Identifying potential predatory mites for the control of the red poultry mite

Compiled and presented by

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PREFACE

This manual is an introductory guide to mites associated with the red poultry mite (RPM) *Dermanyssus gallinae* (De Geer), Dermanyssidae. The content has been compiled from different sources, and is meant as reference material for the training school conducted within the framework of the Working Group 3 of COST Action FA1404 – COREMI 'Improving current understanding and research for sustainable control of the poultry red mite (RPM)'. The training school was held at the Faculty of Agriculture in Rehovot, Hebrew University of Jerusalem, on September 12th through 16th, 2016. The guide is for teaching purposes only and may be supplemented by the user as necessary. The manual is a collaborative effort of the Department of Entomology, Newe-Ya'ar Research Center, Ministry of Agriculture, Ramat Yishay, Israel; Koret School of Veterinary Medicine, Hebrew University of Jerusalem, Rehovot, Israel; Centre d'Ecologie Fonctionnelle et évolutive, Equipe Intéraction Biotiques, Université Paul Valéry Montpellier 3, France; Departamento de Biología Ambiental,Facultad de Ciencias, Universidad de Navarra, Spain and ARC-PPRI Mite Expert Centre of the Biosystematics Program, Arachnology Unit of the ARC-Plant Protection Research Institute, South Africa.

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CONTENTS

1. INTRODUCTION TO MITES IN GENERAL

Mites are very small. Varying from about 6mm (Parasitngona, e.g. Erythraeidae) to 100 micron e.g. Eriophyidae). Mites and ticks belong to the suborder Acari. The Acari is a group of the Arachnida. The class Arachnida contains all the arthropods that among other characteristics, neither have antennae nor mandibles and usually are eight legged as adults (e.g. mites, spiders and scorpions).

How do mites differ from spiders

The mouthparts and legs of spiders are attached to the cephalothorax. The cephalotorax is connected to the abdominal portion by a narrow pedicel.
The mouthparts and related structures of mites (including chelicerae and pedipalps), form a separate structure, situated at the front of the body and gives the impression of a head. This structure is called the gnathosoma. The body segments of mites are fused into one usually oval or round unit or "body" called the idiosoma.

General facts about mites

- Mites and ticks (Acari) form a diverse group that includes predatory, parasitic, plant feeding (phytophagous), fungi-feeding (fungivorous) and scavenger forms.
- Mites occur world-wide and inhabit virtually every environment and habitat that can support live. For example they are found:
  - feeding on plants and fungi
  - parasitizing insects, animals, birds and humans
  - living in soil
  - living on organic material of all kinds (saprophytic)
  - living on stored and processed products
- Mites can be present in very high numbers. Hundreds or even thousands can be found in a single plant gall or soil sample. They are able to increase their numbers with in a short period of time and some can even double their population size within 3-4 days.

- Plant feeding mites are mainly dispersed by wind, as well as by animals and humans or with plant material. Parasites are dispersed by their hosts.
- Mite reproduction is diverse and includes:
  - ovipari (laying eggs)
  - ovivivipari (eggs hatch in females)
  - Vivipari (females produce live young)
  - parthenogenesis (reproduction without fertilization)
  - arrhenotoky (production of males from unfertilized eggs)
- In general a maximum of six stages are found in the life cycle of mites, namely: egg, larva, protonymph, deutonymph, tritonymph and adult, however, it may vary widely between different taxa.

2. KEY TO THE MITE ORDERS REPRESENTED HERE

1. Legs with 6 free segments, coxae I-IV movable (fig.1), legs closely aligned longitudinally on anterior half of body, marginally (fig.1), pretarsi (fig.1) with a cushion-like structure flanked by two claws (fig. 3); tarsus I distally with dorsal sensorial setae; tracheal system with stigmata situated lateral to coxae II-IV typically with an external groove of varying length (peritreme) extending generally anteriorly (fig. 1); fork-like structure (tritosternum) with 1-2 hairy branches (laciniae) usually present ventrally at base of gnathosoma (fig. 2); palp five segmented, small distal segment (palptarsus) with a characteristic tined claw-like structure (apotele) near inner basal surface (fig. 2); incher-like chelicerae; **female** genital opening a transverse slit at about level of anterior margin of basal leg segment (coxa) of leg III-IV and associated with a genital shield (fig. 4), **male** genital opening presternal or between coxae (fig.5) ……...…**Order Mesostigmata**

- Legs with 5 free segments, coxae I-IV fused in the sternal region; palp apotele and tritosternum absent…….2

2. Tracheal system with one pair of stigmata opening between bases of chelicerae or on anterior margin of prodorsum (Figs 7) when present and sometimes associated with discrete tubular peritremes dorsally on the cheliceral bases (Figs 6); leg segments can be reduced in some families (less than five) and fourth segment (femora) can be divided (seven), pretarsi of at least legs II-III usually with two lateral claws and with or rarely without a median empodium that may be pad-like or rayed and often armed with tenent hairs; apotele and tritosternum absent, palps simple or modified into a thumb-claw complex(fig. 8); chelicerae rarely pincher-like (chelate), fixed digit often regressed and movable digit usually hook, knife or stylet-like (fig. 9), cheliceral bases fused or not; genital opening of adults ventrally behind coxae IV or II in Eriophyoidea ……..

……...……..**Order Trombidiformes**

- Tracheal system absent, respiration through cuticle; pretarsi of legs I-IV usually with one or three claws, empodium claw-like often integrated into a membranous pad (fig.10), or sucker-like, never pad-like, rarely rayed, pretarsi III-IV often modified or absent in parasitic forms, coxae fused into ventral surface of body often forming coxisterna (fig. 11); palp two segmented, simple, never with a thumb-claw complex ; chelicerae typically pincher-like (chelate) and with teeth (dentate), rarely attenuate or stylet-like, cheliceral base never fused; posterior half of body usually with a pair of

lateral glands; genital opening of **female** (inversely V, U or Y shaped, fig. 12) and sclerotized penis of **ale** ventrally between coxae III and IV or II and III, male often with a pair of copulatory suckers posteriorly (fig. 13)…….....**Order Sarcoptiformes, Cohort Astigmata**

*

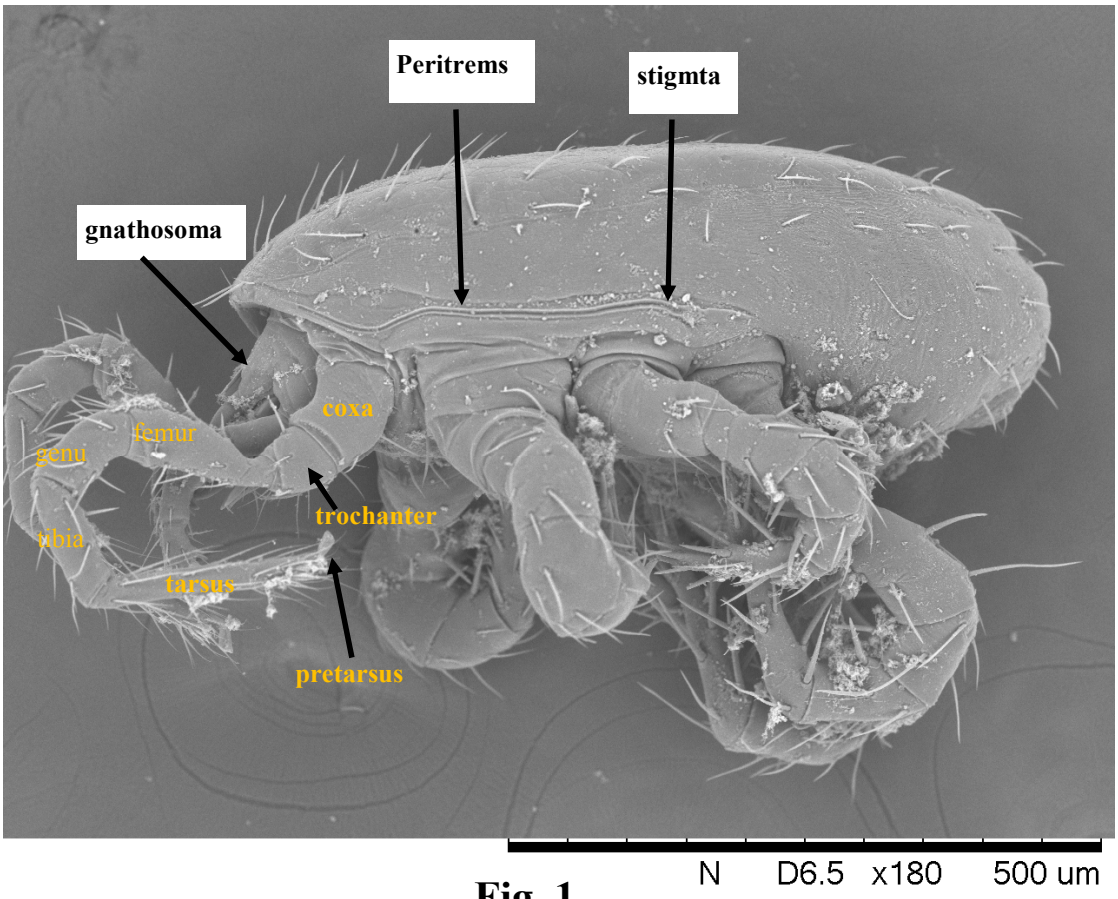

Peritrems
stigmta
gnathosoma
coxa
femur
genu
trochanter
tibia
tarsus
pretarsus
N D6.5 x180 500 um

Fig. 1

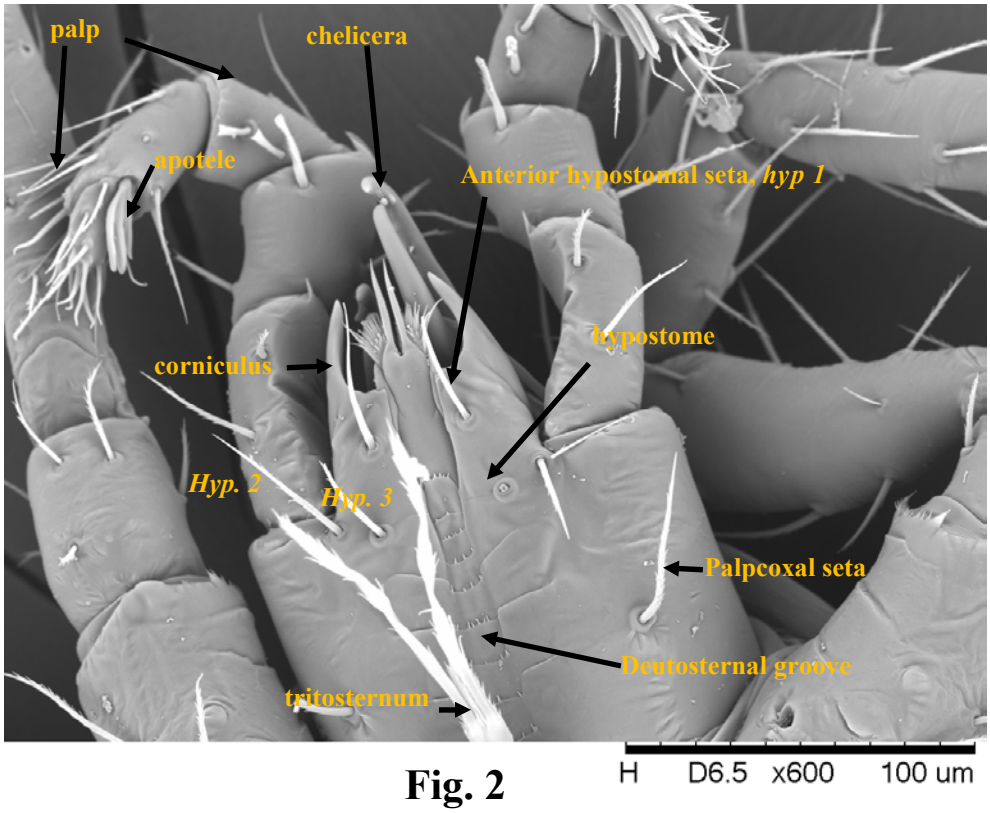
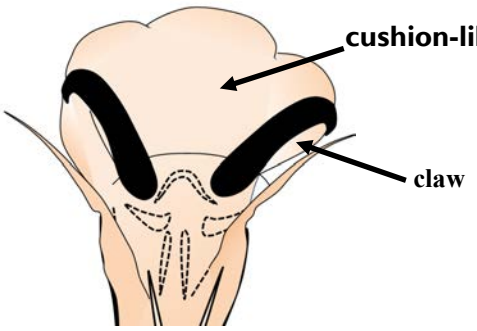

palp
chelicera
apotele
Anterior hypostomal seta, *hyp 1*
hypostome
corniculus
Hyp. 2
Hyp. 3
Palpcoxal seta
Deutosternal groove
tritosternum
H D6.5 x600 100 um

Fig. 2



(Figs 6);

Fig. 3

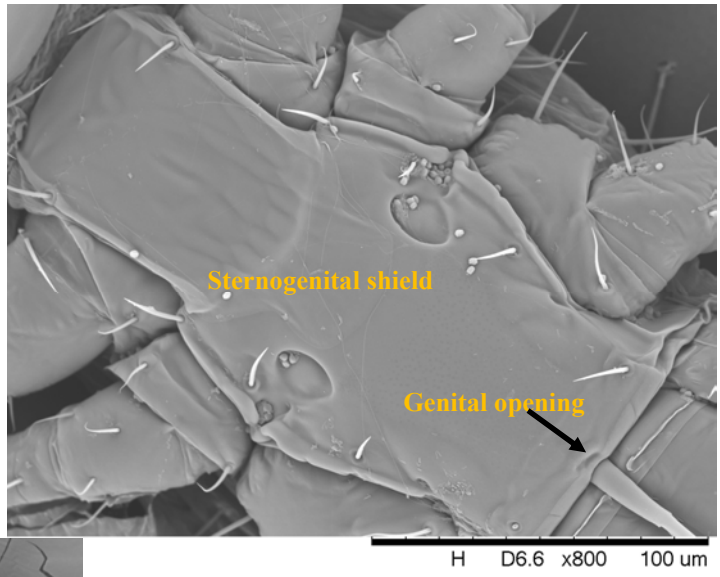


Fig. 5– male

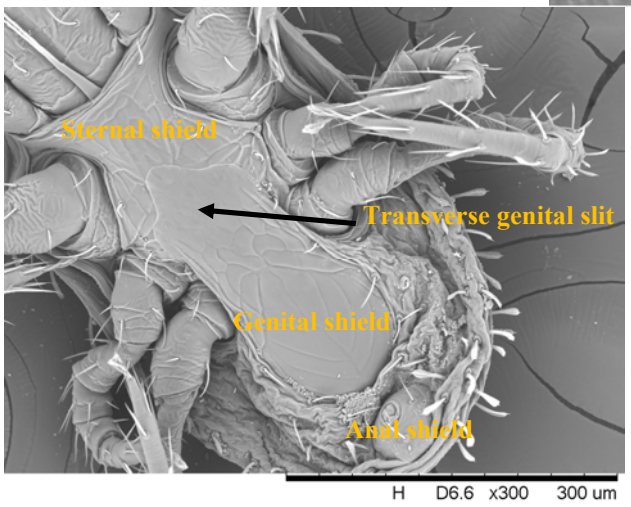


Fig. 4– female

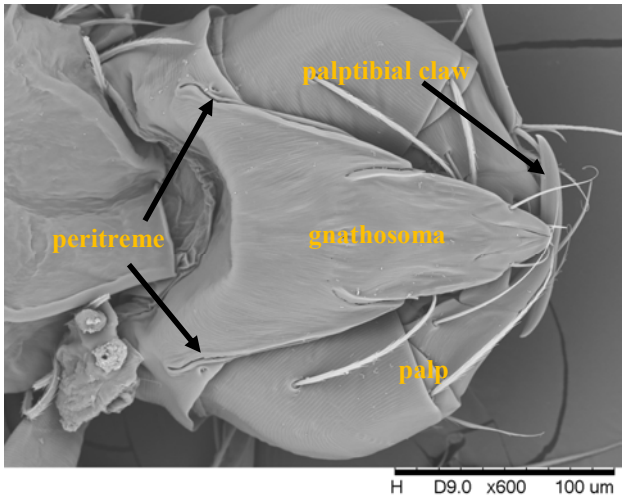


Fig. 6

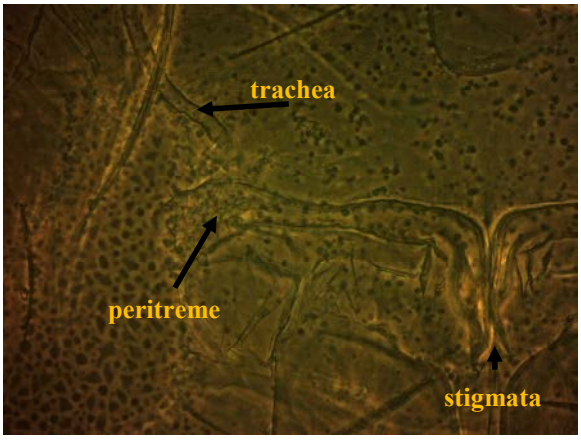


Fig. 7

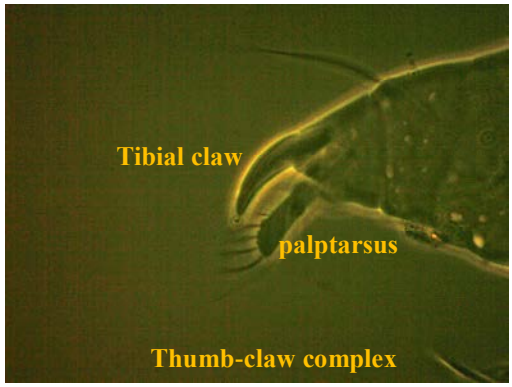


Fig. 8

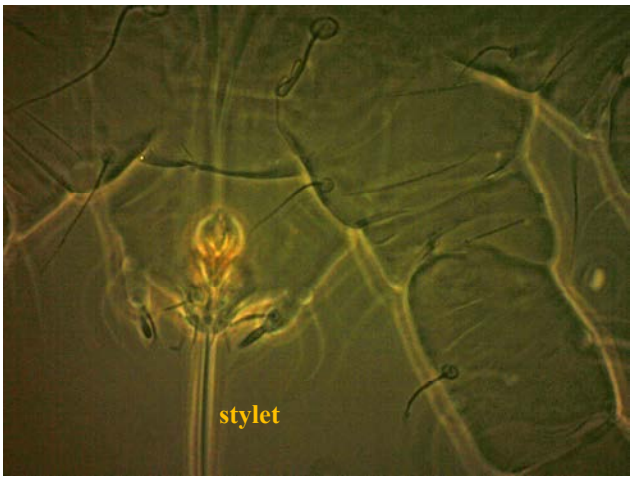


Fig. 9

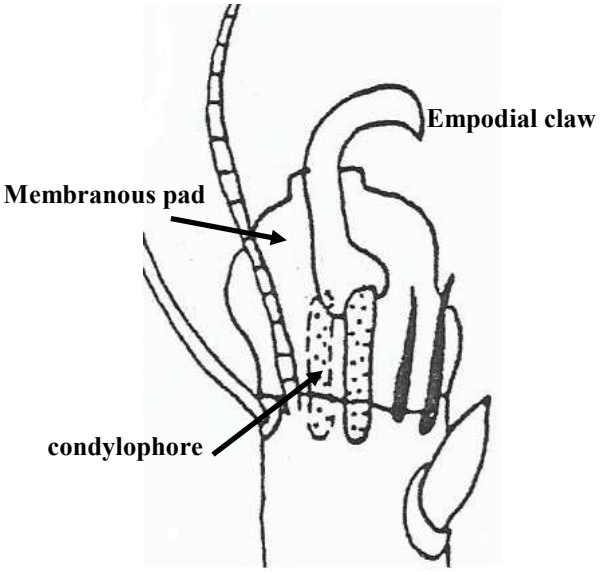


Fig. 10

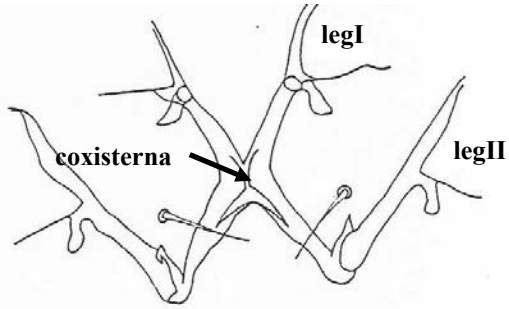


Fig. 11

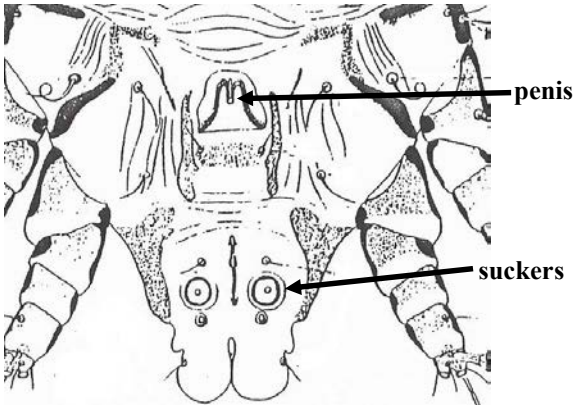


Fig. 13- male

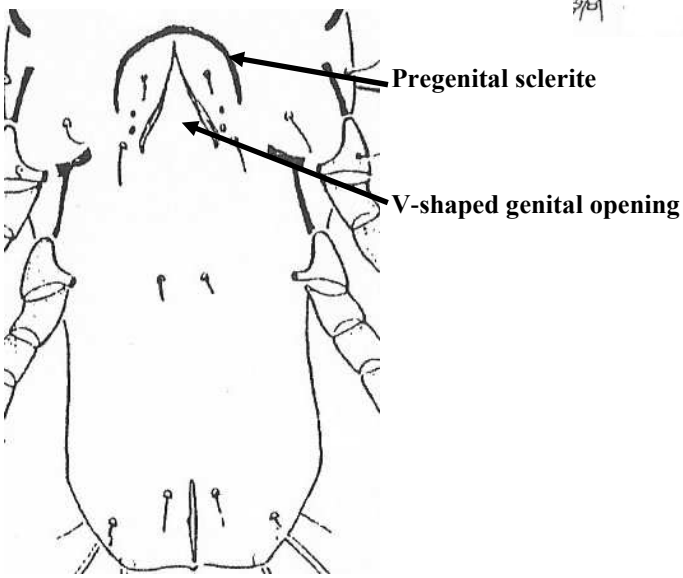


Fig. 12– female

3. KEY TO THE GENERA AND SPECIES OF THE ORDER MESOSTIGMATA

1. Hypostomal and capitular setae together forming a more or less straight column. Tritosternum with base wider than long or with narrow base that is partially or entirely covered by greatly elongated coxae I; genital shield usually located entirely in the intercoxal region; depressions to retract legs in (pedofossae or fovae pedale) often present (fig. 14); dorsum of idiosoma with entire or fragmented marginal shields. Palp genu usually with five setae……...
…...…….Cohort Uropodina……..…2

- Hypostomal and capitular setae not forming straight column. Tritosternal base usually narrow and never covered by coxae I. Genital shield usually not located in intercoxal region. Pedofossae absent. Dorsal marginal shields absent. Palp genu typically with six setae.....
……..Cohort Gamasina……..8

2. Chelicera without internal sclerotized node (fig. 15) associated with the levator tendon ; hypostomatic setae *h1* long and setiform: female genital shield located between coxae II-IV
……..…..Uropodidae ……...……...……..7

- Chelicera with internal sclerotized node (fig. 15) associated with the levator tendon……...…..3

3. Dorsal shield of adults often notched marginally. Hypostomal internal malae simple, no fimbriated or with distal moustache-like excrescence; corniculi distally dentate or divided…….
……Trematuridae …...……..4

- Dorsal shield of adult simple or divided, with postdorsal shield; Hypostomal internal malae fimbriated or with distal moustache-like excrescence; corniculi with smooth tipo; peritreme sometimes very long ….……..Urodynichidae……...5

4. Cheliceral fixed digit without distal sensillae;(fig.16a) movable digit with 3-5 teeth….*Trichouropoda*

- Cheliceral fixed digit with distal sensillae (fig.16b); movable digit with 1-2 teeth ……*Nenteria*…

Female: tectum terminal bifurcated with small medial piston ; hypostome with 4 groups of small teeth; Genital shield with long spike-like structure in the anterior margin; distal portion of

peritreme hook-shaped; dorsal shield finely punctate; most dorsal setae feathery (fig.17)……..

……...…….*N. floralis* c.f. Karg

5. Posterior region of marginal dorsal shield fragmented in sclerites bearing setae; cheliceral movable digit 1/3 of fixed digit…….Uroobovella……...……6

6. Dorsal setae long, on the posterior region of dorsal shield with 4 expanded penicillate setae, between them a furrow extends to the middle of the dorsal shield; marginal shield terminates in round arcs, each with a pubescent seta; anterior margin of genital shield with bidentate spike, posterior margin straight (fig. 18)……..*U. marginata* (C.L. Koch)

- All dorsal setae short and acicular, pubescent setae and furrow absent; dorsal and ventral shields with luminous pores; posterior part of marginal shield is transformed into a soft band with 8 postmarginal platelets bearing setae *J5*, *Z4, Z5* and *S5*; anterior margin of genital shield broadly rounded; anal region of ventral part without luminous pores (fig. 19)…….*U. fimicola* (Berlese)

7. Hypostosomal region between setae *h1-h4* with small teeth……. Uropoda ……..

Female: Dorsal setae acicular, of medium length, in most cases they do not reach the bases of the following setae; setae *j4* and *J4* are expanded, penicillate; genital shield reticulate, anteriorly with a spike of medium length; setae *V3* and *Vx4* penicillate; setae *h1* the longest and smooth, *h2-4* with speculate tips, h4<h2<h3 (fig. 20)……...……. *U. orbicularis* (Müller)

8. Genital shield large, triangular, pointed distally, flanked by large metasternal shields (fig. 21) Ventrianal shield large, contiguous with or fused with genital shield. Palp claw three-tined. Tectum with 3 or 5 tooth-like projections. Tibia I with 4 ventral setae …….Parasitidae……...9

- Genital shield large or small, but not triangular and not flanked by large metasternal shields; metasternal shields present or absent……14

9. Seta *al* of palp femur spatulate or setiform or at most speculate distally; **females** and **deutonymphs** with separate podonotal and opisthosomal shields or female with a schizodorsal shield, in **male** entire……..……10

- Seta *al* of palp femur bifid (forked) or with one or more slender processes; **females** and

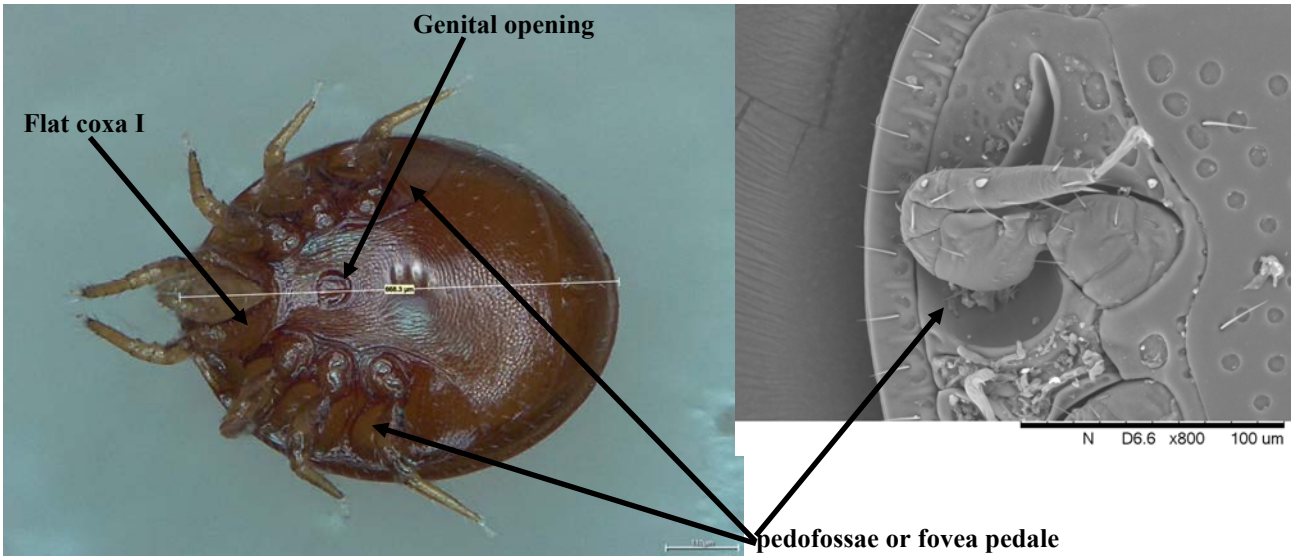


Fig. 14—Uropodid

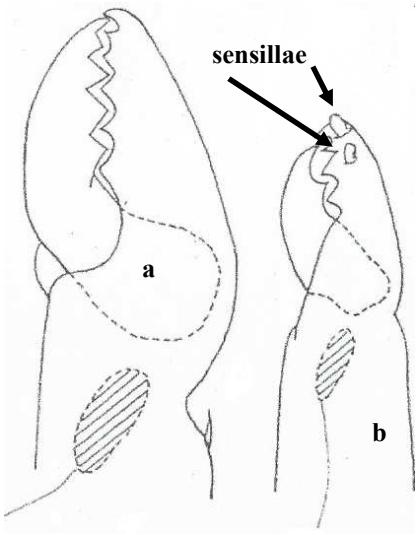


Fig. 16—Uropodid

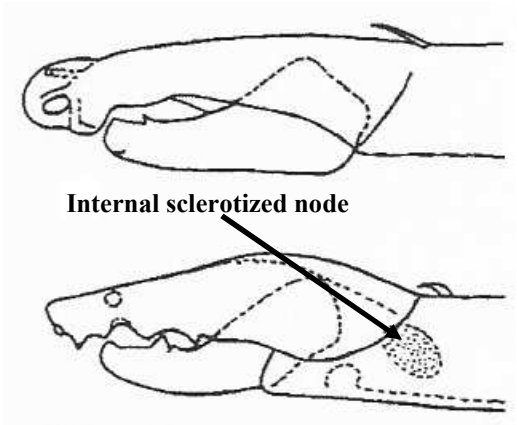
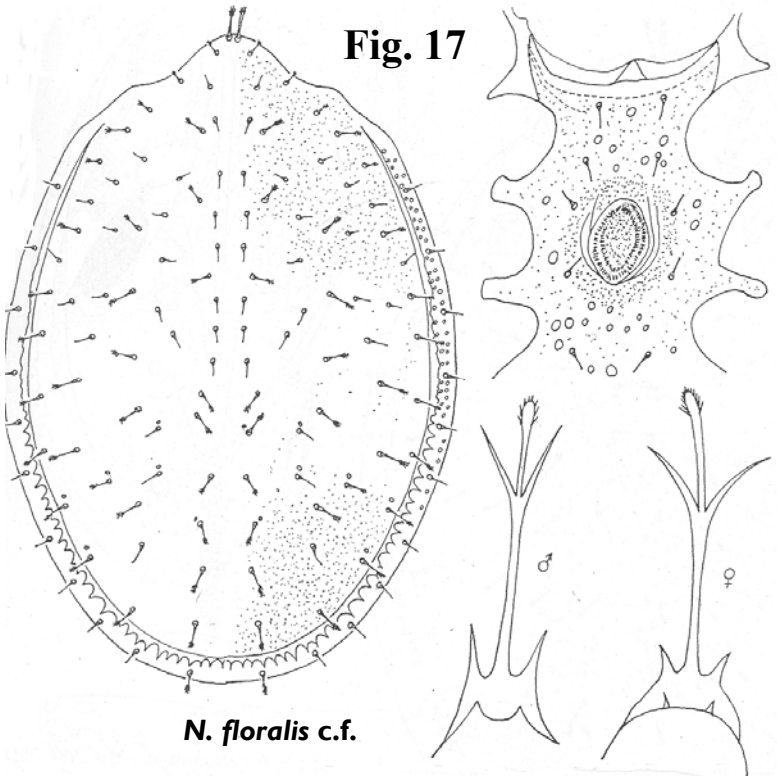


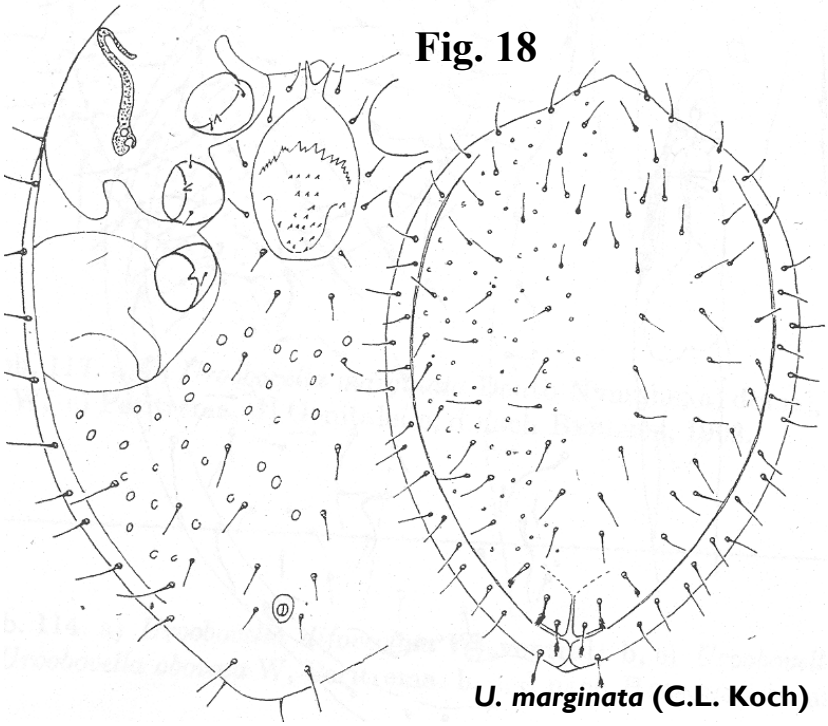
Fig. 15—Uropodid

Fig. 17



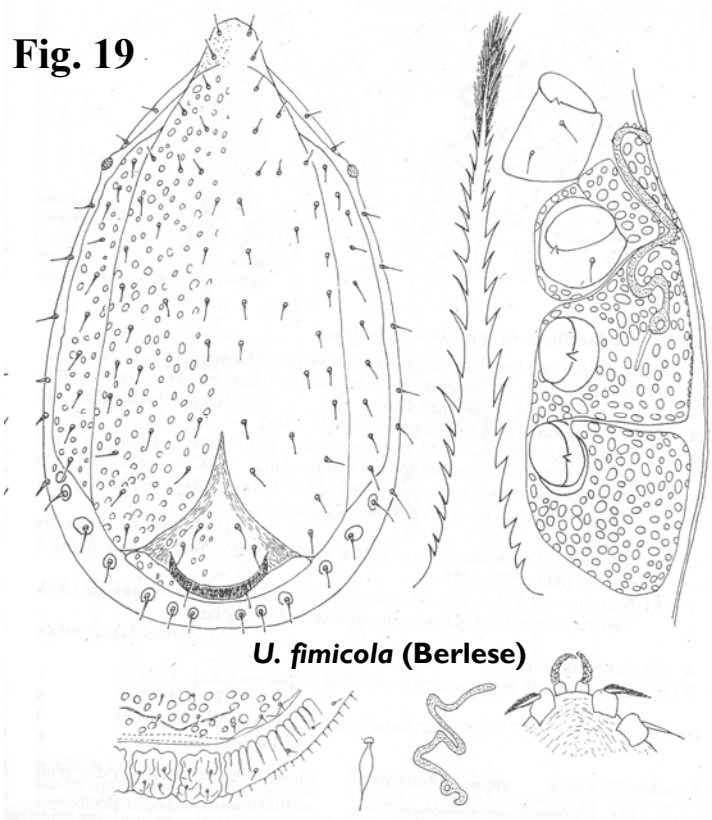
***N. floralis* c.f.**

Fig. 18

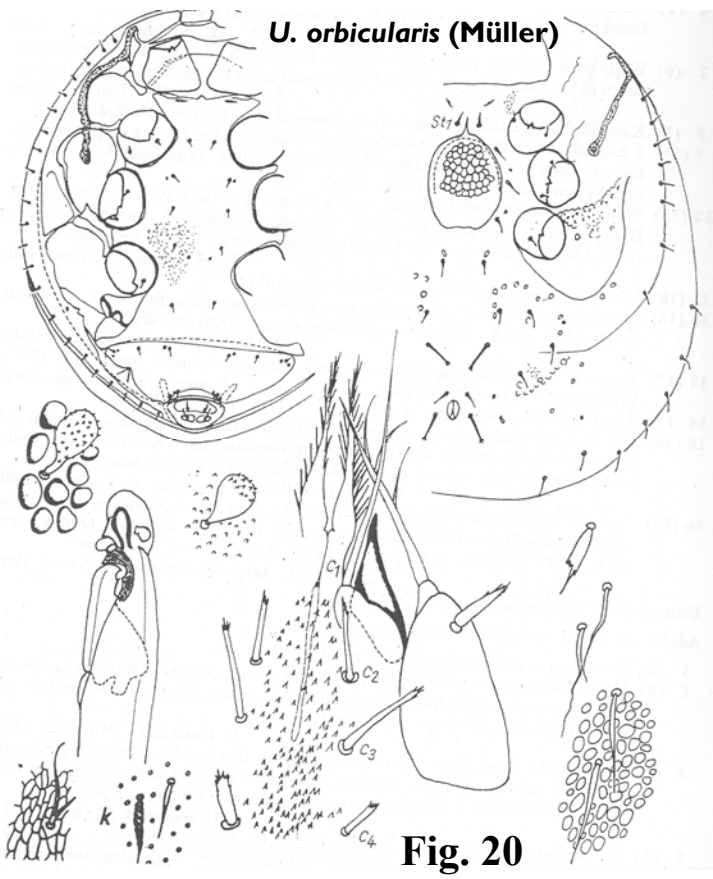


***U. marginata* (C.L. Koch)**

Fig. 19



***U. fimicola* (Berlese)**



***U. orbicularis* (Müller)**

Fig. 20

deutonymphs with separate podonotal and opisthonotal shields, in **male** entire……..……11

10. Setae *z5* of dorsal hexagon similar to setae *j5* and *j6* in females, considerably longer and/or stouter in **deutonymphs** and **males**; corniculi of male usually hooked; **deutonymph** sternal shield sometimes with dark transverse band and with a membranous process at tip of one or both cheliceral digits……..*Poecilochirus*……..…….

Female: setae *j1* and *r3* longest and *z1, s1* and *s2* very short and as rest of dorsal setae finely pilose distally, podonotal shield with 21 pairs of setae and opisthonotal shield with about 40 pairs; tectum a long tapered projection with angular serrated margins. **Male**: Dorsal shield entire but with a dorsal suture behind setae *j6*, podonotal region with 22 pairs of setae, setae as in **female** finely pilose but, setae *j4, z5* and *r3* are the longest; tectum with basal two-thirds broad with margins serrate and distal third more slender and tapered; coxa and femur I with spurs, leg II with a big spur on femur and smaller spurs on genu and tibia. **Deutonymph**: Podonotal shield with 21 pairs of setae with *z5* and *r3* the longest, opisthonotal shield with 13 pairs of setae; sternum with dark sclerotized band between *st1* and *st2*; tectum with 3 slender prongs; fixed digit of chelicerae with a long membranous process at tip; legs II-IV each with an erect dorsal seta distally on femur (fig. 22)……..……..*P. carabi* Canestrini & Canestrini

- Setae *z5* of dorsal hexagon differing in length and form from setae *j6* in **females**, if similar then female with a schizodorsal shield; corniculi of **male** not hooked; sternal shield of **deutonymph** without dark transverse band; leg II of deutonymph with spurs…….*Gamasodes* ……..

Female: All dorsal setae very short, except for *j1, j4, z5, r3, Z1, Z3* and *J5* longest and plumose; genital shield with 2 small teeth just before it tapers into a sharp, slender process anteriorly, opisthogastric region with 7 pairs of setae of which 2 marginal pairs are stout and pilose; tectum with 3 short prongs; femur II a stout tapered seta ventrally. **Male**: Dorsal setae also very short except for 9 setae which are clearly longer and pilose; tectum also with 3 short prongs; leg II with spurs on femur, genu and tibia: **Deutonymph**: with all dorsal setae short, except for setae *J1, r3, Z1, Z3* and *J5* clearly the longest and pilose; sternal shield with two presternal shields

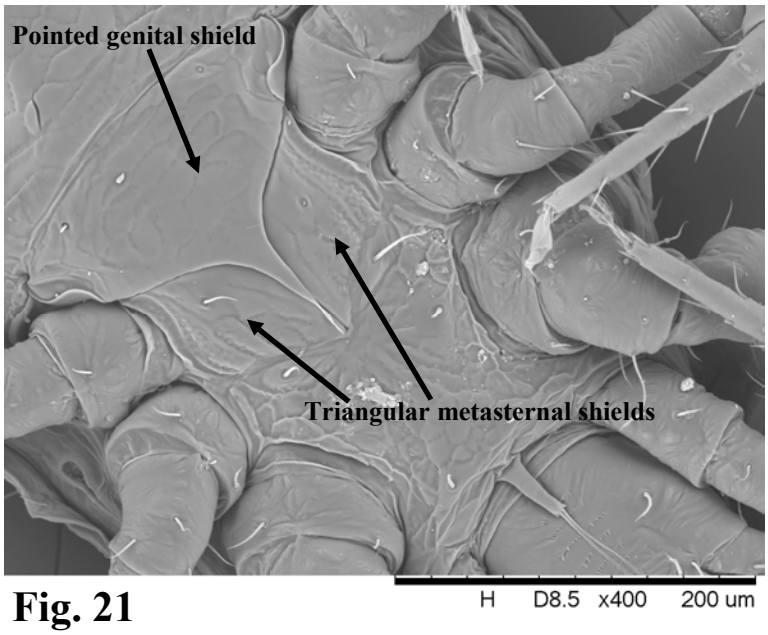


Fig. 21

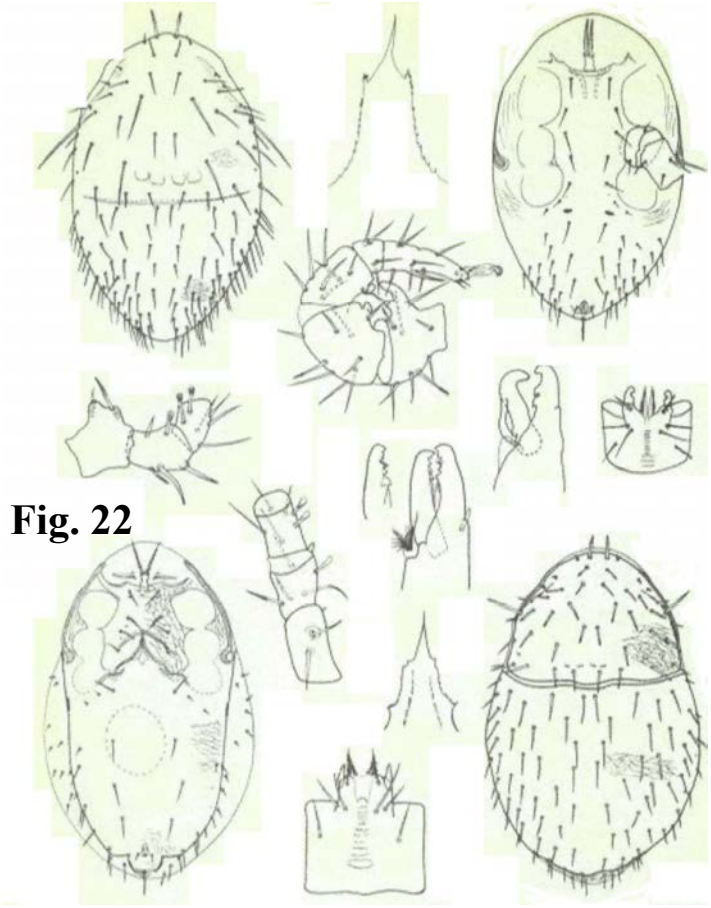


Fig. 22

***Poecilochirus carabi* Canestrini & Canestrini**

anterior; tectum with 3 prongs, median one the longest; Leg II with spurs on femur, genu, tibia and tarsus (fig. 23)……..……..……..*G. spiniger* (Trägårdh)

11. With few exceptions setae *z5* of dorsal hexagon markedly different in form from *j5* and *j6*, usually stout and hairy; tritosternum of male absent or variously modified, if with 2 branches, base closely associated with genital opening……...……*Parasitus*……...……12

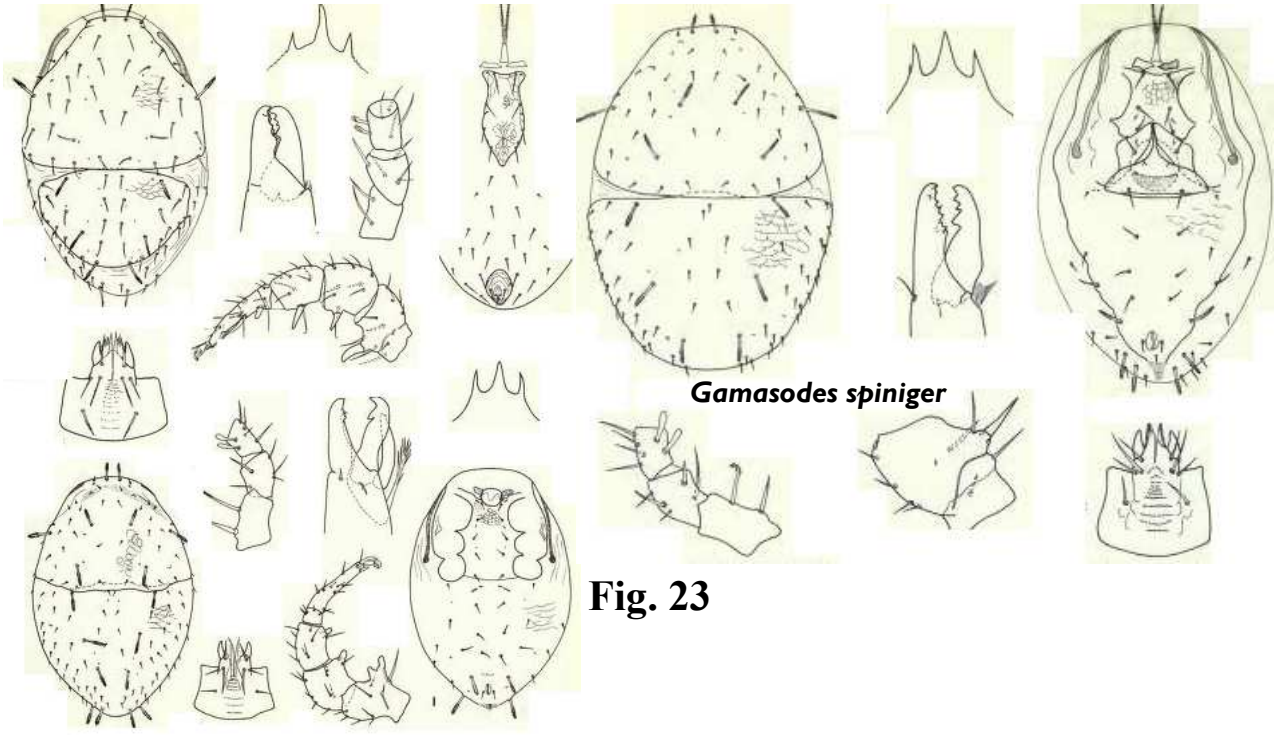
- Setae of dorsal hexagon essentially similar in form; tritosternum normal in both sexes, base never closely associated with genital opening of the male; division between sternal and metasternal shields is not always clearly evident; ventral shield is narrowed towards the posterior and sometimes anal shield separated from ventral shield by a constriction, or rarely anal shield free ……...……*Vulgarogamasus*……...…….

Female: vaginal cavity with unpaired tubercle-like structure, situated on an elevated base; Ventral shield fused with the peritrematal shields; tectum with 3 smooth teeth, central one slightly longer than laterals (fig. 24)…….……...*V. burchanensis* (Oudemans)

12. Deutonymph: Setae *st1* of sternal shield seem to be on separate shields; tectum with 3 prongs the 2 lateral prongs forked distally; podonotal shield with no stout setae clearly differing from other setae. Female: Podonotal shield with setae *j1, j4, z5* and *r3* distinctly longer and stouter than rest of setae; tectum with 3 prongs the median one the longest. Male: Dorsal shield entire with setae *j1, j4, z5* and *r3* distinctly longer and stouter than rest of setae; tectum resembles that of female; paranal setae much shorter than postanal seta ……*P. consanguineous* Oudemans & Voigts

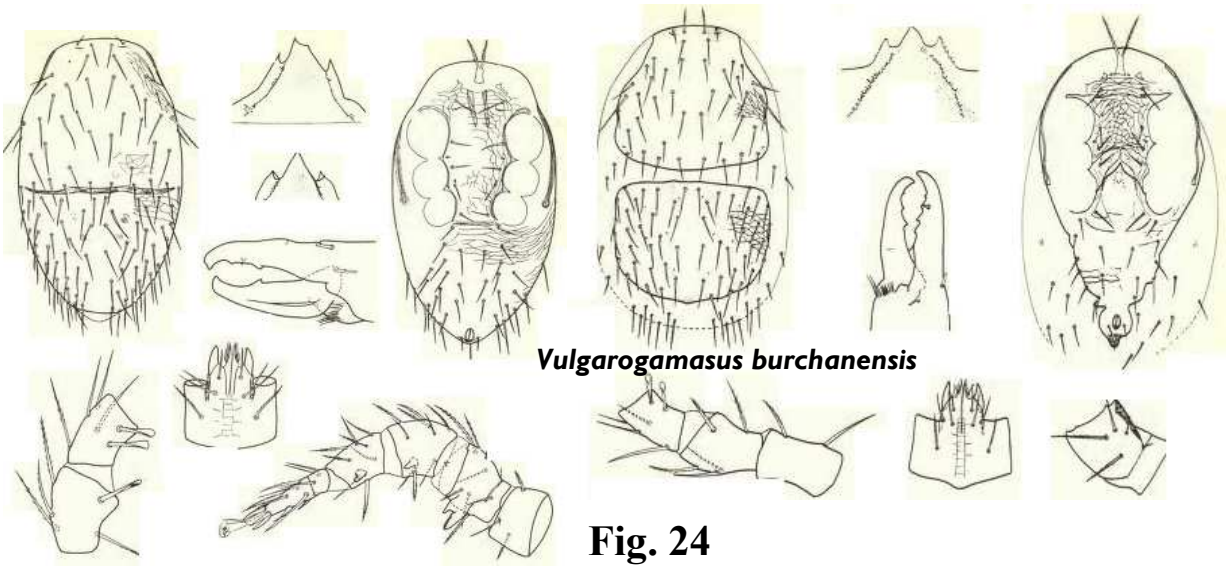
- **Deutonymph**: Setae *st1* of sternal shield clearly on shields; podonotal shield with *r3* longest; tectum with 3 prongs with median prong either blunt or forked distally; anterolateral seta on palp femur deeply bifurcate; **Female**: Opisthogastric shield with 8 pairs of setae ……....13

13. **Deutonymph**: podonotal shield with *j4* and *z5* barely longer than adjacent setae; tarsus IV with long erect dorsal seta. **Female:** Podonotal shield with setae *r3* the longest; setae *j2* and *j5* considerably shorter than the rest of dorsal setae; tectum with 3 prongs; tarsus IV with long erect dorsal seta; vaginal cavity without sclerotized structures (fig. 26)……*P. hyalinus* (Willmann)



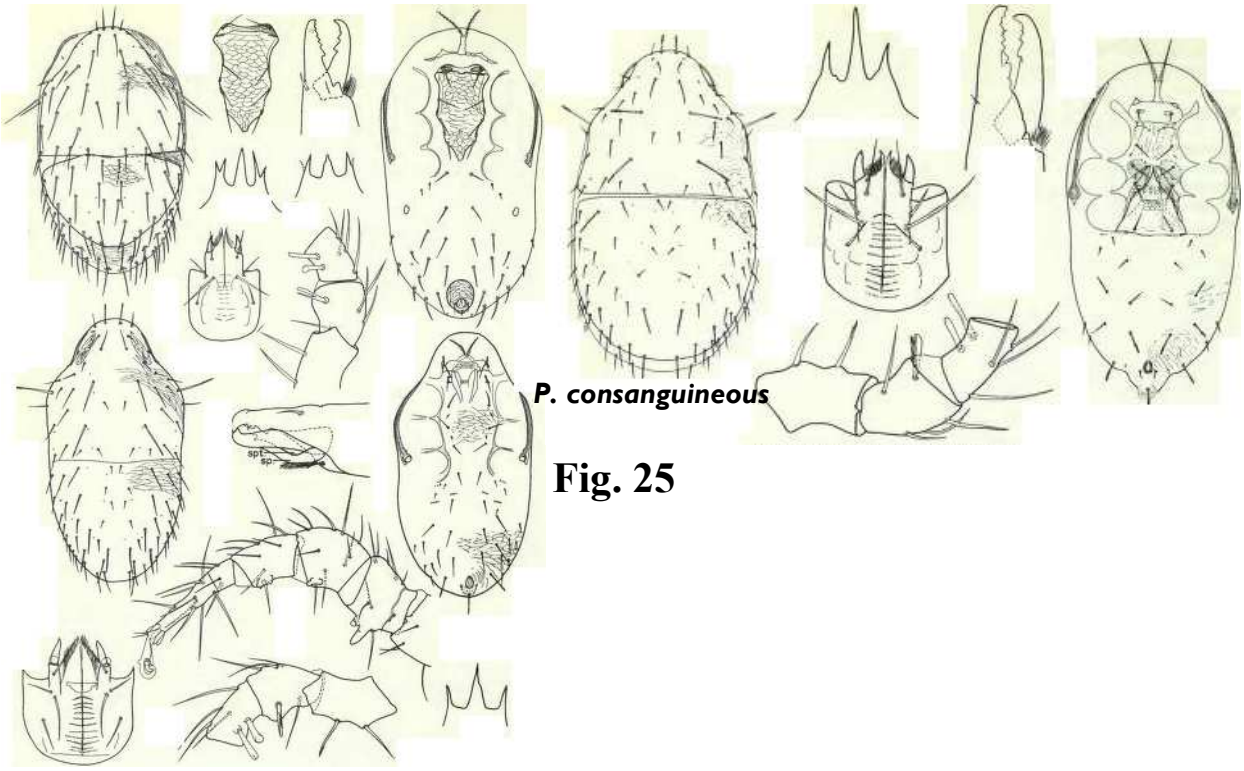
Gamasodes spiniger

Fig. 23



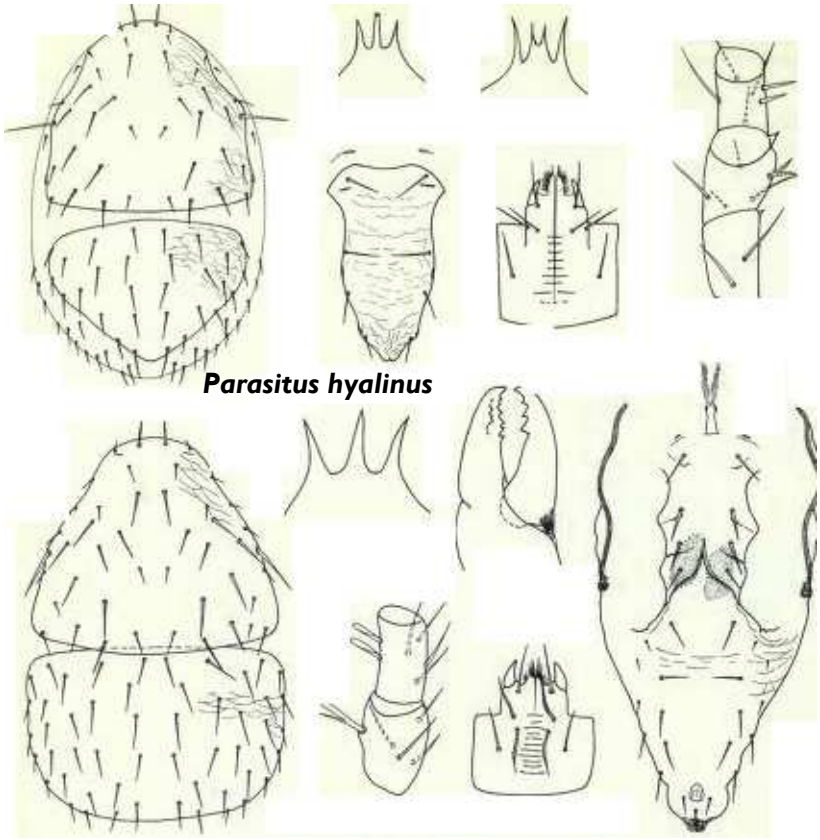
Vulgarogamasus burchanensis

Fig. 24



P. consanguineous

Fig. 25



Parasitus hyalinus

Fig. 26

- **Deutonymph**: podonotal shield with *j1, j4* and *z5* longer than adjacent setae; opisthonotal setae with 2 posterior marginal setae longer and thicker than other marginal setae; Female: Podonotal shield with setae *r3* the longest; setae *j1, z5* longer and thicker than other podonotal setae; setae *j2* and *j5* as long as adjacent setae; tectum with 3 smooth prongs; vaginal cavity with sclerotized Structures (fig. 27)……..……*P. fimetorum* (Berlese)

14. Sternal setae *st4* situated on sternalshield (fig. 28)……...……15

- Sternal setae *st4* situated off shield, on soft cuticle or small metasternal shields……...…18

15. Dorsum covered with two shields, podonotal shield with small chitinized thickenings (scleronoduli) between setae *j5* and *j6* (except four genera), podonotal and opisthonotal shields with or without a punctate band on posterior and anterior margins, respectively; palptarsus with 3-tined claw; tibia I with 6 dorsal setae and 3 to 4 ventral setae, leg I with or without a pretarsus ……Rhodacaridae……...…….16

- Dorsum covered with 1 or 2 shields, generally with small scleronoduli between setae *j5* and *j6* (except in four genera), dorsal and ventral shields without punctate bands; palptarsus with 2-tined claw; tibia I with 5 dorsal setae and 3 ventral setae, leg I with a pretarsus……. ……..Digamasellidae……...……..17

16. Dorsal setae short, except for setae *Z3* and *Z5* on opisthonotal shield; arthrodial process at base of chelicerae shaped as a coronet; setae *j1, j2* and *z1* transversely aligned on anterior margin of prodorsum; 4 scleronoduli near setae *j5*; basitarsus IV with 3 setae; Movable and fixed digits with 2-3 and 4-6 teeth, respectively; tectum with 3 distally serrated prongs and 2 small triangular projections flanking tectum; setae *st1* of sternal shield situated on a porous area; ventrianal shield with 5 pairs of preanal setae, 1 pair in line with anal opening, post anal seta exceptionally long; 2 pairs of opisthogastric setae along anterior margin of ventrianal shield of female (fig. 29)……. …….. *Rhodacarellus silesiacus* Willmann

- Body elongate, podonotal shield with punctate band along posterior margin and opisthonotal shield along anterior margin; dorsal setae short, uniform in length, except for setae *Z5* on

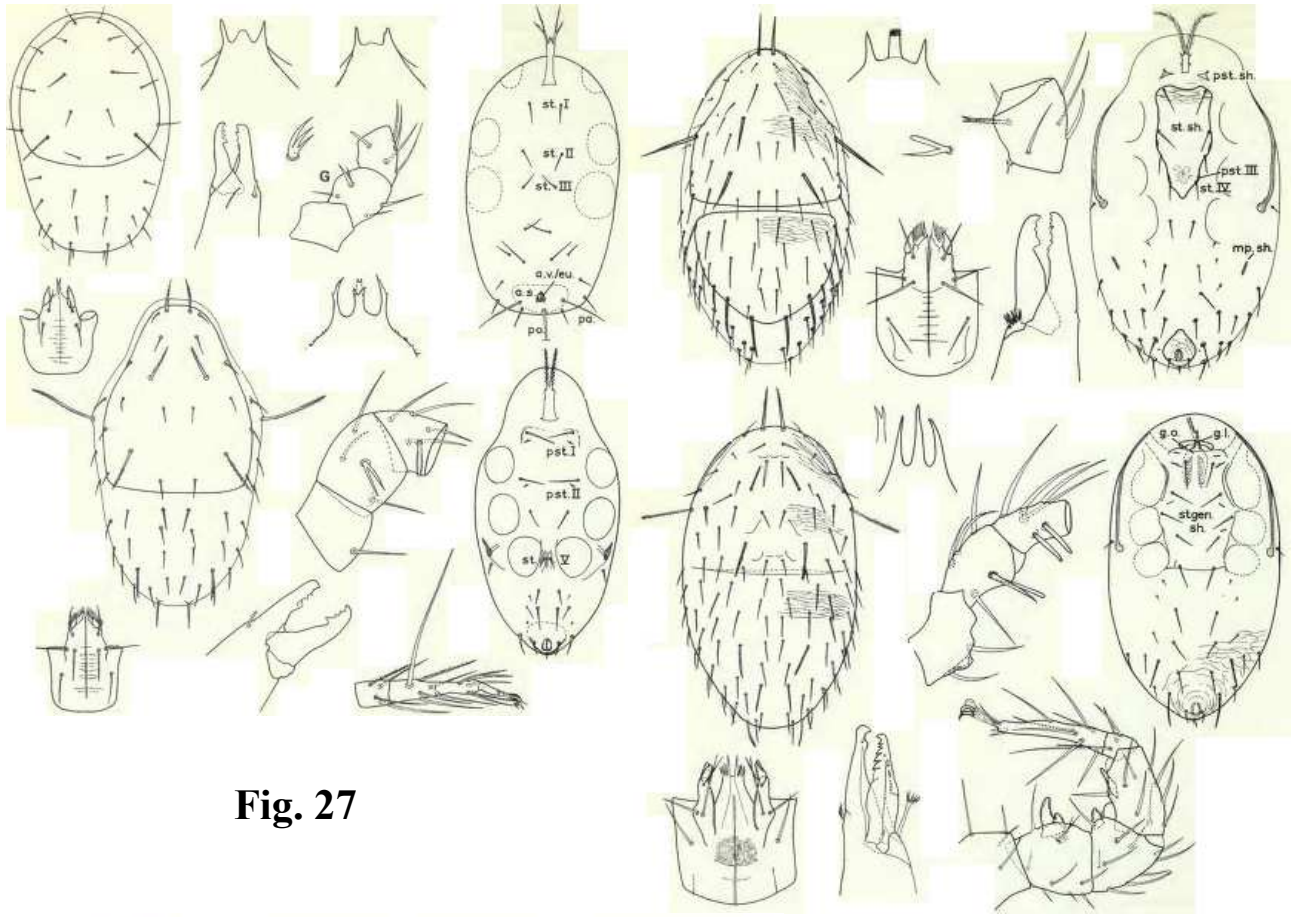
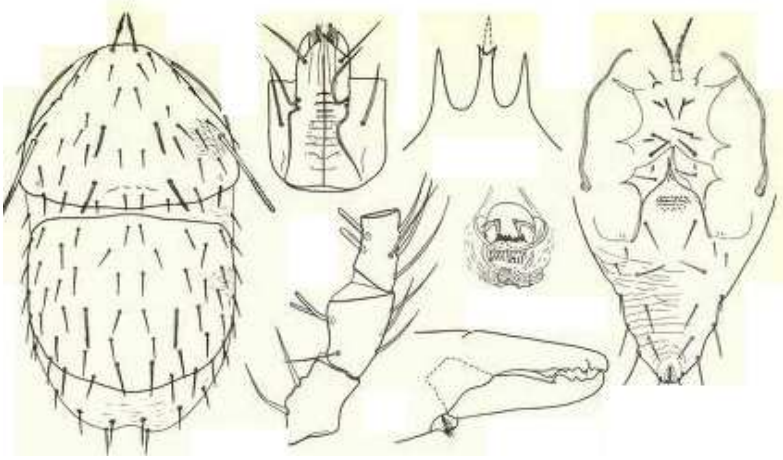


Fig. 27

Parasitus fimetorum



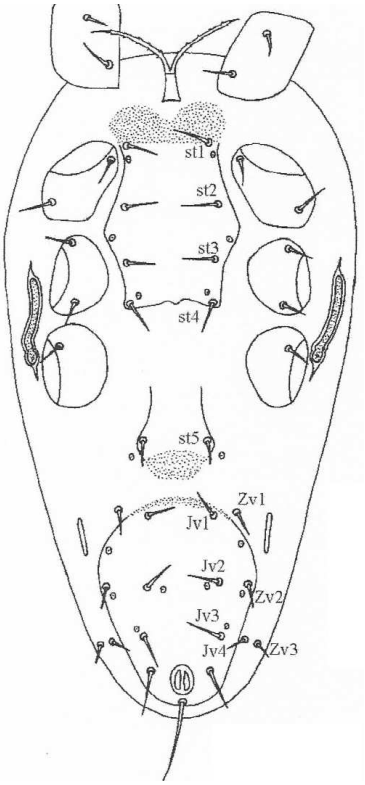


Fig. 28

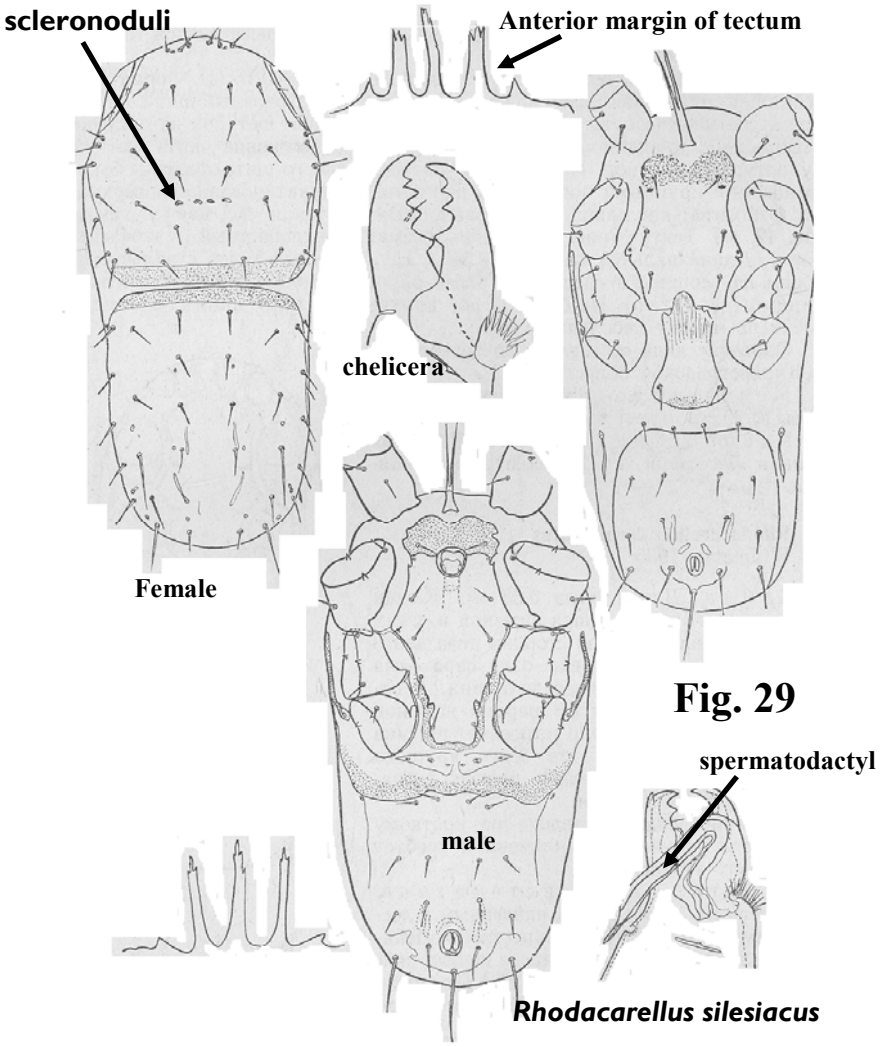


Fig. 29

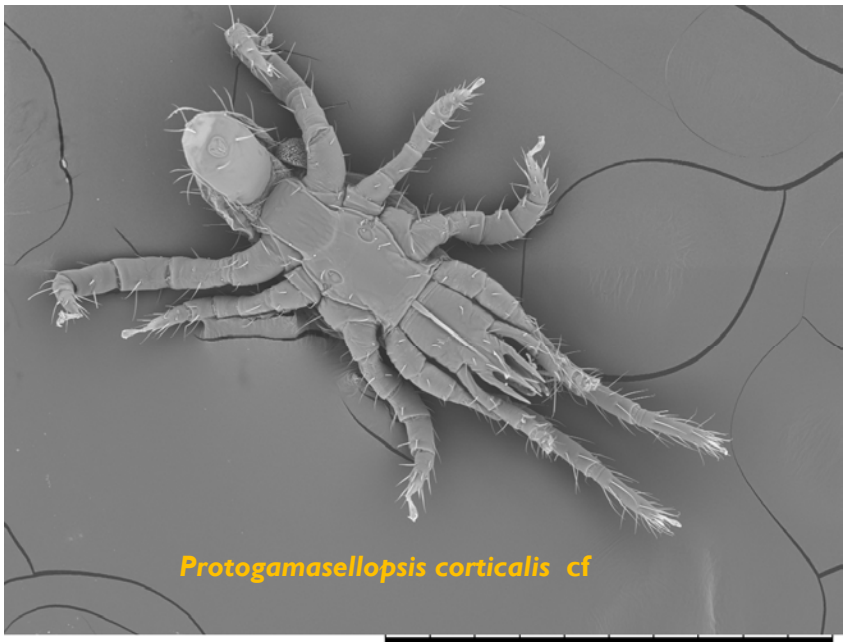


Fig. 30

opisthonotal shield longest; arthrodial process at base of chelicerae shaped as a coronet; setae *j1, j2* and *z1* transversely aligned on anterior margin of prodorsum with *j1* twice or more longer than the other setae; scleronoduli absent; basitarsus IV with 4 setae, coxa I with a dorsal spine; movable and fixed digits with 2 and 6-8 teeth, respectively; anterior region of tectum triangular with median spine-like projection, with small serrations; hypostomal setae *h3* about longitudinally aligned with *h1* and transversely with *h2*; setae *st1* of sternal shield situated on a porous area; ventrianal shield pear-shaped with 1 or 2 pairs of preanal setae; 1 pair of opisthogastric setae along anterior margin of ventrianal shield of female (fig. 30)……..

……..*Protogamasellopsis corticalis* Evans & Purvis

17. Opisthonotal shield with 2 protuberances posteriorly; tectum with 3 prongs, median prong slightly forked, lateral prongs each with a small tooth; ventrianal shield with 5 pairs of preanal setae; all dorsal setae short and simple except for some setae posteriorly which are longer and Spatulate (fig. 31)……..….*Dendrolaelapsis lobatus* Scherbak & Chelebiev

- Podonotal shield with all setae short except for *r3* which are very long, opisthonotal shield also with all setae very short except for setae *Z3*, *S5* and *Z5* which are exceptionally long; opisthonotum without 2 protuberances posteriorly; tectum with 3 serrated prongs; ventrianal shield with 4 pairs of preanal setae, shield narrower anterior and gradually becomes broader Posteriorly (fig. 32)……..……...……..*Dendrolaelaps reticulosus* Hirschmann

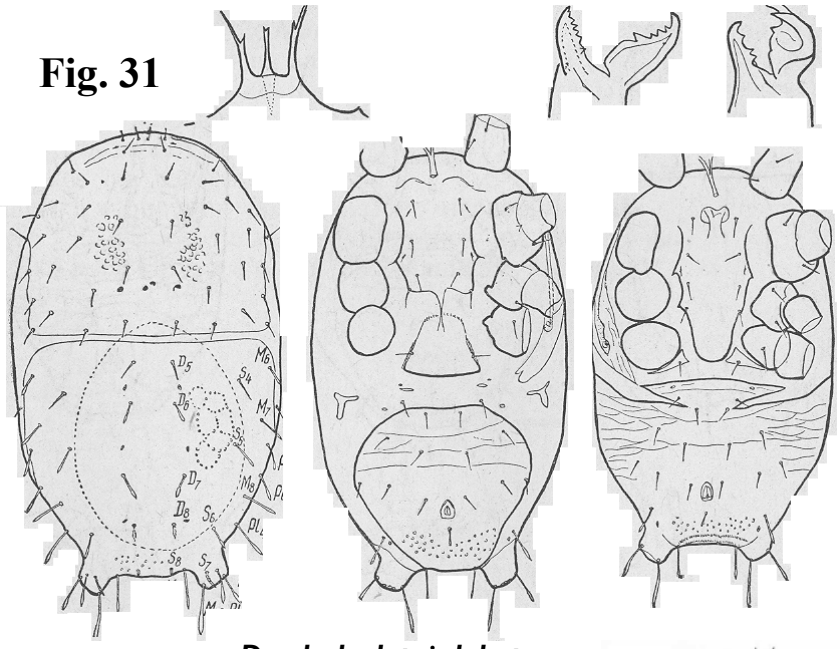
18. Peritreme forming a loop (fig. 33), entering the stigma posteriorly. Accessory genital sclerites (at lateral margin of genital shield) well developed. Leg I without claws; genu I normally with 2 ventral setae…….Macrochelidae……..……19

- Peritreme not forming a loop, entering the stigma anteriorly (normal condition). Accessory sclerites not well developed. Leg I usually with claws, genu I normally with 3 ventral setae…….

…… ……..22

19. All dorsal setae excluding excluding *J5* smooth and short; ventral shields finely ornamented, line between *st2* almost straight to semi-circular (fig. 34)..……. *Macrocheles medarius* (Berlese)

Fig. 31



Dendrolaelapsis lobatus

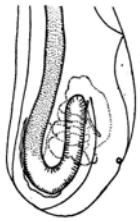


Fig. 33

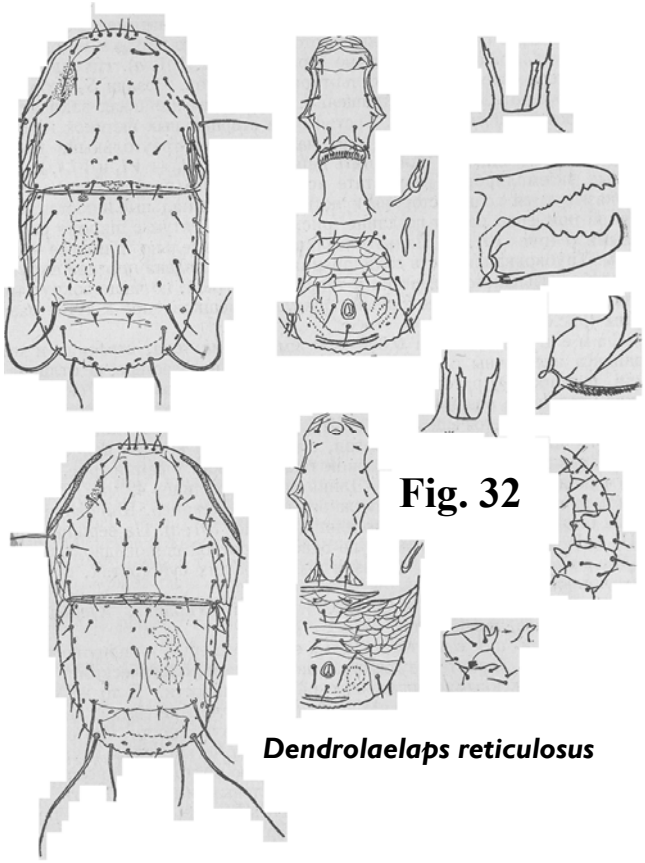


Fig. 32

Dendrolaelaps reticulosus

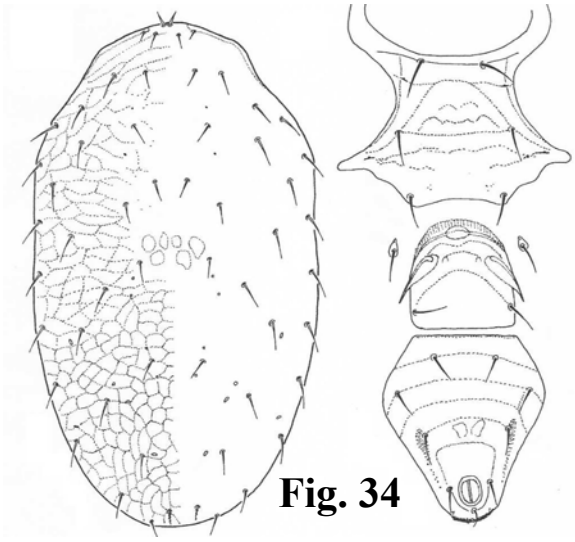


Fig. 34

Macrocheles medarius

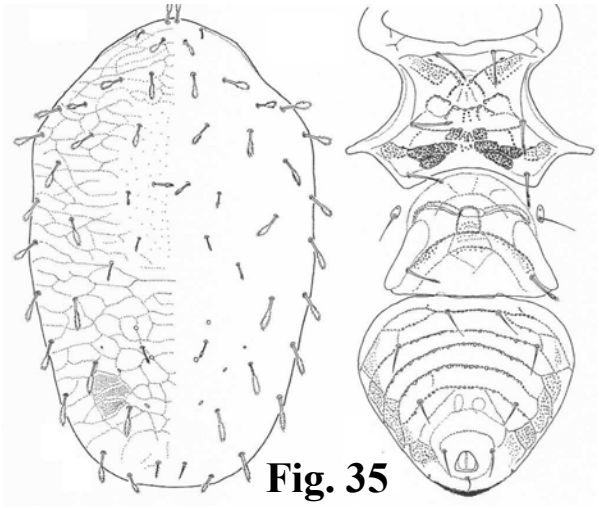


Fig. 35

Macrocheles matrius

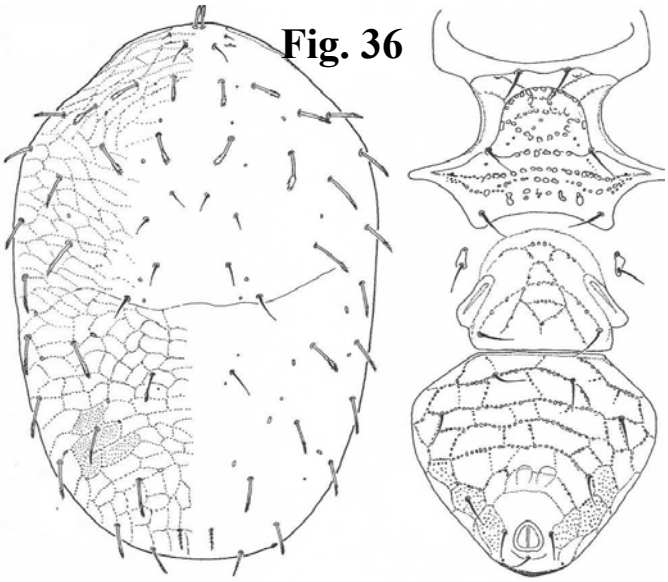


Fig. 36

Macrocheles muscaedomesticus

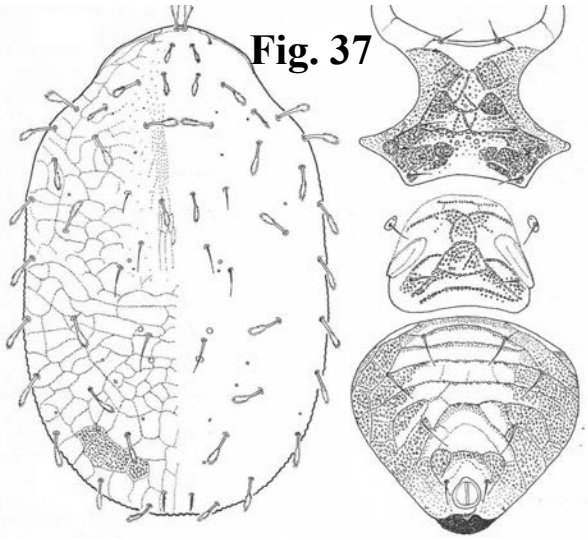


Fig. 37

Macrocheles penicilliger

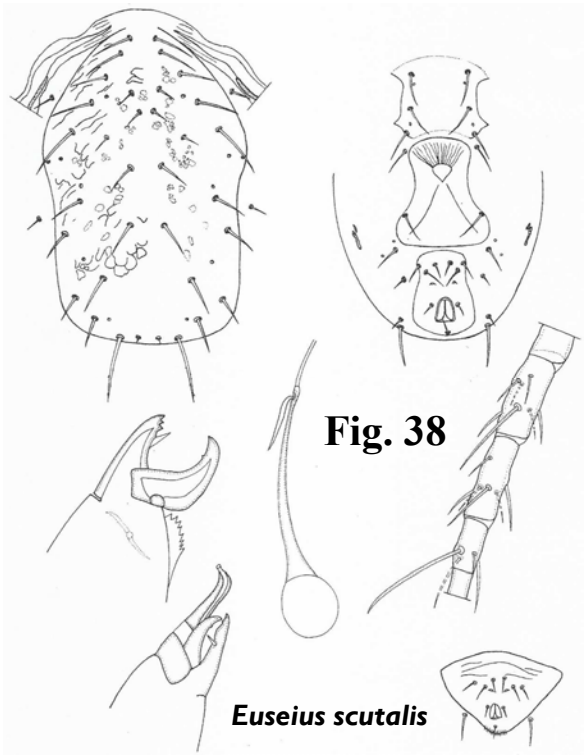


Fig. 38

Euseius scutalis

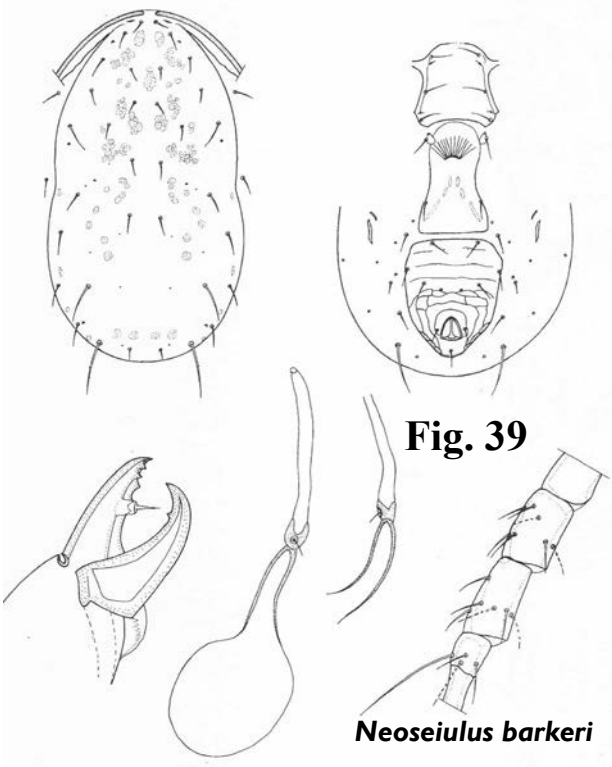


Fig. 39

Neoseiulus barkeri

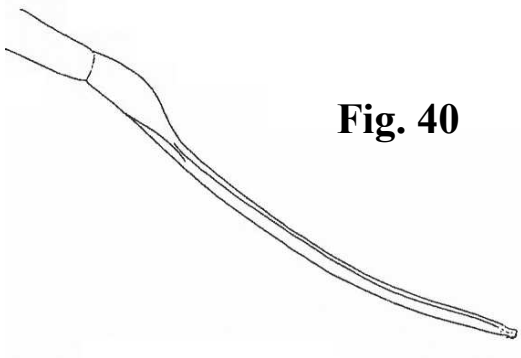


Fig. 40

- Dorsal setae on same shield either hairy (pilose), hairy and slightly expanded distally or short and smooth…….…… 20

20. All dorsal setae hairy: dorsocentral setae and *z1* needle like and hairy the rest distally hairy and expanded; line connecting setae *st2* connected with 2 small punctate areas medially (fig. 35)…….. ……..……*Macrocheles matrius* (Hull)

- Not all dorsal setae hairy; line between setae *st2* ornamented with punctuations and pits.…..….21

21. All dorsal setae hairy with some slightly expanded distally, except for *z1, j2, j5, j6, z5, z6* and *J2* which are shorter and smooth; line connecting setae *st2* almost straight with few large punctations (fig. 36)…….*Macrocheles muscaedomesticus* (Scopoli)

- All dorsal setae hairy and expanded distally except for setae *z1, z5, z6, j6* and *J2* which are smooth with *z1* minute, *J5* is only hairy and not expanded distally; sternal shield with large punctuated areas, line between setae *st2* undulate and edged by punctuations (fig. 37)…… ……..*Macrocheles penicilliger* (Berlese)

22. Dorsal chaetotaxy much reduced; usually 20 or fewer pairs of setae present. Tibia and genu I typically with 4 dorsal setae……Phytoseiidae……..23

- Dorsal chaetotaxy not so reduced; usually 25 or more pairs of setae (including marginal setae that may be off or on the dorsal shield). Tibia and genu I with more than 4 dorsal setae……..…24

23. Most dorsal setae short, except for setae *s4* and *Z5* which can be clearly longer; sternal shield with a median projection; ventrianal shied reduced, vase-shape or ovoid; preanal setae almost aligned in 2 or 1 row with setae *Jv1* in line with *Zv2*; macrosetae on leg IV, genua II and III and in a few on genu I; peritreme short, reach to a level between setae *z2* and *z4*; spermatheca (reproduction organ)a long slender tube gradually flaring towards vesicle…….. …… ……*Euseius scutalis* (Athias-Henriot)

- Most dorsal setae short, except for setae *Z5* and sometimes *Z4* which can clearly longer; sternal shield without a median projection; ventrianal shied never vase-shape or ovoid; preanal setae not

aligned, setae *Jv1* on anterior margin of ventrianal shiels; macrosetae only on leg IV; peritreme usually reach to level of setae *j1* but some can be shorter; spermatheca tube-like slightly flared towards vesicle, atrium bifid……...…….*Neoseiulus barkeri* Hughes

24. Chelicerae with the second segment greatly elongated (fig. 40), stylet-like; cheliceral digits (chelae) minute, never chelate; corniculi membranous; sternal shield broader than long; anal shield in the female D-shaped; males with fixed digit reduced and the elongate spermadactyl entirely fused with the movable digit; tarsi III and IV of the male with seta *pv2* modified into a short, tooth-like projection. Nest parasites of birds and mammals ……Dermanyssidae…… Dorsal shield with 4 pairs of dorsocentral setae (j-J), *J2* present, setae *z6* present, al1 seta of palp genu lanceolate, shield tapers posteriorly but posterior margin is truncate; genua II and III each with 2 *pl* setae (fig. 41)……...……..……..*Dermanyssus gallinae* (De Geer)

- Chelicerae never with second segment greatly elongated, stylet-like, one or both digits (chelae) well-developed; tarsi III and IV of the male with seta *pv2* not modified into a short, tooth-like projection……..…….25

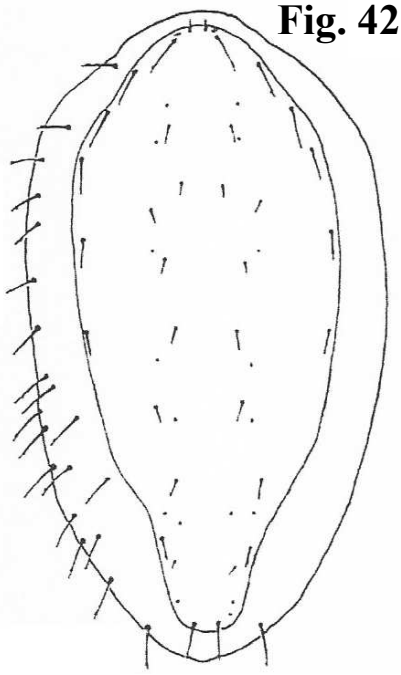
25. Female with genital shield truncate or weakly convex posteriorly and narrowly separated from or abutting a ventrianal shield or widely separated from an anal shield that is round or oval but usually not inversely subtriangular……31

- Female with genital shield broadly or narrowly rounded posteriorly, usually widely separated from inversely subtriangular anal shield or genital shield expanded into a genitoventral shield with more than one pair of setae, genus *Ololaelaps* with genital, ventral and anal shields fused, or dorsal and ventral shields can be reduced with dorsal and genital shields mostly narrowing or tapering posteriorly……..26

26. Corniculi horn-like, strongly or weakly sclerotized. Chelicerae usually chelae-dentate; if teeth absent, then pilus dentilis present. Genital shield sometimes enlarged and with more than one pair of setae. Free-living predators, associates of arthropods, nest associates and/or parasites of birds and mammals…….Laelapidae……..28

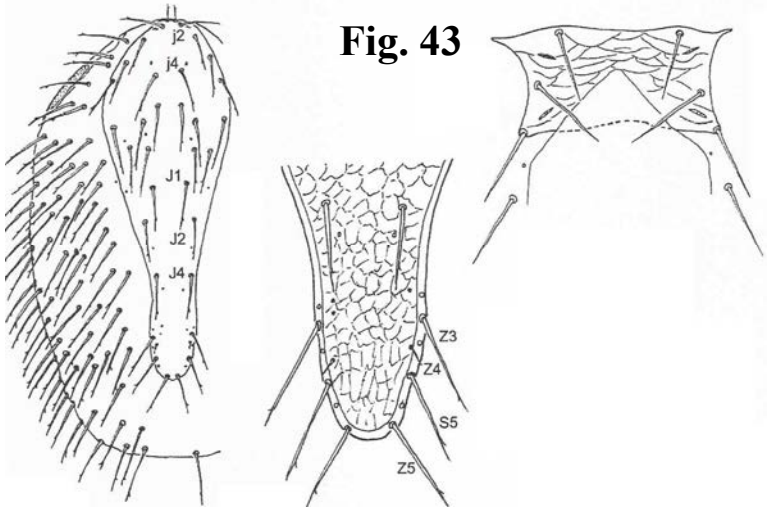
Fig. 41 ***Dermanyssus gallinae***

Fig. 42

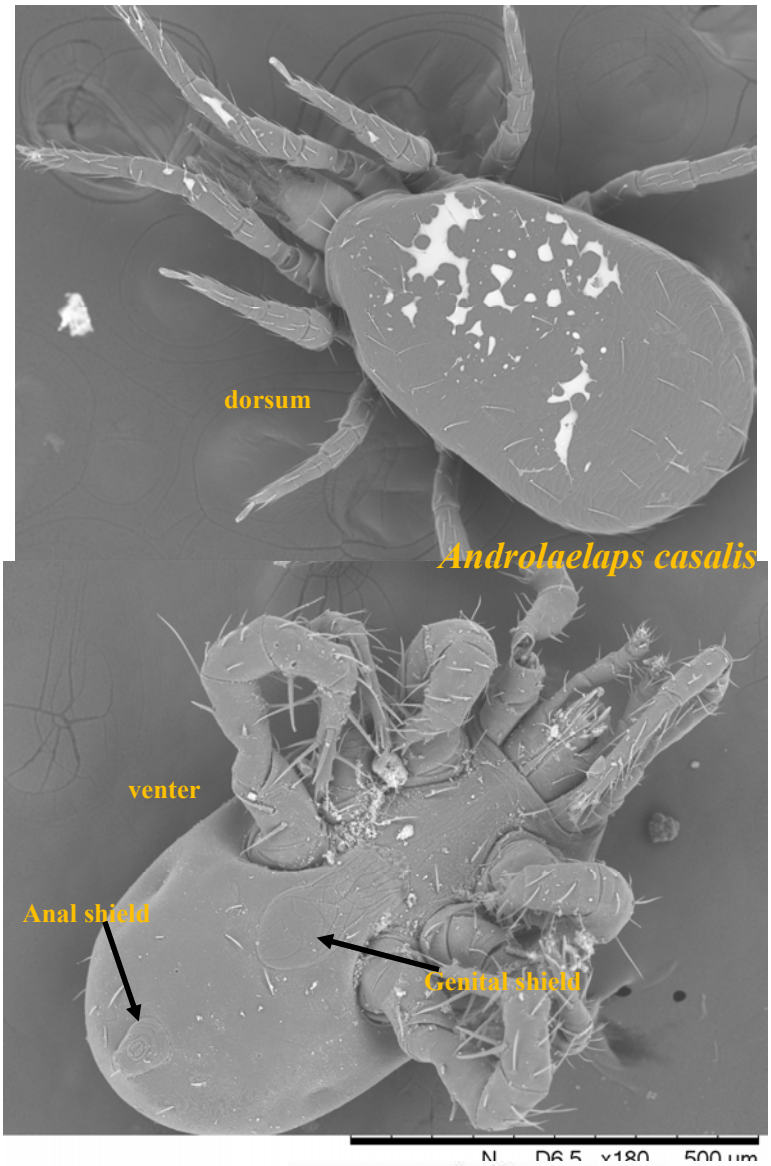


Ornithonyssus sylviarum

Fig. 43



Ornithonyssus bacoti



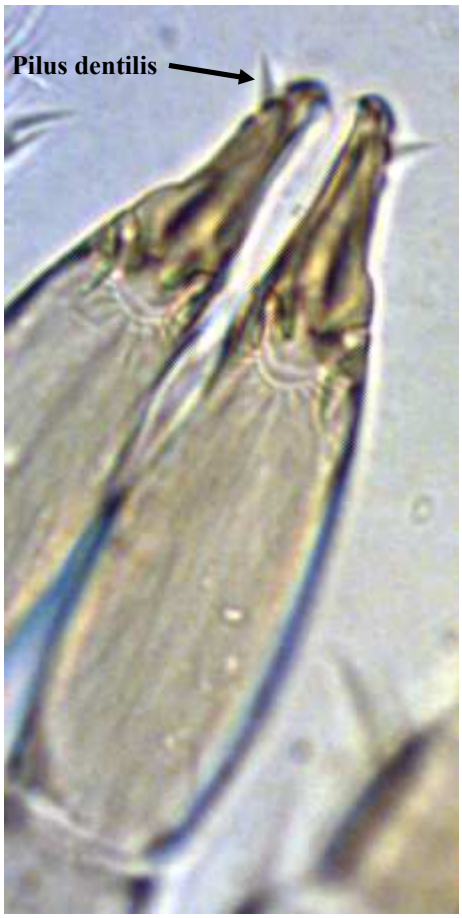
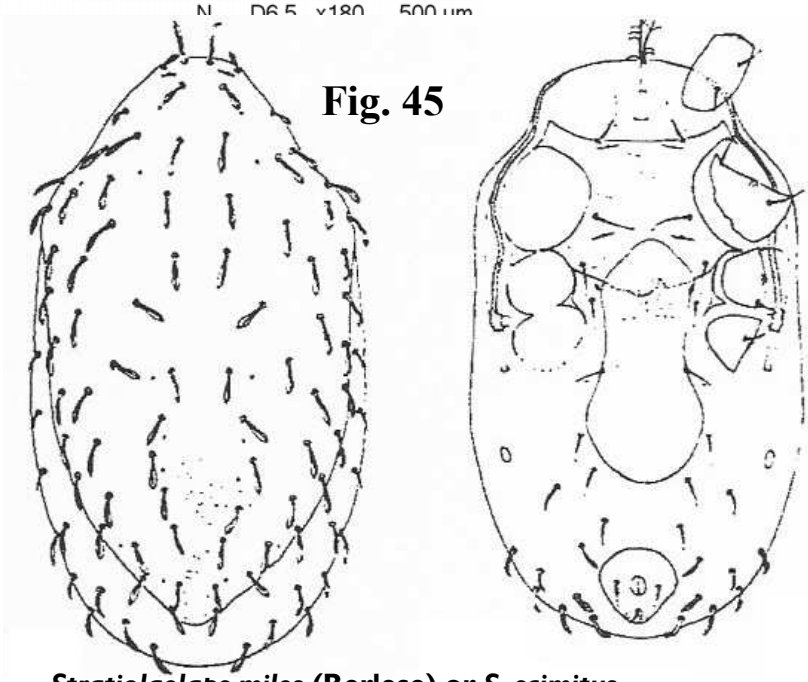


Fig. 44

Fig. 45



Stratiolaelaps miles* (Berlese) or *S. scimitus

- Coniculi never horn-like, usually in form of hyaline lobes. Chelicerae slender, digits edentate and pilus dentilis absent. Genital shield never expanded to include more than one pair of setae. Nest and host-dwelling parasites of reptiles, birds and mammals……..Macronyssidae……..
  …….Dorsal and genital shields taper posteriorly, setae *j3* absent; sternal shield broader than long, usually with 3 pairs of setae; coxa I may have blunt spur or knob, coxa II has a small spike-like anterior spur, rarely absent; palp trochanter with small ventral process; length of second segment of chelicera 8-20 times width of shaft……*Ornithonyssus*……..27

27. Setae on dorsal shield very short, setae *S5* absent; spur on coxa II absent (fig. 42)……
  ……..…..*O. sylviarum* (Canestrini & Fanzago)

- Setae on dorsal shield much longer reach to or pass setae next behind, setae *S5* present; spur on coxa II present (fig. 43)……...……..*O. bacoti* (Hirst)

28. Genu IVwith 10 setae; pilus dentilis long, slender or inflated; chelicerae of male with fixed digit reduced and movable digit partially or entirely fused with elongate grooved spermatodactyl, male chelicerae never chelate-dentate; genital shield with one pair of setae (*st5*), expanded posteriorly but not abutting anal shield, one pair of setae between genital and anal shields, genital and anal shield surrounded with about 20 pairs of setae; pilus dentilis quite long, slender and clearly Visible (fig. 44)……..……...*Androlaelaps casalis* (Berlese)

- Genu IV with 9 setae; if with 10 setae then pilus dentilis short, setiform; chelicerae of male chelate-dentate, spermatodactyl free……...……29

29. Corniculi long, slender, extending almost to level of anterior margin of palp femur; dorsal setae leaf-like, spatulate. ……Dorsal shield setae leaf-like with a distal sharp point; edge of tectum irregularly toothed with small median spine (fig. 45)……
  ……. *Stratiolaelaps miles* (Berlese) or *S. scimitus* (Womersley)

- Corniculi relatively short reaching about middle of palp femur; dorsal setae simple, spatulate, cuneiform or scimitar-like……..…..…….30

29. Dorsal setae spatulate, cuneiform or scimitar-like; genital shield can be slightly expanded posteriorly……..……..*Cosmolaelaps*

- Dorsal setae simple, setae uniformly long, dorsal shield usually with 39 pairs of setae; genital shield tongue-shaped; anterior margin of tectum rounded or subtriangular, sometimes almost straight, occasionally with few short projections, exceptionally with a narrow subtriangular projection……..…… *Gaeolaelaps*……30

30. Tarsus IV with thick long spiniform setae; many setae on legs II-IV very thick and spiniform; opisthosomal setae short, some dorsal setae sword-shaped; seta *al1* on palpgenu blunt rounded, hypostomal seta *h3* level with or slightly anterior to *h2* (fig. 46*)*……*G. aculeifer* (Canestrini)

- Tarsus IV without long spiniform setae; dorsal setae uniform; fixed cheliceral digit with 3 teeth .(fig. 47)…….*G. intermedius* Bernhard

31. Corniculi divided distally. Dorsal shield setae *J5* absent (also in *Ornithonyssus*, Macronyssidae). Sternal shield bearing sternal setae *st1* and *st2*; setae *st3* usually on small shields. Dorsal shield entire, ornamented in various ways and with dorsal setae expanded or elongated…… …….. Ameroseiidae…….Dorsal shield strongly sculptured or ornamented with series of interconnecting ridges with 29 pairs of setae, setae usually large and plumose or serrate; sternal shield with two pairs (rarely three) of setae; genu with 2 ventral setae ……..*Ameroseius* sp.

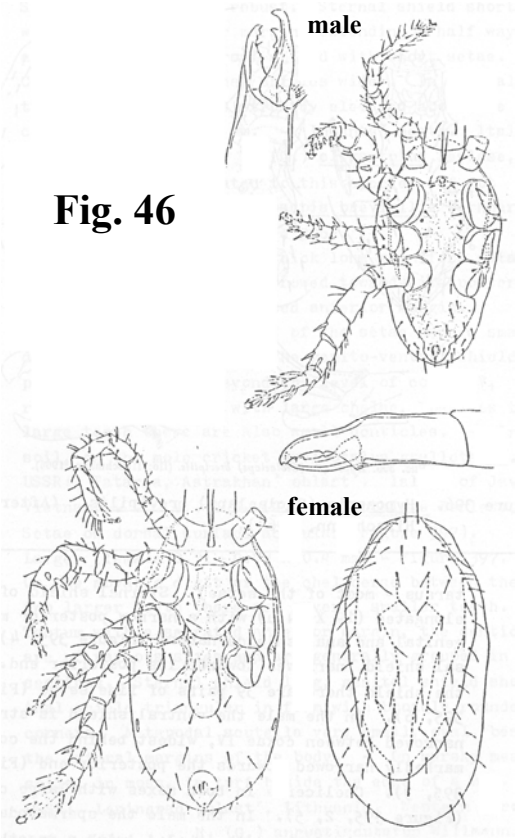
- Corniculi not divided distally (if, divided or cleft distally as in a few Ascidae and Laelapidae, then the dorsal setae are simple: not expanded or greatly elongated). Dorsal shield setae *J5* present ……...……..……..32

32. Female with third pair of sternal pores on posterolateral corners of sternal shield, with sternal setae *st4* usually free on soft cuticle; movable digit usually with 2 teeth……..…Ascidae

- Female with third pair of sternal pores off sternal shield associated with sternal setae *st4* on soft cuticle or metasternal shields; movable digit with zero to many, often with 3 teeth….. ……33

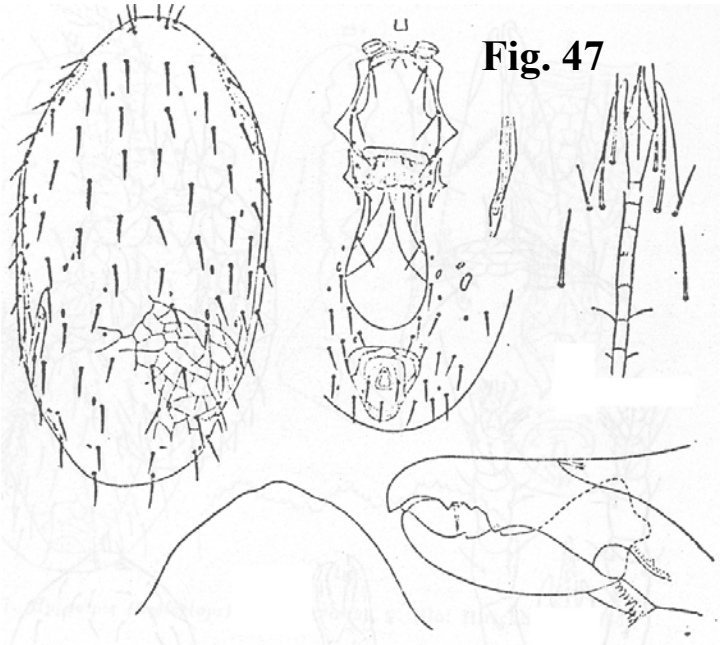
33. Fixed cheliceral digit with pilus dentilis modified to a hyaline flap, movable digit with a pointed process (mucro) on its mid-ventral face; eproductive system (spermatheca) of female with

Fig. 46



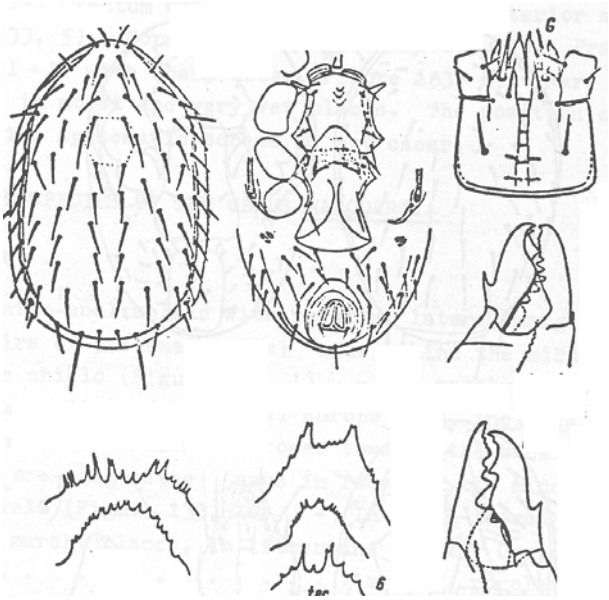
Gaeolaelaps aculeifer

Fig. 47



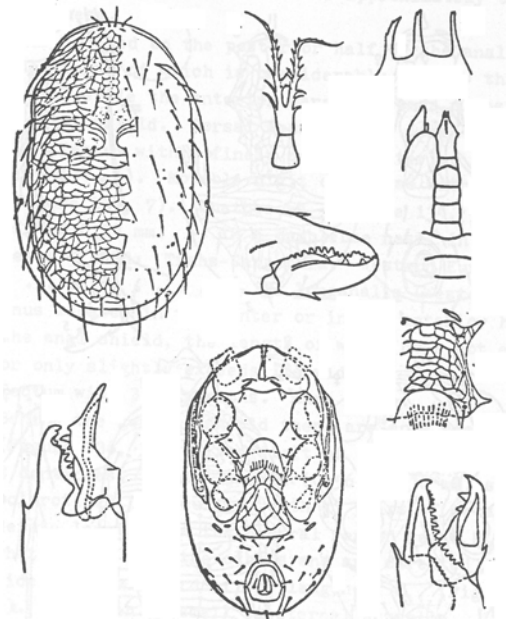
Gaeolaelaps intermedius

Fig. 48



Proctolaelaps pygmaeus

Fig. 49



Proctolaelaps scolyti

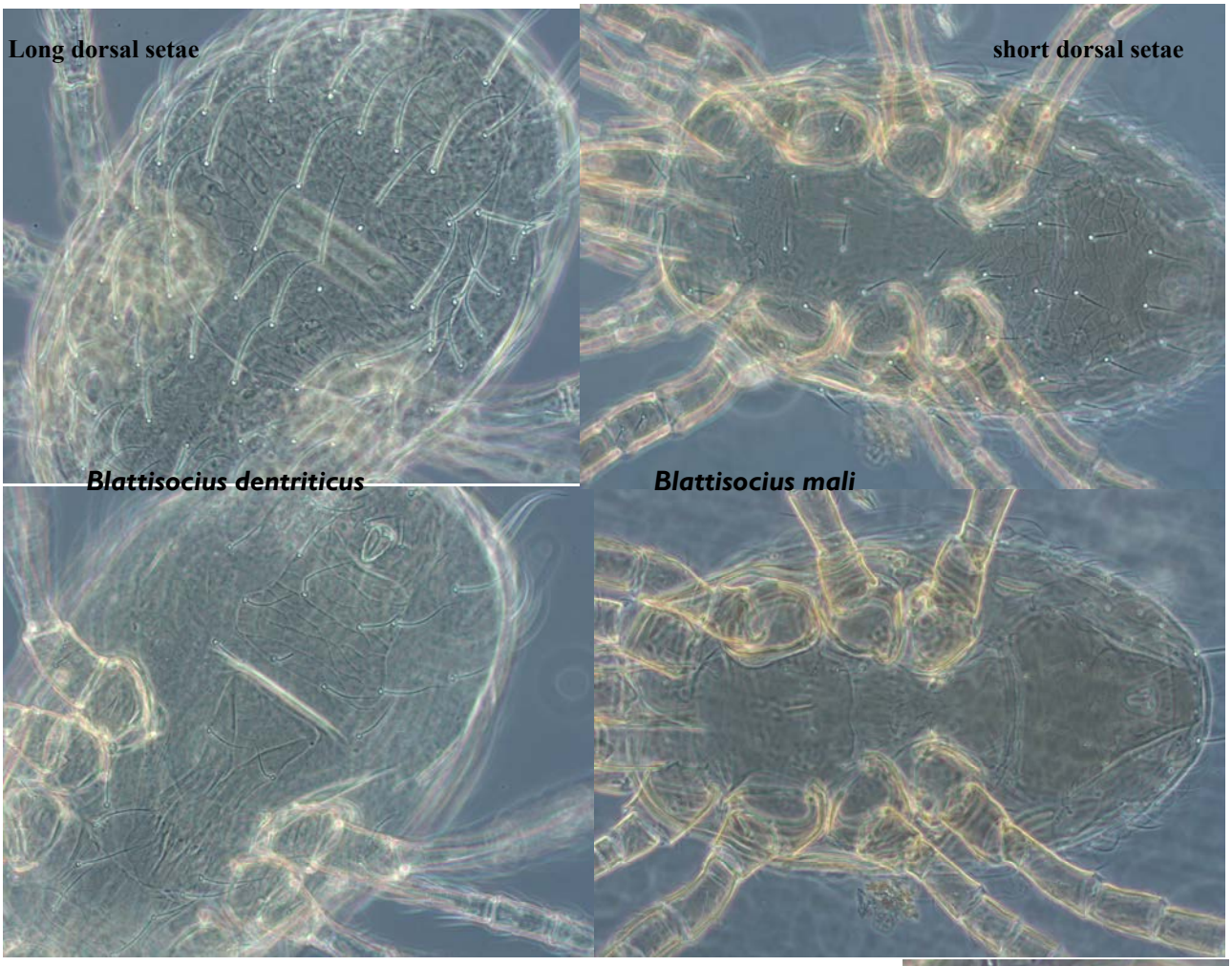


Fig. 50

Fig. 51

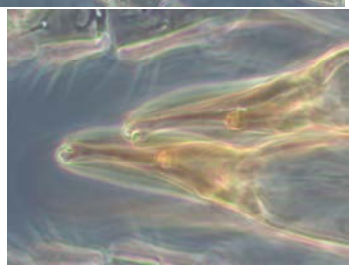
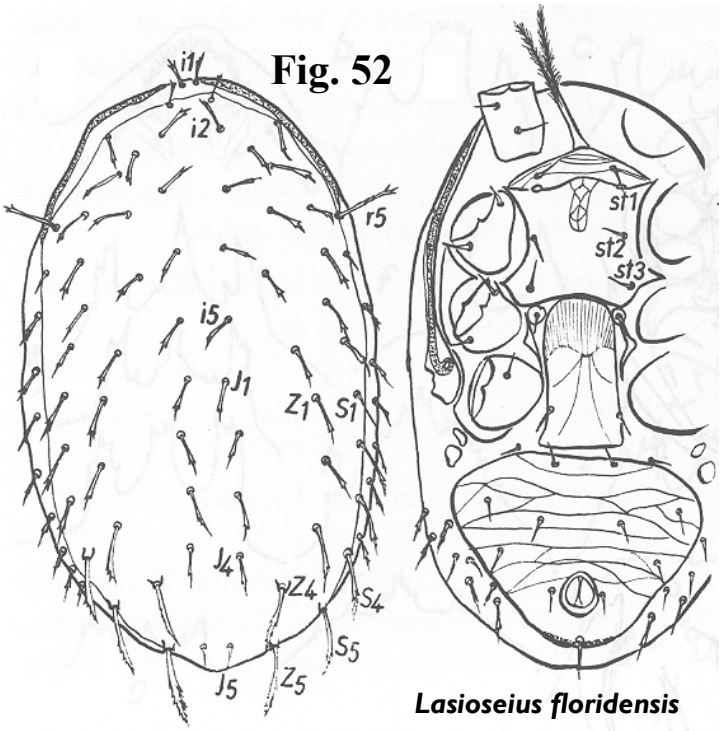


Fig. 52



Lasioseius floridensis

two tubes each originating on a coxa III and connecting with a calyx (laelapid type). Female genital shield gently rounded posteriorly and usually with an oval anal shield bearing only three anal setae ……..Melicharidae……...…….

Anal shield with 3 circumanal setae (3 setae surrounding anal opening); genital shield somewhat broadned posterior part and with 1 pair of setae; fixed cheliceral digit with s row of small teeth; anal opening large, rarely of medium size……..…..*Proctolaelaps* ……..…..34

- Fixed cheliceral digit with pilus dentilis unmodified, movable digit without a pointed process (mucro). Reproductive system of female comprising two separate spermathecae each with its own calyx originating between coxae III and IV. Female genital shield truncate posteriorly and usually with a ventrianal shield with 2-7 pairs of preanal setae in addition to 3 anal setae……. ……..…...Blattisociidae ……...……35

34. Anterior hypostomal setae *h1* thicker than the others; 43 pairs of setae on dorsal shield, most fairly long; tectum with numerous denticles (fig. 48)……*P. pygmaeus* (Müller)

- All hypostomal setae of approximately the same thickness; 42 pairs of fairly long setae on reticulate dorsal shield; tectum serrate; tritosternum with short base; genital shield reticulate with straight posterior margin (fig. 49)……...……*P. scolyti* Evans

35. Most dorsal setae longer than distances to next posterior setae; sternal shield with 2 pairs of setae with *st1* on shield and *st3* and *st4* on a metasternal shield narrowly connected to sternal shield; pilus dentilus very short (fig 50)……..…….*Blattisocius dentriticus* (Berlese)

- Most dorsal setae shorter than distances to next posterior setae; sternal shield with 3 pairs of setae with *st1* off shield and *st4* on soft cuticle; pilus dentilus distinctly long (fig. 51)…….. …….*Blattisocius mali* (Oudemans)
- Dorsal shield entirely reticulated and punctate in area between setae *J4, Z4 and Z5,* setae *Z3-Z5, S4, S5* and *JV5* tricarinate and serrate, almost all dorsal setae tricuspid distally; sternal setae *st1* on weakly sclerotized anterior area; fixed cheliceral digit with 12 teeth and movable digit with 3; tectum triramous with each prong denticulate (fig. 52)…….....……*Lasioseius floridensis* Berlese

4. KEY TO THE GENERA AND SPECIES OF THE ORDER TROMBIDIFORMES

1. Peritreme situated on the gnathosoma, distinct ……..…..2

- Peritreme on anterior margin of prodorsum or between, at base of chelicerae or cheliceral vault, distinct or indistinct……...…….6

2. Body oval or elongate; palp a thumb-claw complex, palptarsus with 2 comblike and 2 sickle-shaped setae, tibia with a strong claw; free living predators……Cheyletidae……3

- Body elongate, almost worm-like; palpi four-segmented not a thumb-claw complex, tarsi with 2 claw-like eupathidia and 1 short stout eupathidium, living in large feather shafts of birds (fig. 53)…. ……..…….Syringophilidae

3. Eyes present …….....….5

- Eyes absent; palp with 2 comb-like setae; peritremes M or an inverted U-shape, posterior peritrematal link not abruptly bent inwards (fig. 6); palp tibial claw with 1-4 teeth…...*Cheyletus*.....4

4. Females without median setae on dorsal shields; guard seta closely associated with solenidion on tarsus of leg I twice or more shorter than solenidion (fig. 54); femur IV with 2 setae..... ……. *C. eruditus* (Schrank)

- Females without median setae on dorsal shields; guard seta closely associated with solenidion on tarsus of leg I twice or more shorter than solenidion; femur IV with one seta; distance between prodorsal and opisthosomal shields less than half length of opisthosomal setae *l1*, setae *l2* situated far behind anterior margin of opisthosomal shield; setae vi and sc*i* subequal, setae *l1*, *l2* and *l3* subequal; rostrum with pair of lateral teeth……...…..…*C. bidentatus* Fain & Nadchatram cf

5. Leg I as long as or longer than body, leg I with pretarsal claws minute or absent..……..…….*Cheletomorpha*

- Leg I clearly shorter than body, leg I with pretarsal claws absent, replaced by 4 conspicuous terminal Setae (fig. 55)……...……..…….*Prosocheyla*

6. Large mites with long hairy legs, body longer than wide; palp a thumb-claw complex with palptibia with 2

Fig. 53

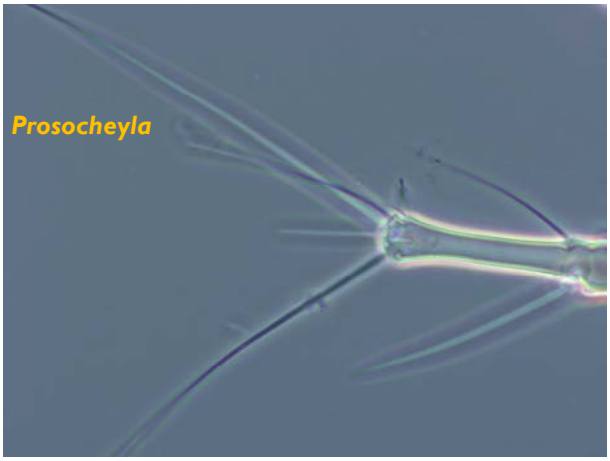
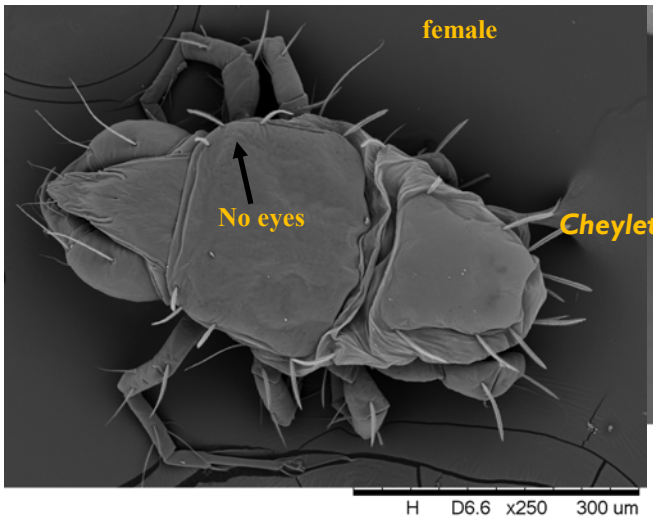
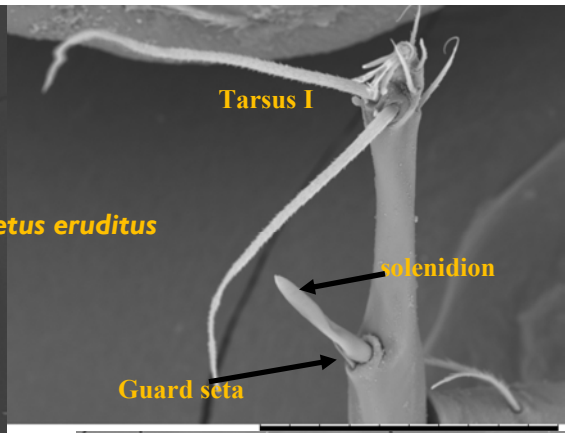


Fig. 55

Syringophilidae





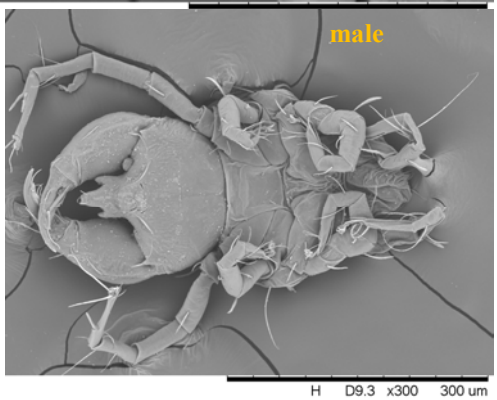


Fig. 54

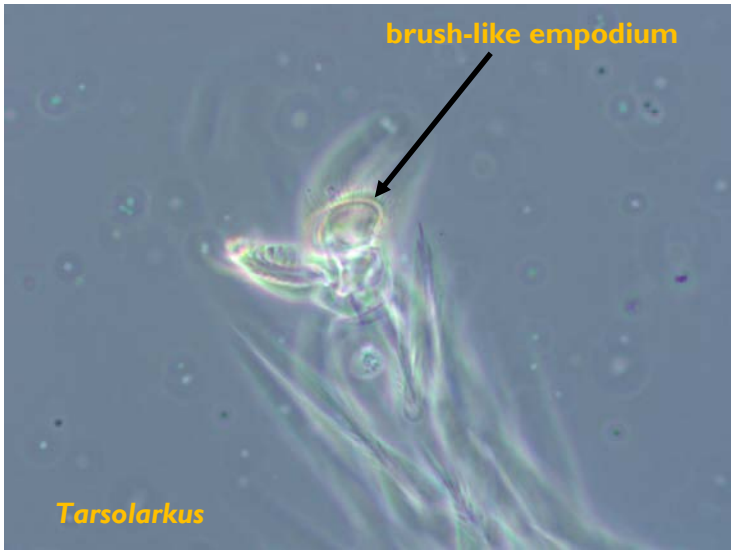


Fig. 56

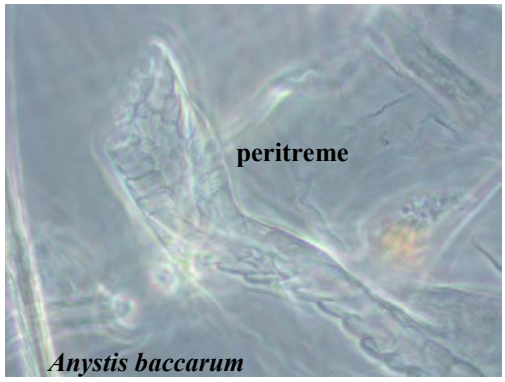


Fig. 57

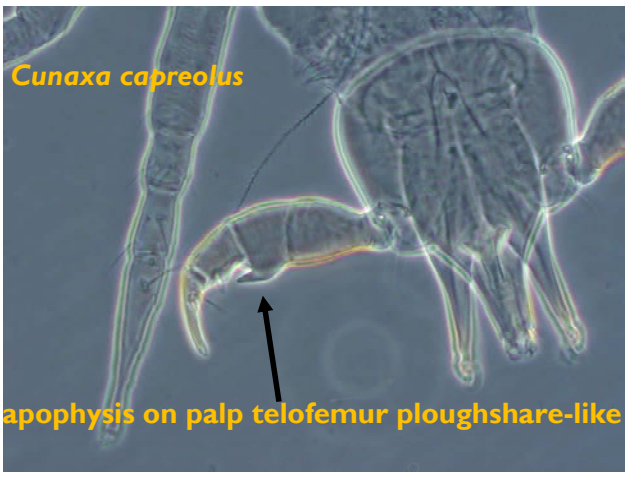


Fig. 58

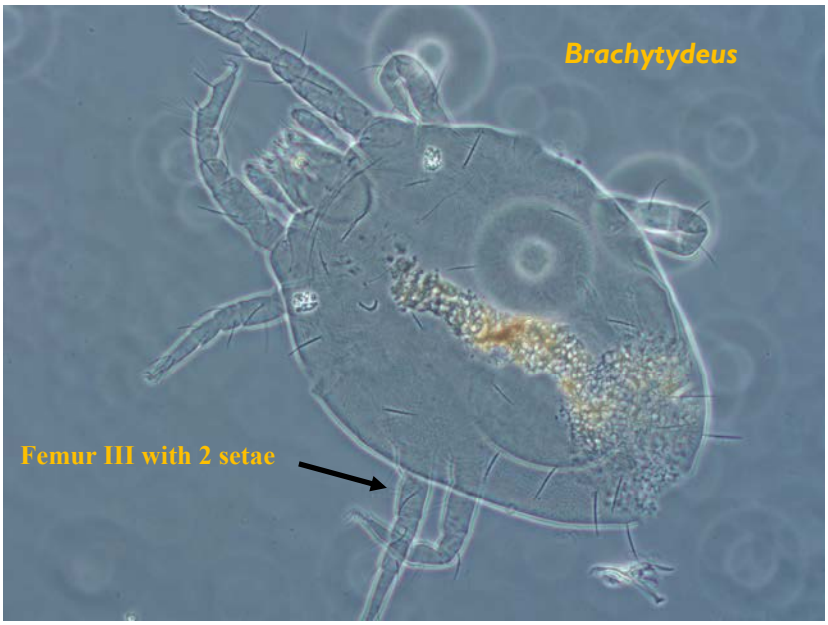


Fig. 59

sensory setae in pits……Erythracaridae……pretarsi of legs with a brush-like empodium between 2 large pectinate claws (fig. 56)……..….*Tarsolarkus*

- Large mites with long, hairy radiating legs, body short and broad; palp a thumb-claw complex, palptibia with 3 denticulate claws…….Anystidae……..…… Prodorsal shield kidney-shaped, peritreme flared distally (fig. 57)...…….*Anystis baccarum* (Linn)
- Small mites with legs not long and hairy; palp not a thumb-claw complex, tibiae not with claws ……..7

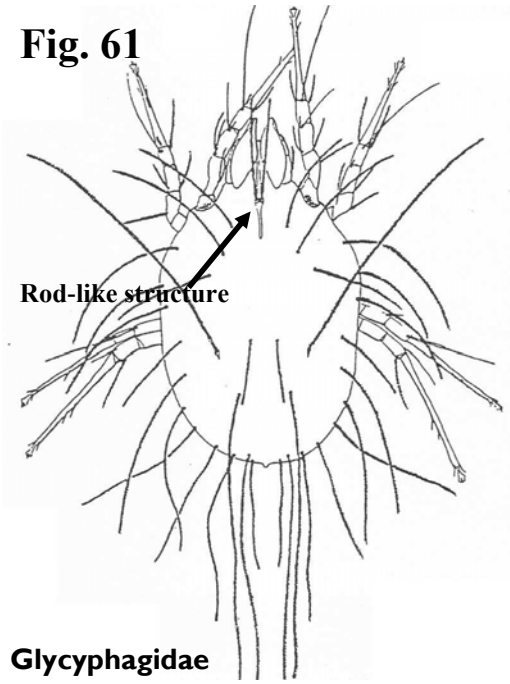
7. Very small, mites with simple palpi; prodorsum with one pair of sensory setae in pits; all legs with pretarsi with 2 claws and a brush-like empodium……Tydeidae……..8

- Larger mites, with large 3 to 5 segmented palpi, palptarsus ending in a stout claw; prodorsum with 2 pairs of long hairy sensory setae in pits; pretarsi with 2 claws and 3 rayed empodium……. ……Cunaxidae……..Dorsal shields never reticulate; palp five segmented; setal count of coxae II-IV, 1-3-2; apophysis on palp telofemur ploughshare-like; on genua a large apophysis with a forwardly directed apex (fig. 58)…..…….*Cunaxa capreolus* Berlese

8. Setal count of leg genua 3-2-1-1, setal count of leg femora 3-2-1-1……*Tydeus*

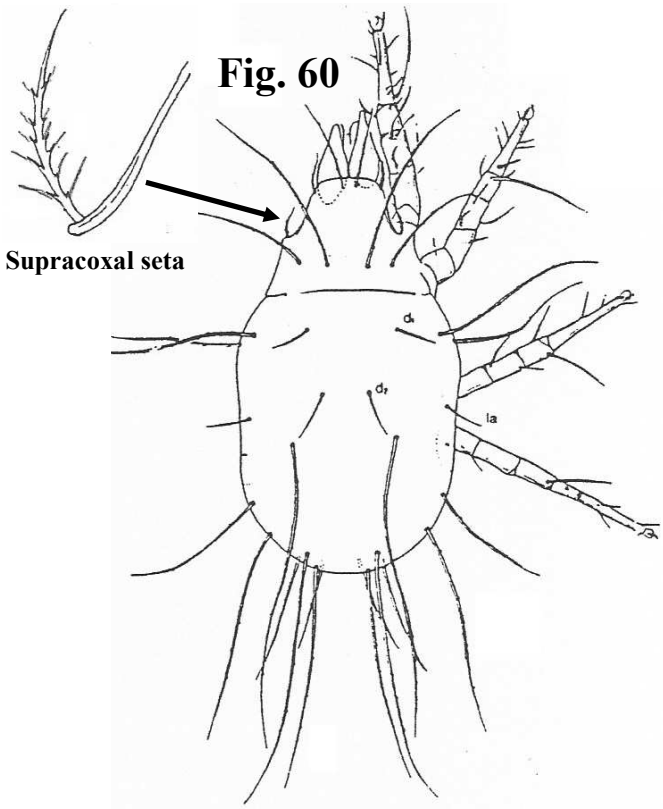
- Setal count of leg genua 3-2-1-1, setal count of leg femora 3-3-2-1 (fig. 59)……..……*Brachytydeus*

Fig. 61



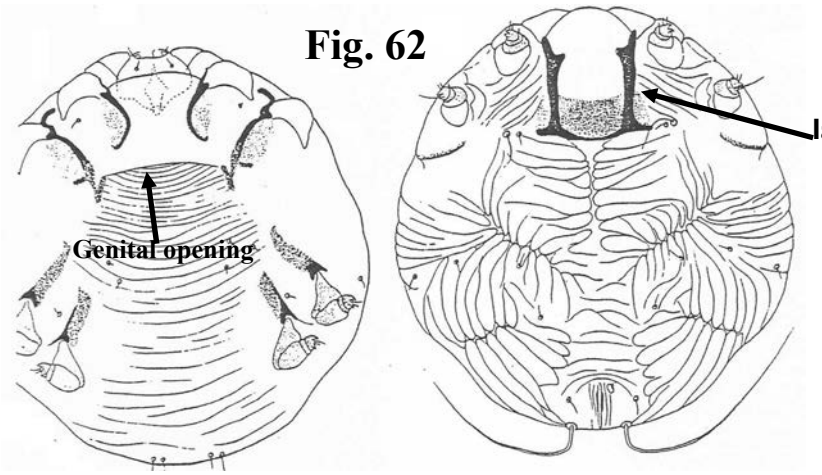
Glycyphagidae

Fig. 60



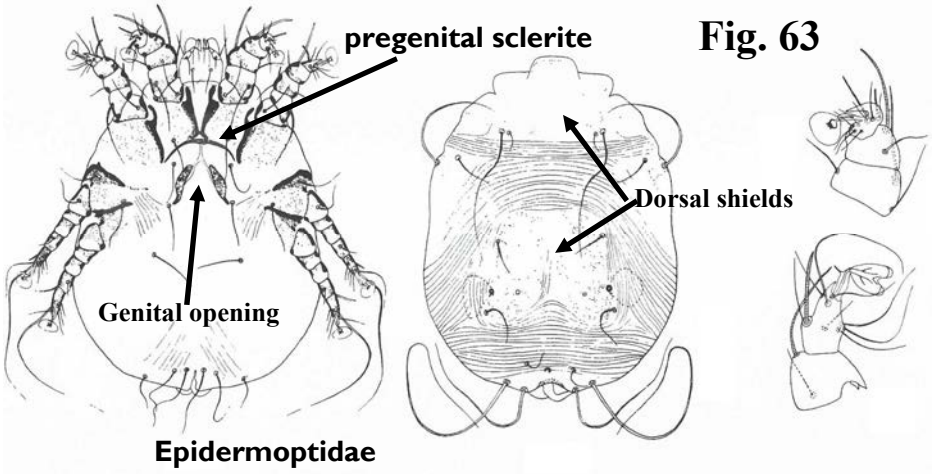
Tyrophagus longior

Fig. 62



Knemidocoptidae

Fig. 63



Epidermoptidae

5. KEY TO THE GENERA AND SPECIES OF THE ORDER SARCOPTIFORMES, COHORT ASTIGMATA

1. Free-, nest-living; ambulacrum (pretarsus) simple composed of a membranous cushion-like pad and a distinct claw usually attached to tarsus by a pair of condylophores , pad broadly attached to tarsus, round, bell, trumpet or other shape……..2

- Ectoparasite or endoparasite of mammals and birds. Ambulacral claw absent or ambulacrum (pretarsus) absent or displaced laterally and in each case apex of tarsus is claw-like; cushion-like pad of ambulacrum large, round, leaf, bell or trumpet shaped and usually with complex internal structures……..……..……4

2. Claw attached to apex of tarsus by a pair of short, thick condylophores surrounded by short cushion-like pad (fig. 10), broadly attached to tarsus; prodorsum and opisthosoma separated by a sejugal furrow; female genital opening without a pregenital sclerite (epipigynium)…….. ……Acaridae……Tibia I with 2 tactile setae (not solenidia); I of 2 solenidia distally on genu I not three time longer than the other member; internal scapular setae (*sci* longer than external scapular (*sce)*, all dorsal setae, except for *di* and or *d2* and or *l2*, may be very long; tarsus I with 5 spines ventro-distally; supracoxal setae (lateral to prodorsal shield) with short pectinations; solenidion on tarsus I long, slender, tapering towards tip and terminating into a pointed tip or slightly expanded (fig. 60)……...……..*Tyrophagus longior* Gervais cf.

- Claw free in cushion-like pad and condylophores absent or claw attached to a pair of long condylophores ……...…..…3

3. Apodemes of legs I and II of adults united with sternum to form a characteristic shape, (fig. 11) if not, pregenital sclerite (epigynium) is very large and bow-shaped; claws large, free, condylophores free, long and rod-like; most leg setae short spines; leg tarsi do not taper distally; most dorsal setae not exceptionally long; prodorsum without a long, sclerotized rod-like structure with a pair

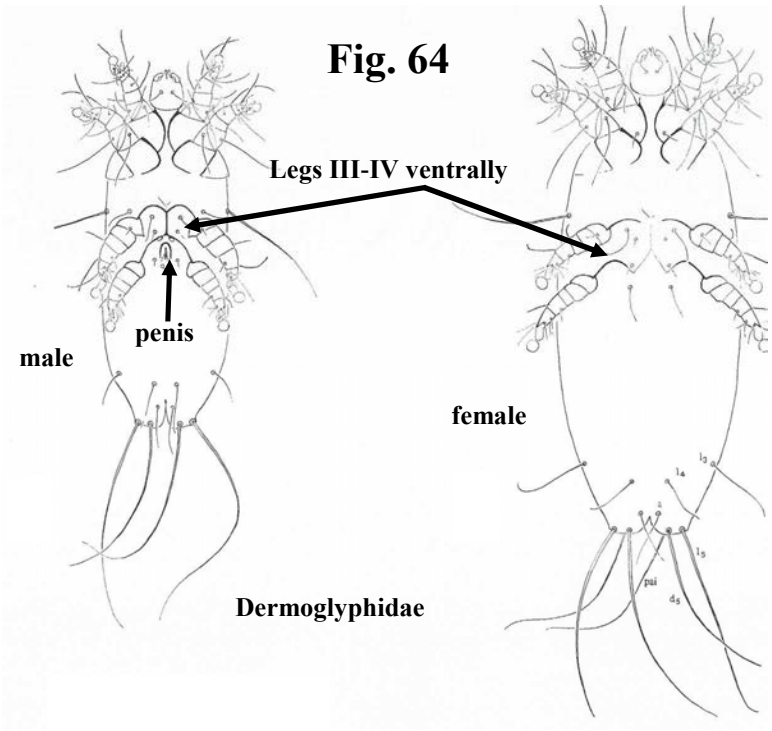


Fig. 64
Legs III-IV ventrally
penis
male
female
Dermoglyphidae

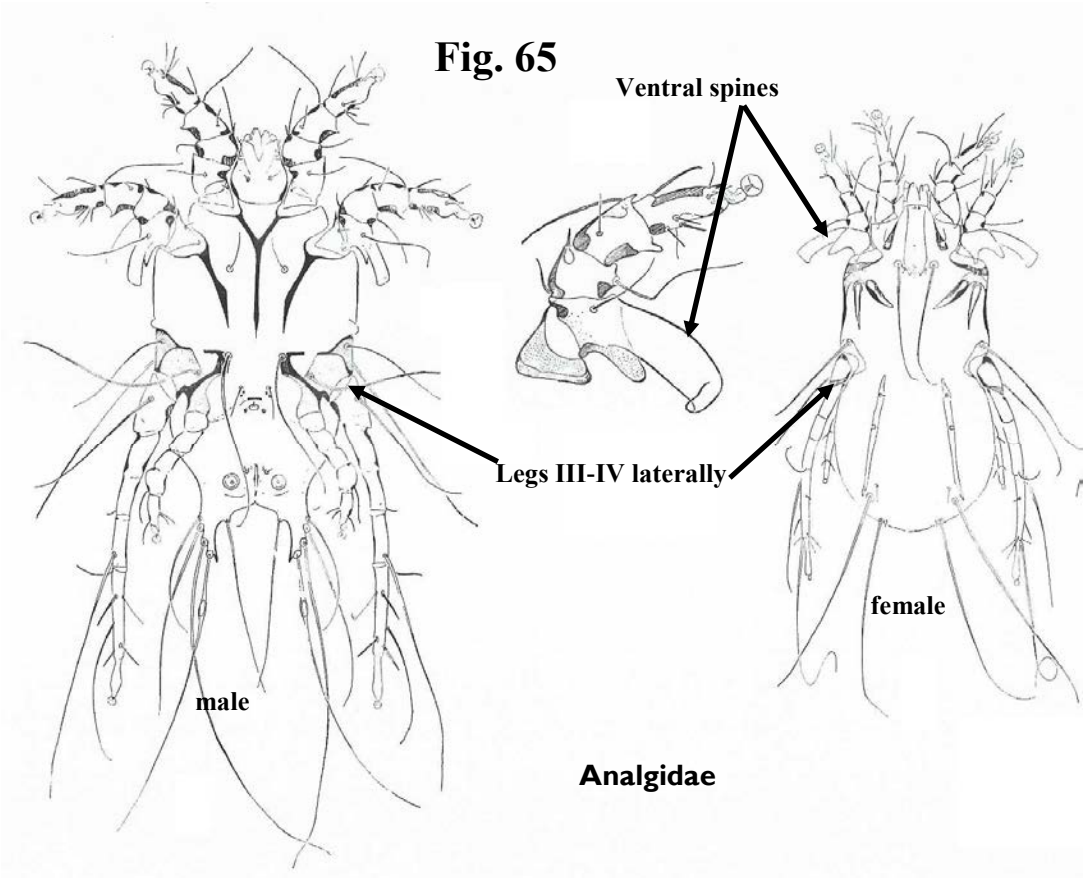


Fig. 65
Ventral spines
Legs III-IV laterally
male
female
Analgidae

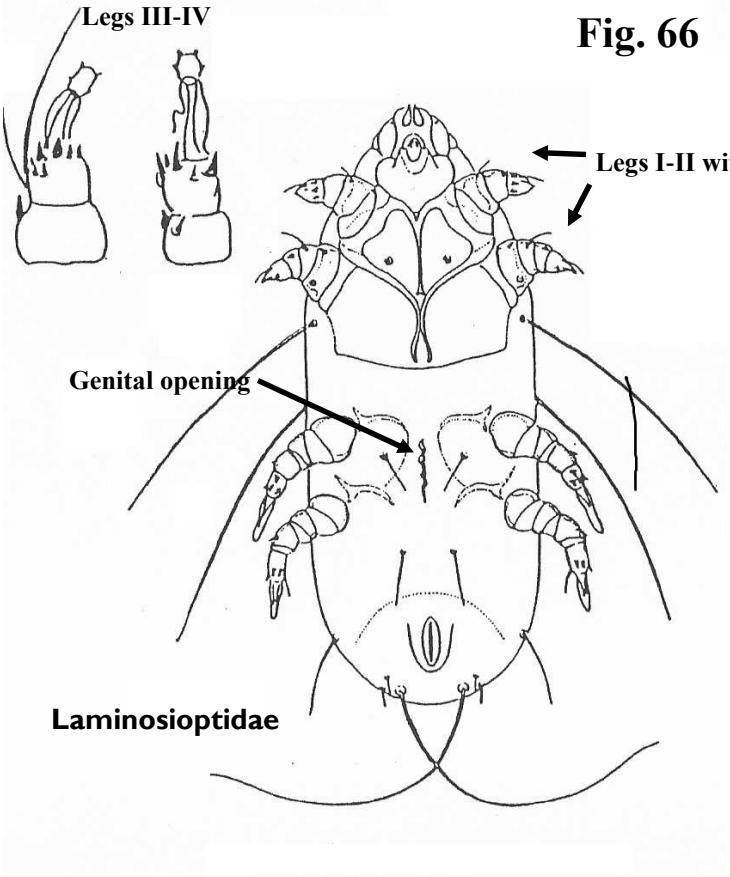

Legs III-IV
Legs I-II without pretarsi
Genital opening
Laminosioptidae

Fig. 66

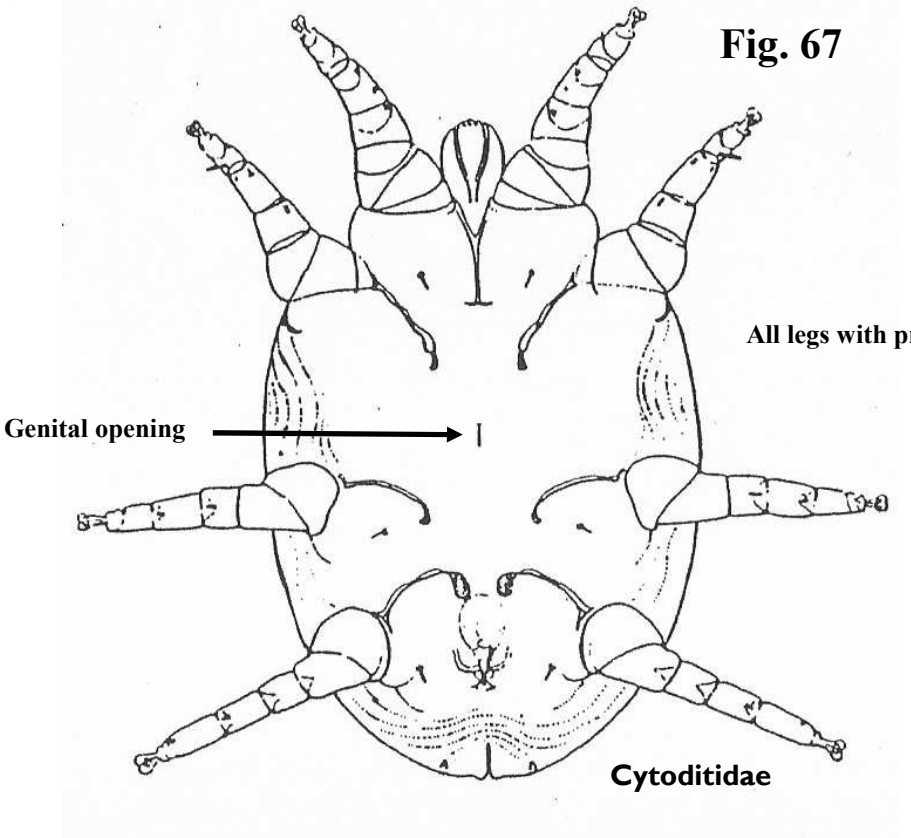

All legs with pretarsi but latter without
Genital opening
Cytoditidae

Fig. 67

of setae medially……..……..……..Carpoglyphidae

- Apodemes of legs I and II not united in above manner, claws small and free in cushion-like pad; all dorsal setae exceptionally long and plumose; prodorsum medially with a sclerotized rod-like structure with a pair of long setae; leg tarsi taper distally (fig. 61)……...…….Glycyphagidae

4. Female genital opening a simple transverse slit without a pregenital sclerite (epigynium); body fairly circular; prodorsal shield flanked with distinct lateral sclerites; female tarsi I and II without stalked empodial suckers legs very short; ; epimeres I free but fused into a Y-shape in males; skin parasites of birds (fig. 62)…… Knemidocoptidae (now subfamily of Epidermoptidae)

- Female genital opening a longitudinal slit, sometimes diverging posteriorly to form a very narrow V or Y shape; pregenital sclerite absent or minute; all legs without long setae……..……...7
- Female genital opening an inverted V or Y shape ……..5

5. Prodorsal and opisthosomal shields present; prodorsal shield without lateral sclerites; female tarsi I and II with stalked, round empodial suckers, legs long, solenidion on genu III absent; genital opening with a bow-like pregenital sclerite (epigynium); epimeres I free or contiguous at posterior tips; bird parasites (fig. 63)……..……..……..Epidermoptidae

- Opisthosomal shield can be absent in males; pregenital sclerite (epigynium) absent or present; epimeres I free or connected to epimeres II; solenidion present on genu III…..……..…..…6

6. Legs III to IV inserted ventrally, tibiae I and II without ventral spines; females without a pregenital sclerite (epigynium); male usually without opisthosomal shield (fig. 64)……....Dermoglyphidae

- Legs III to IV inserted laterally, rarely sublaterally in which case the epigynium is present in females and opisthosomal present in males; tibiae I and II with ventral spines (fig. 65)……...…Analgidae

7. Tarsi I and II lack pretarsi, these tarsi terminate in a claw-like process, legs I and II very short; mouth parts normal; found in subcutaneous tissue of domestic fowl (fig. 66)…....Laminosioptidae

- Pretarsi without claws, present on all tarsi, all legs almost equally long; mouth parts form a sucking tube; found in air-sacs of fowl (fig. 67)…….....Cytoditidae

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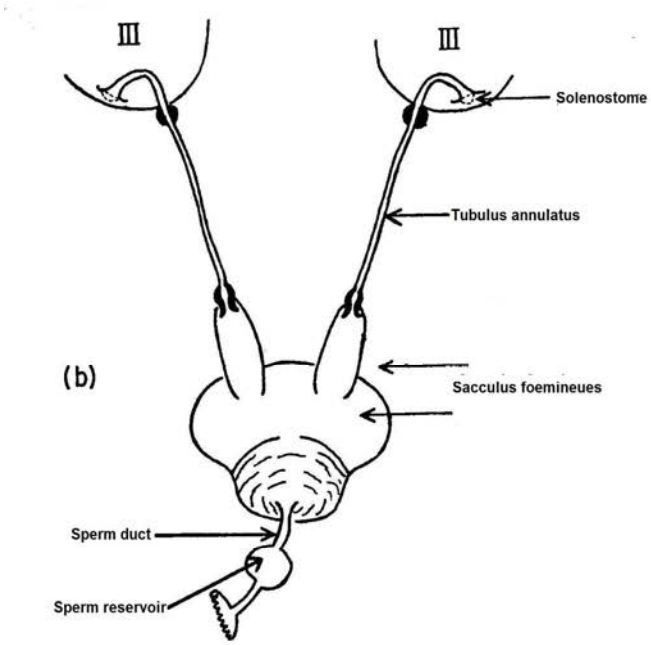
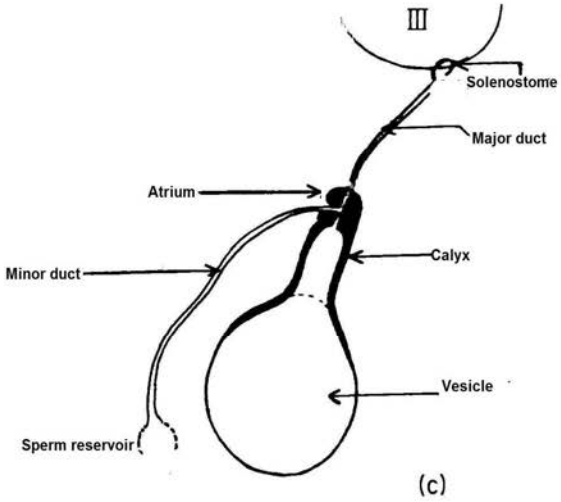
FIGURES



LAELAPID-TYPE



PHYTOSEIID - TYPE