Ecology of parasitoid wasp



- Development rate varies with temperature. It takes about 12 days to go from egg to adult at 25 °C and 14L:10D.
- A single female can lay up to 300 eggs at 25-30 °C (Chu and Chien, 1991; Étienne et al. 2001).

<https://biocontrol.entomology.cornell.edu/parasitoids/Tamarixia.php>

Taxonomy and Ecology of parasitoid wasp

PARASITIODS	PEST ATTACKED
<i>Ichneumonidae</i> wasps	Larva of noctuids* (noctuids include helioverpa, armyworms, cutworms and loopers)
<i>Microplitis</i> (WASP)	Helioverpa larvae
Tachinid flies (Tachinidae)	Larva of noctuids
Trichogramma Wasp	Eggs of noctuids
Chalcid wasps	Aphids
Braconid wasps	beetles, caterpillars, flies and sawflies.

Module# 165 Taxonomy and Ecology of Whitefly

- There are 1550 species worldwide under two subfamilies.
- 70 in Punjab Pakistan
- Cosmopolitan insects
- Most abundant in the tropical and subtropical countries of the world.

Taxonomy and Ecology of Whitefly



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Why called Whitefly?

- White appearance of adults due to deposition of wax on the on body and wings

Taxonomy and Ecology of Whitefly



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- Adult whiteflies are small, approximately 1-2 mm in length.
- Adults with wingspan less than 3mm.
- With a yellow body and two pairs of white wings.
- The compound eyes are red.

Taxonomy and Ecology of Whitefly



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- Sucking and piercing mouthparts.
- Both sexes have functional mouth parts and two pairs of functional membranous wings.
- Nymphs are initially semi-transparent, later becoming creamy yellow to pale-green.