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# Key to the Phytoseiid Predatory Mites Found on California Crops

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***Note:*** A separate document, the appendix to Key to the Phytoseiid Predatory Mites Found on California Crops, provides photos of key characteristics of slide-mounted mites taken through a compound microscope. The appendix, which includes photos of forty-five of the forty-six mite species found in the key, will greatly aid in identification of these species. For the majority of mite species, photos of the dorsum, venter, ventrianal shield, spermatheca, and chelicera are provided. For some species, additional photos are included for structures that are especially important for confirming identification, such as the peritreme, macrosetae, pores, and dorsal shield indentations.

## Dedication

This publication is dedicated to Dr. James Allen McMurtry (1932–2017), who spent his life studying phytoseiids—as well as organizing his knowledge and sharing it with scientists, students, and biocontrol and plant-protection officers around the world. He produced sixty-eight publications on the morphology and taxonomy of phytoseiids (Demite et al. 2020). He and his collaborators described seventy-one species and twenty-six genera from thirty-six countries and reclassified the phytoseiids based on their feeding habits. His contributions to our understanding of the significance of phytoseiids for agricultural crops went far beyond taxonomy and included the introduction of new species and demonstrations of the impact of augmentative releases. He was generous with his knowledge and inspired many research projects, including surveys of phytoseiids in field crops, fruit trees, ornamentals, and wild plants. This publication, which encapsulates his knowledge of the taxonomy, feeding habits, known host plants, and distribution of phytoseiids of California crops, will benefit many generations to come.

## Introduction

Predatory mites in the family Phytoseiidae are known throughout the world in agricultural crops as important predators of pest mites, especially the spider mites (Tetranychidae), as well as small insects such as thrips, psyllids, scales, aphids, and whiteflies (McMurtry and Croft 1997; Gerson et al. 2003; Hoy 2011). More than 2,000 species are known worldwide and probably many times that number have yet to be discovered (McMurtry et al. 2015; Demite et al. 2020). Within the United States, H.A. Denmark and G.A. Evans (2011) described more than 320 species of Phytoseiids (including synonyms) belonging to thirty-six genera. The extensive monograph of R.O. Schuster and A.E. Pritchard (1963) on the Phytoseiidae of California listed and described fifty-two species, and about sixteen species that have been discovered or introduced since that time can be added to their listings. The current key is intended as an aid to identification of the forty-six most common phytoseiid mites found on crop plants, and in some instances, adjacent wild plants in California. Therefore, many species listed by R.O. Schuster and A.E. Pritchard (1963), such as those known only from soil or humus habitats, are not included here. Many of the species described by R.O. Schuster and A.E. Pritchard (1963) were renamed or reorganized into different genera by H.A. Denmark and G.A. Evans (2011).

During the 1960s and 1970s, studies of phytoseiid predatory mites in California agriculture focused on a very few species: *Phytoseiulus persimilis* in berries, *Galendromus occidentalis* and *Neoseiulus californicus* in stone fruit, nuts, and vines, and *Euseius* species in subtropical crops (McMurtry and Johnson 1965, 1966; Oatman and McMurtry 1966; Oatman et al. 1967, 1968; McMurtry et al. 1971; Kinn and Doutt 1972; Rice et al. 1976; McMurtry and Flaherty 1977; Rice and Jones 1978; Hoy et al. 1979). Studies of augmentative releases of phytoseiids for mite and thrips control (Oatman and McMurtry 1966; Oatman et al. 1967, 1968, 1976, 1977; Hoy 1982; Tanigoshi et al. 1985; McMurtry et al. 1992) led to the creation of private insectaries and the common use of phytoseiids as biocontrol agents in berries, fruit trees, and nuts. Insectaries in North America

currently produce native and introduced phytoseiids including *P. persimilis*, *G. occidentalis, N. californicus, N. fallacis, N. cucumeris, Amblyseius andersoni, A. swirskii, Ipheseius degenerans*, and *P. longipes* (LeBeck and Leppla 2021).

In early pest management guidelines from the University of California (UC) Statewide Integrated Pest Management Program, the thresholds and recommendations for use of predatory mites on California crops were based on these early studies of a small number of phytoseiid species. For many years, there was a presumption by pest control advisors, who are limited to identification with a hand lens, that any predatory mite observed was one of these species or a closely related species. Accurate identification requires mounting mites on slides and using a compound microscope with phase contrast. Between 2001 and 2018, collections of phytoseiids from tree, vine, and berry crops including citrus (*Citrus* spp.), avocado (*Persea americana*), cherimoya (*Annona cherimola*), strawberry (*Fragaria* spp.), raspberry and blackberry (*Rubus* spp.), peach, nectarine, plum, and prune (*Prunus* spp.), pear (*Pyrus* spp.), apple (*Malus* spp.), walnut (*Juglans* spp.), almond (*Prunus dulcis*), and grape (*Vitis* spp.) were conducted in a number of agricultural regions of California (Grafton-Cardwell et al. 2020). The phytoseiids in those collections were identified using this key and identifications revealed a higher level of diversity of species in some of these crops than expected. In addition, the E.E. Grafton-Cardwell et al. (2020) collections showed that *G. occidentalis*, long presumed to be the dominant species in vine, stone fruit, and nut crops, often played a minor role. The E.E. Grafton-Cardwell et al. (2020) collections also revealed major regional differences in phytoseiid species composition within the grape and walnut crops. Additional research is needed to determine the level of control exerted by phytoseiids other than *G. occidentalis* on pest populations within these crop systems, and this key will aid those studies.

The systematics of the phytoseiids is influenced by their morphology, food habits, and lifestyles, which vary considerably, but might be assigned to four categories (McMurtry and Croft 1997; McMurtry et al. 2013). Type 1 phytoseiids are highly specialized predators of spider mites that produce dense, irregular webbing (represented by *Phytoseiulus* spp.). They inhabit and lay their eggs on the webbing of their prey, are unaffected by leaf architecture, and aggregate in response to volatiles produced by their prey. Type 2 phytoseiids prefer web-spinning spider mites as prey but also prey on other kinds of mites, such as eriophyids (rust or bud mites), tarsonemids, and tydeids (phytoseiid examples include all *Galendromus* species, *N. fallacis*, *N. californicus,* and *Typhlodromus rickeri*). Type 2 phytoseiids live in dense or loose web nests, include pollen in their diet, and are somewhat influenced by leaf architecture—for example, *Galendromus occidentalis* prefers to reside along midrib veins. Phytoseiid species in categories 1 and 2 demonstrate greater pest population regulation than the other categories due to their specificity and tend to have longer setae on the medial and lateral surfaces, which are thought to assist them with moving through webbing. Type 3 phytoseiids are generalist feeders that avoid the heavy webbing produced by *Tetranychus* spp., feeding on mites that don't produce much webbing, such as eriophyids, tarsonemids, tydeids, and *Panonychus* species, as well as pollen, plant exudates, or small insects such as thrips, whiteflies and scale crawlers (phytoseiid examples include *Typhlodromus pyri, Typhlodromalus peregrinus, Amblyseius andersoni*, and *Amblydromalus limonicus*). Type 4 phytoseiids, represented by Euseius spp., are extreme generalists that are highly adapted to pollen feeding and feed on plant exudates; thus their populations respond to leaf flush and flowering periods of plants and they can survive without arthropod prey. They help suppress populations of non–web spinning mites and thrips and other small insect stages. Phytoseiids in categories 3 and 4 are more closely associated with the phenology of their plant substrate than those in 1 and 2, and their distribution is often more closely correlated with leaf structures such as veins, hairs, or other protected areas than with a specific prey (McMurtry et al. 2013).

The predatory mite family Phytoseiidae belongs to the order Mesostigmata (=Gamasida) (superorder Parasitiformes), which is characterized by the presence of a palptarsal apotele claw (used in manipulating prey); the presence of a tritosternum (which redirects fluids to the mouth) arising from the anteromedial area of the idiosomal venter; and stigmata (respiratory openings) usually present at the level between the bases of legs III and IV (fig. 1a). The majority of the Mesostigmata are free-living predators, but some are parasites or symbionts on insects, other arthropods, or various other animals. The soil/humus habitat is rich in species of Mesostigmata. There are more than 70 families and about 12,000 species in this

order (Krantz and Walter 2009). The other suborders of mites that may be found on crops—Prostigmata, Astigmata, and Oribatida (superorder Acariformes)—lack the tritosternum and the palptarsal claw, and the stigmata are located in the head area of the mite or are absent altogether.

Prostigmata (=Actinedida) (fig. 1b) is a very diverse group, containing many families that occur on crop plants, including both pests and natural enemies. Three major crop pest groups—the superfamilies Tetranychoidea (spider mites and false spider mites), the Eriophyoidea (rust mites and gall mites) and the Tarsonemidae family (for example, cyclamen and broad mites)—belong to the Prostigmata (Krantz and Walter 2009). All of these groups have highly modified mouthparts for piercing plant tissue and sucking liquids from plants. Some Prostigamatid families are predatory, such as the Stimaeidae, Cheyletidae, Bdellidae, and Anystidae, which feed on mites or small insects on plants. Some families have been classed as fungivores, scavengers, and pollen feeders, such as Tydeidae (*Tydeus* or *Lorryia* spp.). Although they are often found on crop plants, the feeding habits of this latter group are not well known. There are about 150 families of Prostigmata and tens of thousands of species (Krantz and Walter 2009). They are characterized by having stigmata usually present between the bases of the chelicerae or at the humeral angles (shoulders) of prodorsum, and the chelicerae are typically hook- or bladelike, or styletiform (Krantz and Walter 2009).

A few species of Astigmata (=Acaridida) (fig. 1c) are serious pests of stored products and some probably feed on decaying matter or various microorganisms. Those found on crops are most likely feeding on fungi and may move to plants from soil/humus habitats. One tiny species, *Czenspinskia transversostriata*, is collected occasionally on foliage, and is associated with fungi such as sooty mold (Hughes 1962). The Astigmata contains over 70 families and more than 5,000 known species (Krantz and Walter 2009). They lack discrete stigmata and their chelicerae are chelate or dentate.

The oribatid mites (fig. 1d) are common in soil/humus habitats and are seldom seen on foliage except in moist conditions. They are largely detritus and microorganism feeders. There are 172 families and more than 9,000 described species (Krantz and Walter 2009). They are characterized by a heavily sclerotized body. They have specialized sensory setae on their prodorsum, they lack stigmata, and their chelicerae are chelate.

## *Key to orders and suborders of mites on higher plants**

1. Palptarsal claw (apotele) present near base of segment; tritosternum arising from anteromedial area of idiosomal venter; stigmata present dorsolateral to and at level between bases of legs III and IV; leg coxae free from ventral body wall (see fig. 1a). . . . . **Order Mesostigmata**

– Without palptarsal claw; without tritosternum; stigmata located anterodorsally, or absent; leg coxae fused to ventral body wall . . . . . **2**

2. Stigmata usually present at base of gnathosoma or at humeral angles of prodorsum; chelicerae typically hook- or bladelike, or styletiform (see fig. 1b) . . . . . **Order Trombidiformes, Suborder Prostigmata**

– Without discrete stigmata; chelicerae chelate-dentate . . . . . **Order Sarcoptiformes 3**

3. Palpi only 2-segmented; usually weakly sclerotized; without specialized sensory setae on prodorsum (see fig. 1c) . . . . . **Suborder Astigmata**

– Palpi with more than 2 segments; adults heavily sclerotized; specialized sensory setae present on prodorsum (see fig. 1d) . . . . . **Suborder Oribatida**

*Modified from Krantz and Walter (2009).

Within the Mesostigmata, the Phytoseiidae is by far the most common family found on the aerial parts of plants. Only two other families, the Ascidae and Ameroseiidae (fig. 2), might be encountered on crop plants in California, although many additional families occur in soil or humus habitats. Ameroseiidae are often associated with fungi, such as sooty mold developing on honeydew from whiteflies, mealybugs, or aphids. Ascidae, often slightly larger than phytoseiids, may be predacious or fungal feeders. Because

Ameroseiidae and Ascidae are more common in soil/humus habitats, they are most likely to be encountered on low-growing or greenhouse crops. The Phytoseiidae can be distinguished from these other two groups by the lack of divided corniculi (compare with Ameroseiidae) and <20 setae on the dorsal plate (compare with Ascidae) (see fig. 2). The Phytoseiidae are more common than the other two families and more important for predation of agricultural pests. This key focuses on the common phytoseiid species inhabiting crops in California.

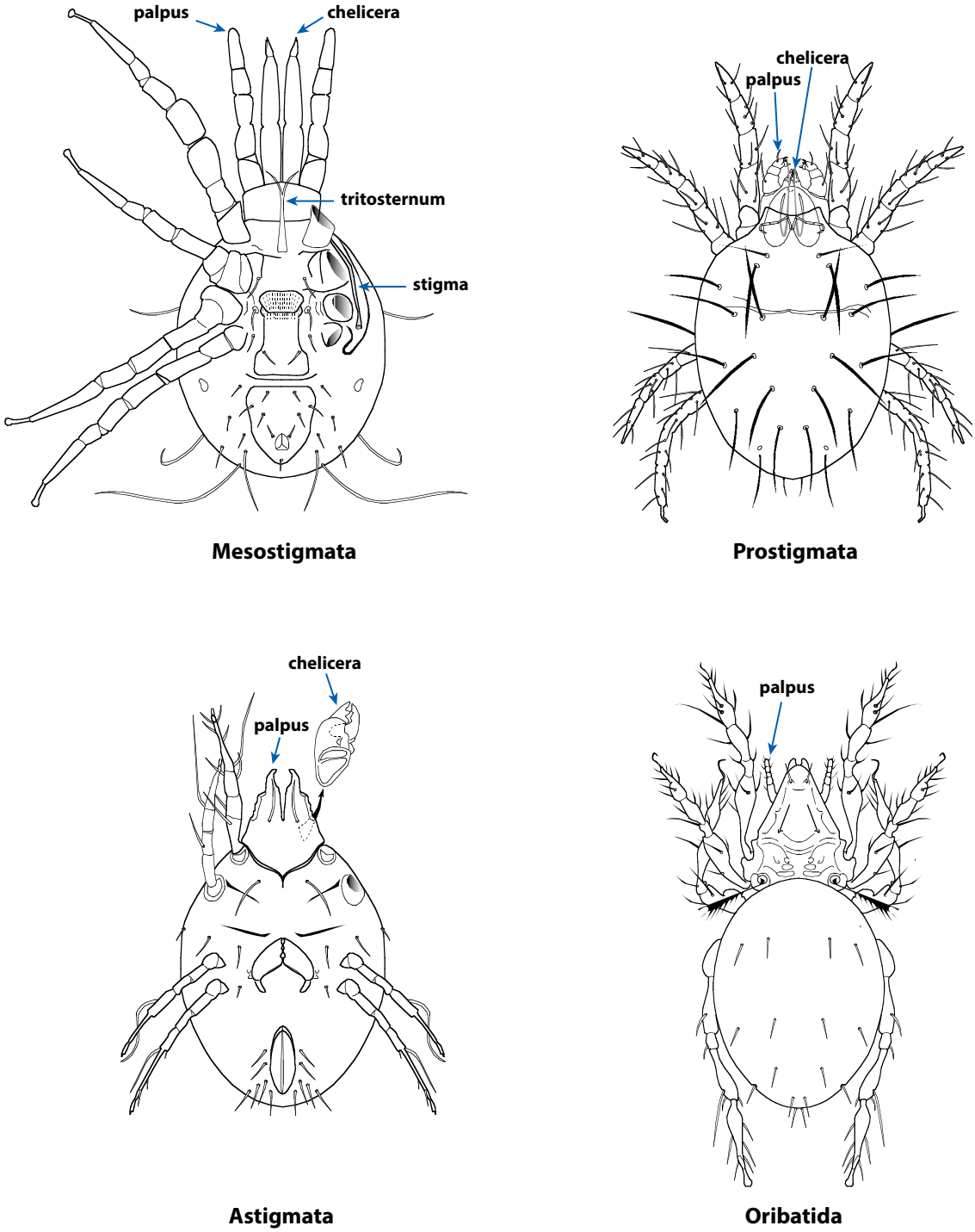


**Figure 1.** Four major orders and suborders of mites found in agricultural crops: Mesostigmata, Prostigmata, Astigmata, and Oribatida (after Krantz and Walter 2009).

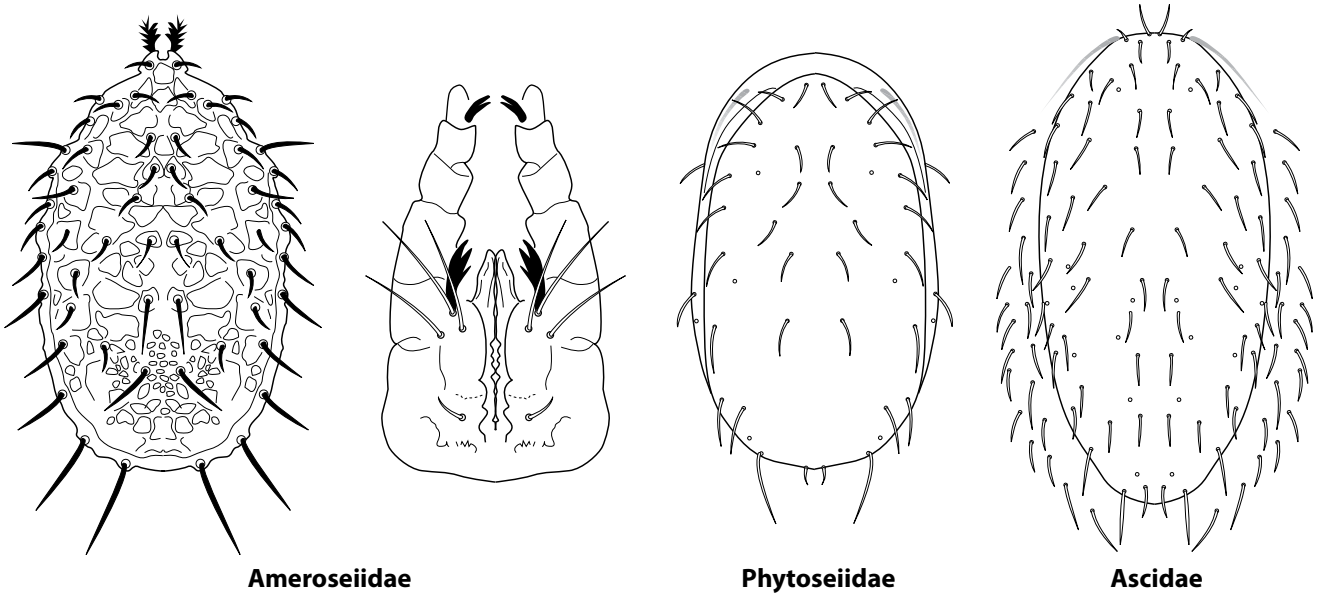


**Figure 2.** Three major families of predatory mites that may be found on agricultural crops: Ameroseiidae, Phytoseiidae, and Ascidae (after Krantz and Walter 2009).

## *Key to common families of Mesostigmata on plants in California*

1. Corniculi divided distally; dorsal shield markedly ornamented or sculptured . . . . . **Ameroseiidae**
– Corniculi not divided distally; dorsal shield may be reticulated, but not markedly ornamented. . . . . **2**
2. Fewer than 20 pairs of dorsal setae present; no more than 2 pairs in r-R series . . . . . **Phytoseiidae**
– Usually 25 or more pairs of dorsal setae present; more than 2 pairs in r-R series . . . . . **Ascidae**

The taxonomic system used here for Phytoseiidae is based on the revisions of D.A. Chant and J.A. McMurtry (1994, 2003, 2004a, 2004b, 2005a, 2005b, 2006, 2007). However, the following key is restricted to genera that are known to occur on California crops. The taxonomic key utilizes female mites, because they are larger in size, they are usually more numerous than males, and they have a larger number of taxonomic characters than males—such as the shape of the shields on the ventral surface and the presence of a spermatheca (fig. 3). Immature stages (larvae, protonymph, and deutonymph) are inadequate for keying species because the shields on the ventral surface, as well as the reproductive structures, are not yet formed and the final array of setae may not yet be complete. Figure 3 shows a generalized view of the female phytoseiid, identifying characters and terms that are important for taxonomy. These terms are also referenced in the glossary.

Setal patterns described in the key follow the system of E.E. Lindquist and G.O. Evans (1965) adopted for the Phytoseiidae by H.J. Rowell et al. (1978). The system for the dorsal shields (fig. 4) is based on vertical rows of setae including the j-J or "inner" row, the z-Z or "middle" row, the s-S or "side" row, and the r-R or "marginal" row. The system designates setae in the podonotal (anterior) region of the dorsal shield by lower case letters (for example, j1, z2, s4, r3) and in the opisthonotal (posterior) region by capital letters (for example, J2, Z1, S2, R1). "Landmarks" to aid in determining separation of the two regions are j6 (podonotal) and R1 (opisthonotal) (see fig. 4).

The ventral shields include the sternal (ST, anterior), genital (G, central), and ventrianal (VA, posterior) (fig. 5). The ventrianal shield numbering system is based on vertical rows of setae including the JV (inner row) and the ZV (outer row). Figure 6 shows the three basic ventrianal shield types that will be encountered in this key. The vase-shaped ventrianal shield is typical of *Euseius*, *Amblydromalus*, and *Typhlodromus* species of mites. Generally, the genital shield is wider than the ventrianal shield in these species. The pentagonal-shaped ventrianal shield is typical of the *Neoseiulus* and *Proprioseiopsis* species and the genital shield is commonly smaller than the ventrianal shield at the margin where they meet. The

rounded ventrianal shield is typical of *Phytoseiulus persimilis*. Some genera (*Amblyseius*, *Metaseiulus*, *Phytoseiulus*) have a mixture of vase, pentagonal or round-shaped ventrianal shields and this character is used to differentiate species.

The spermatheca is a specialized pouch in the female in which spermatozoa are stored and maintained after mating (Di Palma and Alberti 2001). Figure 7 shows a generalized description and some of the various shapes of spermatheca that may be encountered in this key. The major duct opens between coxae III and IV into the valve-like atrium. The atrium of the tube may be long or short and it may have a constriction. The minor duct that leads to the ovary connects to the atrium. The calyx (=cervix) is a sclerotized structure that may be horn-shaped, cup- or bell-shaped, saccular, or like a funnel. The calyx opens up into a vesicle that holds the spermatophores. The male uses its spermadactyl to transfer spermatophores to the female. The shape of the spermatheca (specifically the atrium and calyx) is one of the most important characters for distinguishing phytoseiids at the species level.

Figure 8 shows a generalized drawing of the chelicera, which is used to hold and crush prey. Phytoseiid chelicerae have teeth, a movable digit, a fixed digit, and pilus dentilis. The pilus dentilis is a hairlike structure that acts as a mechanoreceptor and informs the mite when it has grasped prey.

See G.W. Krantz and D.E. Walter (2009) for methods of slide-mounting phytoseiids. A compound microscope with a 40x ocular, fitted with phase contrast, is necessary for visualizing the structures of the mites. The key is based on specimens from the collection at UC Davis, Jim McMurtry's personal collection, and the collections made during the 2001–2018 surveys (Grafton-Cardwell et al. 2020). The following keys utilize the general characteristics shown in figures 3–8 and the detailed drawings in figures 9–54 to differentiate the genera and species of phytoseiids commonly found on California crops.

The sections describing the biology and distribution of the phytoseiids provide practitioners with an idea of the regions where they might encounter each species, the host plants the species might be found on, and what prey they may be feeding on. Many of these phytoseiid species have not been studied in depth, especially with regard to their feeding habits.

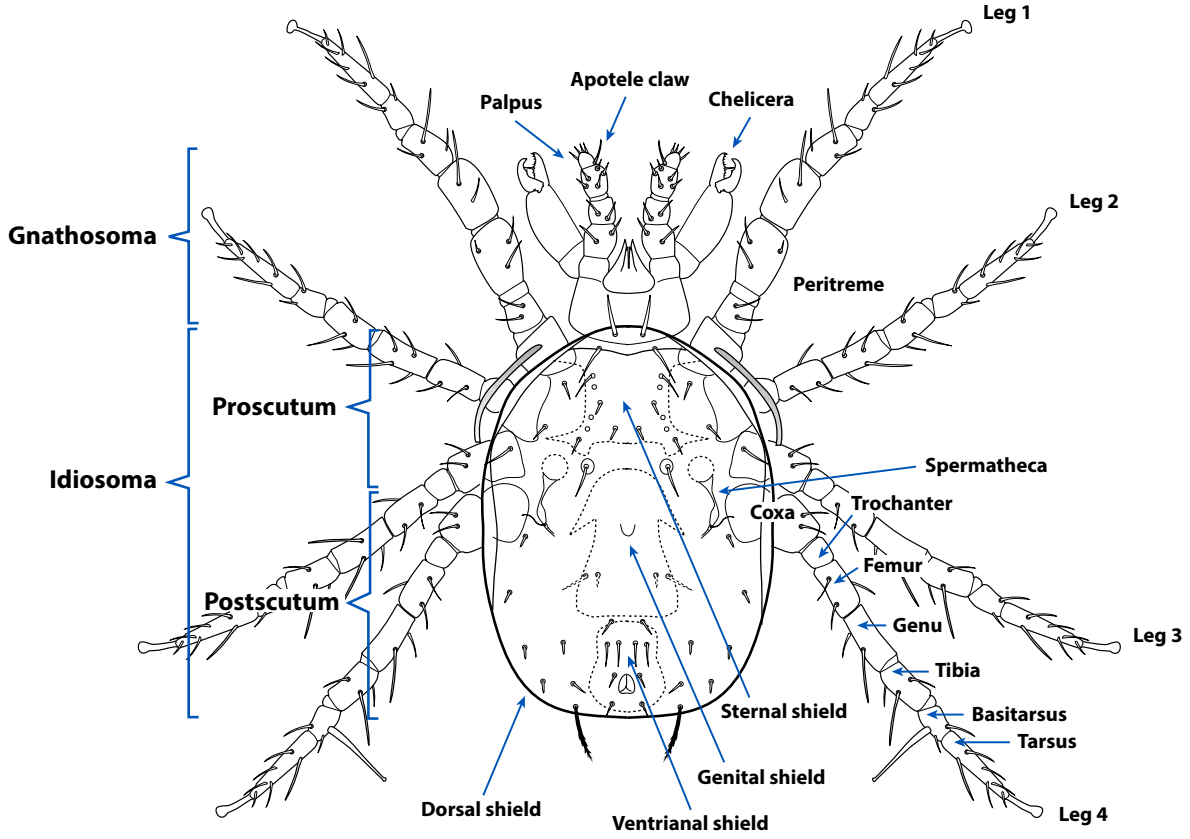


**Figure 3.** Generalized drawing of the structures of a phytoseiid mite (after Krantz and Walter 2009).

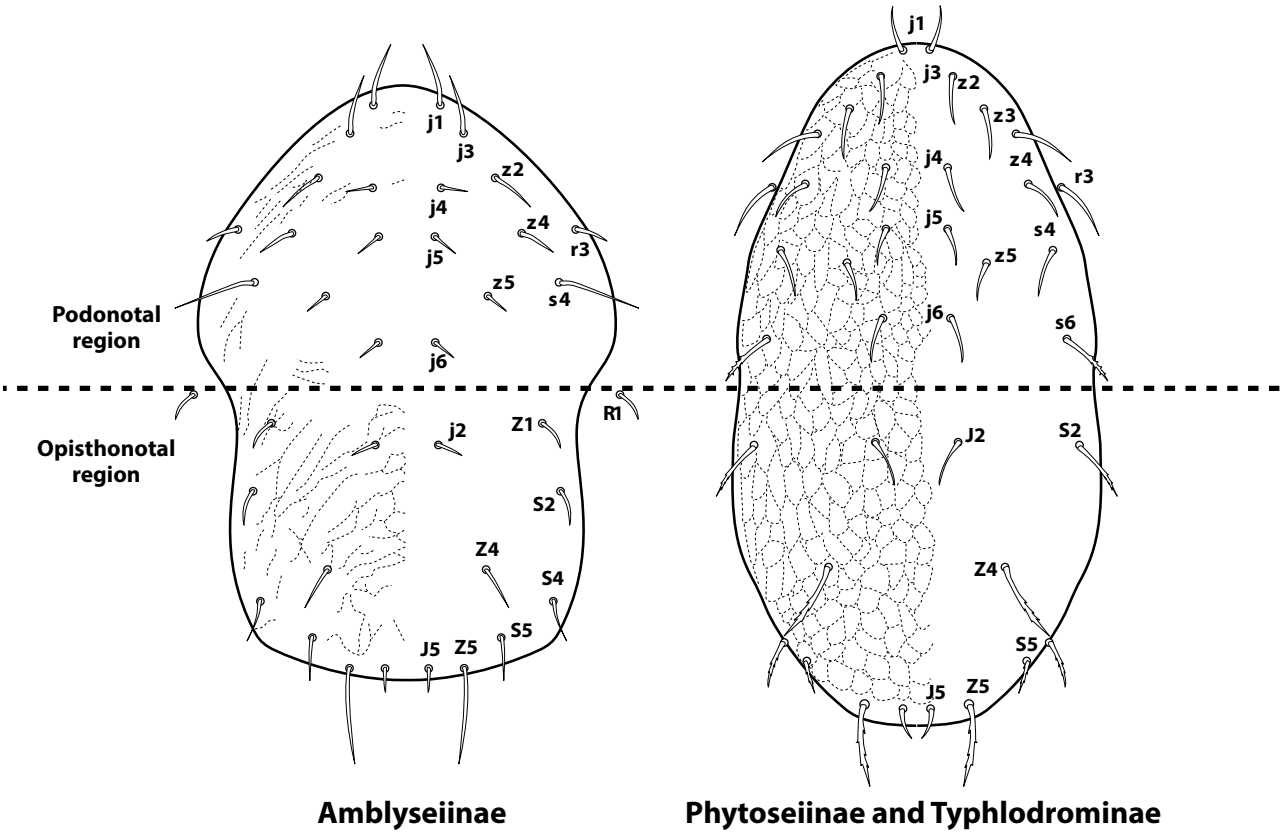


**Figure 4.** Typical setal patterns for the dorsum of the subfamilies Amblyseiinae and Phytoseiinae and Typhlodrominae (after Krantz and Walter 2009).

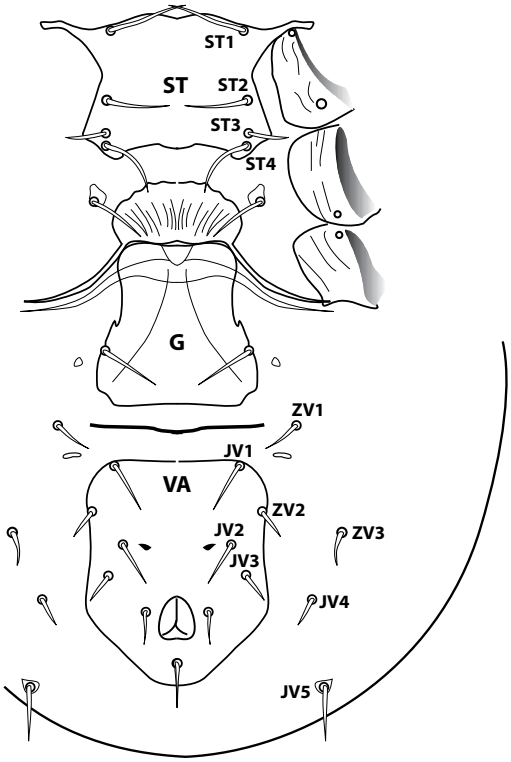


**Figure 5.** Generalized setal patterns for the ventrum of a phytoseiid (after Krantz and Walter 2009).

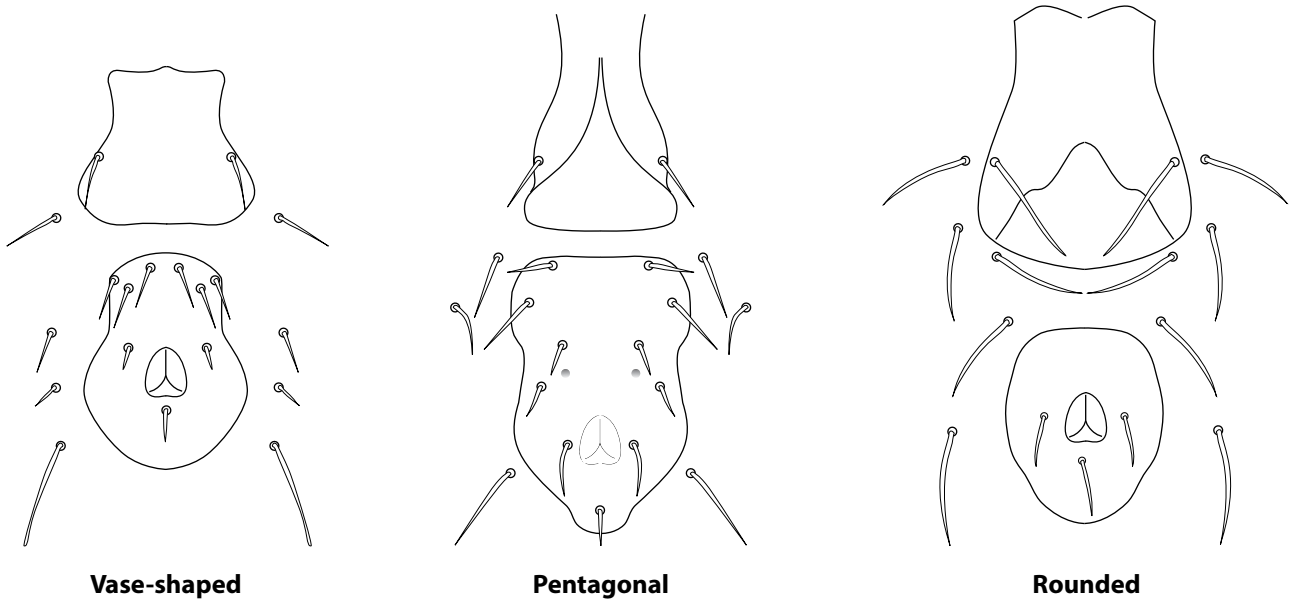


**Figure 6.** Three major ventrianal shield shapes in phytoseiids (after Krantz and Walter 2009).

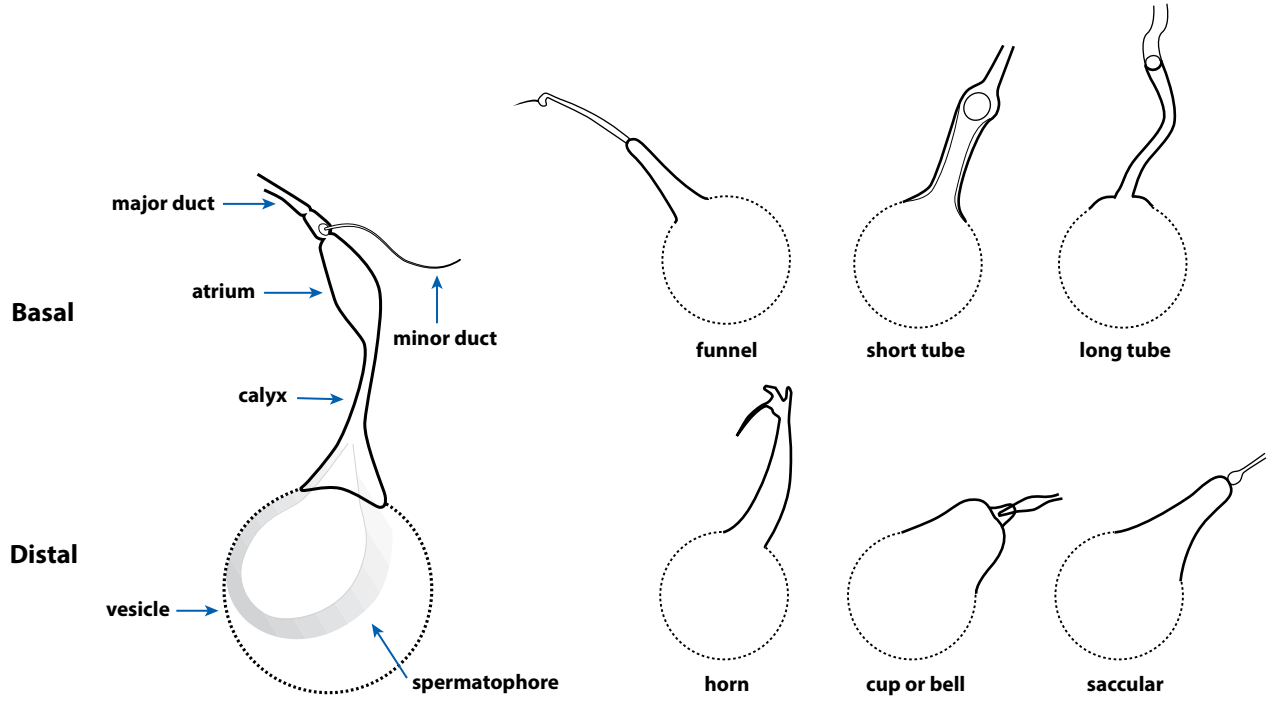


**Figure 7.** Generalized description of the spermatheca and various spermatheca shapes.

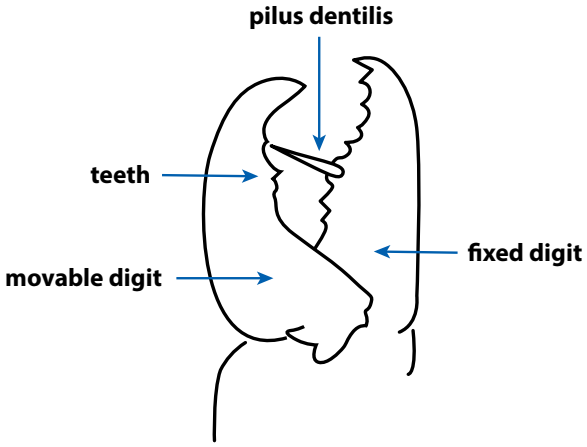


**Figure 8.** Generalized description of the chelicera (after Krantz and Walter 2009).

## *Key to genera of Phytoseiidae found on crop plants in California (adult females)*

1. Podonotal region of dorsal shield with 4 pairs of "anterolateral" setae (j3, z2, z4, s4); lacking setae z3 and s6 (fig. 4) Subfamily AMBLYSEIINAE Muma . . . . . **2**

– Podonotal region of dorsal shield with 5 or 6 pairs of "anterolateral"setae; with setae z3 and/or s6 present (fig. 4) Subfamilies PHYTOSEIINAE Berlese, TYPHLODROMINAE Scheuten . . . . . **11**

2. Setae j6 two or more times as long as the distance between their bases; ventrianal shield with no or only 1 pair of preanal setae (fig. 9-10) . . . key page 12 . . . . . ***Phytoseiulus*** Berlese

– Setae j6 less than twice as long as the distance between their bases; ventrianal shield with 1, 2 or 3 pairs of preanal setae . . . . . **3**

3. Ventrianal shield vase-shaped (fig. 6, wider at level of anus than at level of insertions of setae ZV2), with preanal setae on anterior portion of shield; genital shield markedly wider than ventrianal; posterior margin of sternal shield with median lobe; shield sometimes weakly sclerotized or indistinct . . . . . **4**

– Ventrianal shield usually pentagonal (as wide as or wider at level of ZV2 compared to level of anus); preanal setae not confined to anterior portion of shield; at least one pair of preanal setae inserted on posterior two-thirds of shield; genital shield not markedly wider than ventrianal, sometimes narrower; posterior margin of sternal shield straight or concave, without median lobe . . . . . **6**

4. Cheliceral digits short, stubby, fixed digit with a few small teeth confined to distal region; peritreme usually short, not reaching to bases of setae j3 (fig. 11-15) . . . key page 15 . . . . . ***Euseius*** Wainstein

– Cheliceral digits normal, fixed digit with 6-10 large teeth evenly spaced along digit; peritreme long, reaching to bases of setae j1 . . . . . **5**

5. Seta Z4 minute, not extending to near base of Z5, dorsal shield smooth (fig. 16) . . . . . ***Amblydromalus*** Chant & McMurtry; ***limonicus*** (Garman & McGregor)

– Seta Z4 longer, extending to near base of Z5; dorsal shield with rugose ornamentation (fig. 17) . . . . . ***Typhlodromalus*** Muma; ***peregrinus*** (Muma)

6. Setae s4 not greatly longer than Z1, ratio of s4:Z1 at most 2:1; only leg IV bears macrosetae (figs. 18-23)…. key page 24 . . . . . ***Neoseiulus*** Hughes

– Setae s4 markedly longer than Z1, s4:Z1= 3 or greater …. . . . . **7**

7. Setae J2 absent (figs. 24-28) . . . key page 32 . . . . . ***Proprioseiopsis*** Muma

– Setae J2 present…. . . . . **8**

8. Sternal and/or ventrianal shields markedly wider than long; heavily sclerotized, body convex (fig. 29) . . . . . ***Arrenoseius*** Wainstein; ***palustris*** (Chant)

– Sternal and/or ventrianal shields not markedly wider than long; usually lightly sclerotized, body not markedly convex. . . . . **9**

9. Atrium of spermatheca elongate; no distinct macrosetae on genu I-III; spermatodactyl of male T-shaped (fig. 30) . . . . . ***Graminaseius*** Chant & McMurtry; ***graminis*** (Chant)

– Atrium of spermatheca not elongate; usually nodular or indistinct; genu II, III and sometimes I with macrosetae, spermatodactyl of male not T-shaped…... . . . . **10**

10. Setae S2 long, > 50% the length of s4 (fig. 31) . . . . . ***Transeius*** Chant & McMurtry; ***newelli*** (Chant)

– Seta S2 short, < 25% of length of s4 (figs. 32-34) . . . key page 41 . . . . . ***Amblyseius*** Berlese

11. Setae r3 of females inserted on dorsal shield; all S setae absent PHYTOSEIINAE (fig. 35) . . . . . ***Phytoseius*** Ribaga; ***finitimus*** (Ribaga)

– Setae r3 of females on integument next to margin of dorsal shield; one to three S setae present TYPHLODROMINAE…. . . . . **12**

12. Setae z6 present (fig. 36)…. . . . . .***Paraseiulus*** Muma; ***triporus*** (Chant & Yoshida-Shaul)*

– Setae z6 absent . . . . . .**13**

13. Insertion of setae j3 closer to bases of j1 than to those of z2; setae S5 inserted about equidistant between bases of Z4 and Z5 (figs. 37-41) . . . key page 47 . . . . . ***Galendromus*** Muma

– Insertion of j3 about midway between bases of j1 and z2 or closer to z2; setae S5 when present inserted closer to Z5 than to Z4 . . . . . .**14**

14. Setae S4 and JV4 present (figs. 42-45) . . . key page 53. . . . . ***Typhlodromus*** Scheuten

– Setae S4 and JV4 absent. . . . . .**15**

15. Setae R1 much shorter than s6; setae S5 and Z5 approximately equal in length; calyx of spermatheca tubular-saccular, atrium much smaller than base of calyx; dorsal shield without indentations near bases of setae S5 (fig. 46) . . . . . ***Typhlodromina*** Muma: ***eharai*** Muma & Denmark

– Setae R1 and s6 approximately equal in length; S5 markedly shorter than Z5; calyx of spermatheca funnel-like, flaring slightly at distal end, truncate at base, atrium usually same width as base of calyx, dorsal shield with indentations near bases of setae S5 (figs. 47-54) . . . key page 59 . . . . . .***Metaseiulus*** Muma

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**P. soleiger* was redescribed by R.O. Schuster and A.E. Pritchard (1963) based on California specimens. Examination of specimens in the Schuster collection at UC Davis in 2010 (by J.A. McMurtry) indicated that the California species should be called ***triporus***, described in D.A. Chant and E. Yoshida-Shaul (1982). This species was reported from Washington by B.D. Congdon (2002). It has a bell-shaped calyx of the spermatheca as opposed to a long, horn-shaped calyx for ***soleiger***. Although spermathecae were difficult to see in specimens in the Schuster collection, those specimens do not have the elongated calyx as in ***soleiger***. Moreover, the setal measurements and presence of pores on the dorsal shield as given by Schuster and Pritchard coincide with those of ***triporus*** rather than ***soleiger***, as distinguished by D.A. Chant and E. Yoshida-Shaul (1982).

## *Key to species of Phytoseiulus*

1. Ventrianal shield pentagonal (fig. 9), anterior margin of shield straight, with one pair of preanal setae . . . . . ***macropilis*** (Banks)

– Ventrianal shield rounded (fig. 10), anterior margin of shield strongly curved (convex) with no preanal seta . . . . . ***persimilis*** Athias-Henriot

### *Biology and distribution of Phytoseiulus species*

***Phytoseiulus* lifestyle – Type I** – Phytoseiids in this genus have extremely narrow dietary habits, specializing on spider mites in the Tetranychidae that produce profuse webbing. Because of their specificity, these phytoseiids are regularly produced commercially and used in augmentative releases for spider mite control in high-value crops such as strawberry, caneberry, and greenhouse crops.

#### ***Phytoseiulus macropilis* (Denmark and Schicha 1983)**

**California distribution:** coastal areas.

**Recorded cultivated host plants in California:** strawberry (Schuster and Pritchard 1963).

**Feeding habits:** primarily web-spinning spider mites (twospotted spider mite *Tetranychus urticae* Koch, Pacific spider mite *T. pacificus* McGregor, and strawberry spider mite *T. turkestani* Urgarov and Nikolski).

#### ***Phytoseiulus persimilis* (Denmark and Schicha 1983)**

**California distribution:** introduced to California in 1963 (McMurtry et al. 1978). It is currently established in coastal areas.

**Recorded cultivated host plants in California:** strawberry, lima bean, raspberry, and grape (Oatman and McMurtry 1966; Oatman et al. 1967, 1968; McMurtry et al. 1978; Howell and Daugovish 2013; Grafton-Cardwell et al. 2020).

**Feeding habits:** primarily web-spinning spider mites (*T. urticae*, *T. pacificus*, and *T. turkestani)*. Produced commercially for control of spider mites (LeBeck and Leppla 2021).

## *Phytoseiulus macropilis*

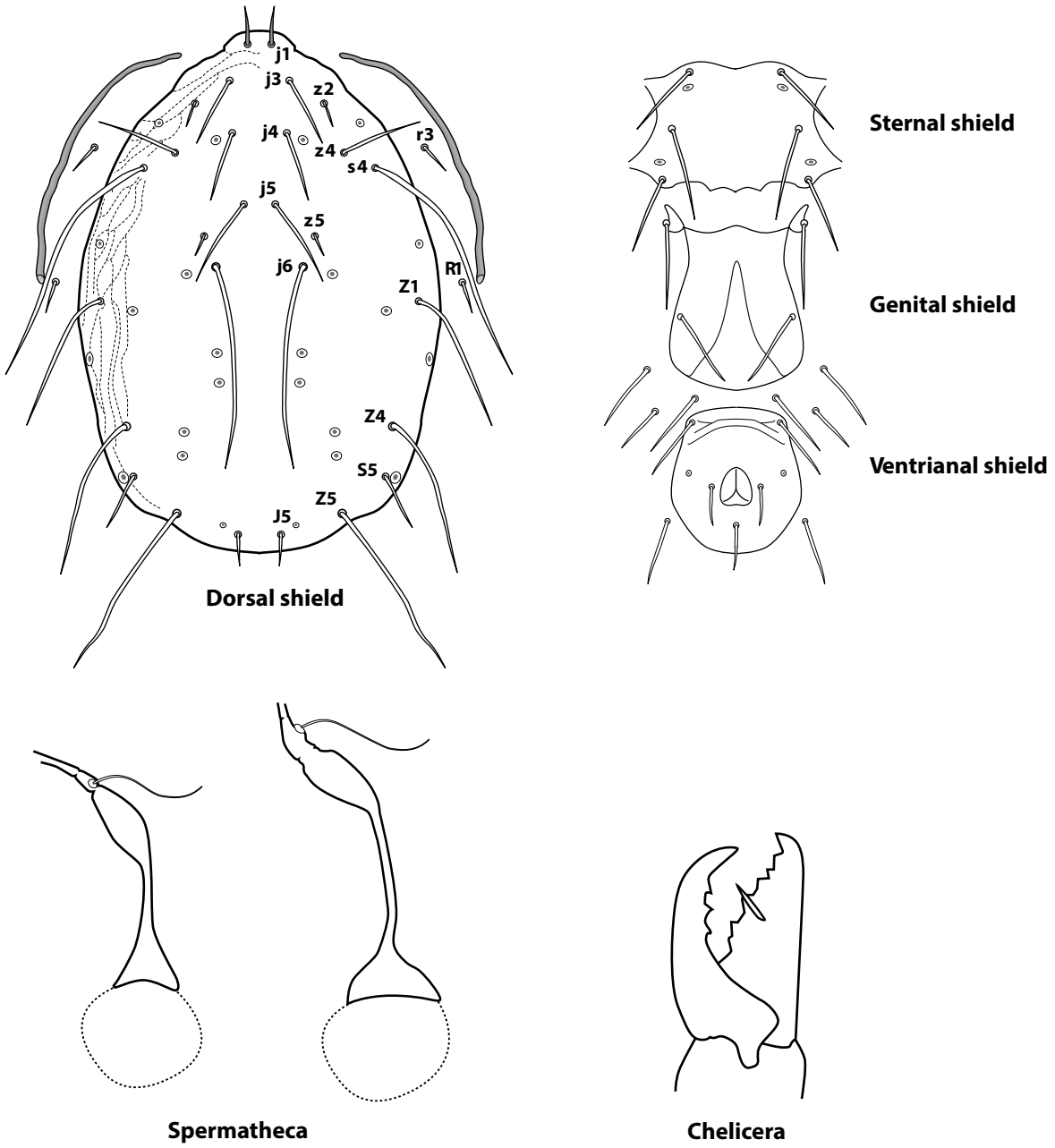



**Figure 9.** *Phytoseiulus macropilis* (Banks) dorsal shield, ventral shields, spermatheca, and chelicera (Denmark and Schicha 1983).

## *Phytoseiulus persimilis*

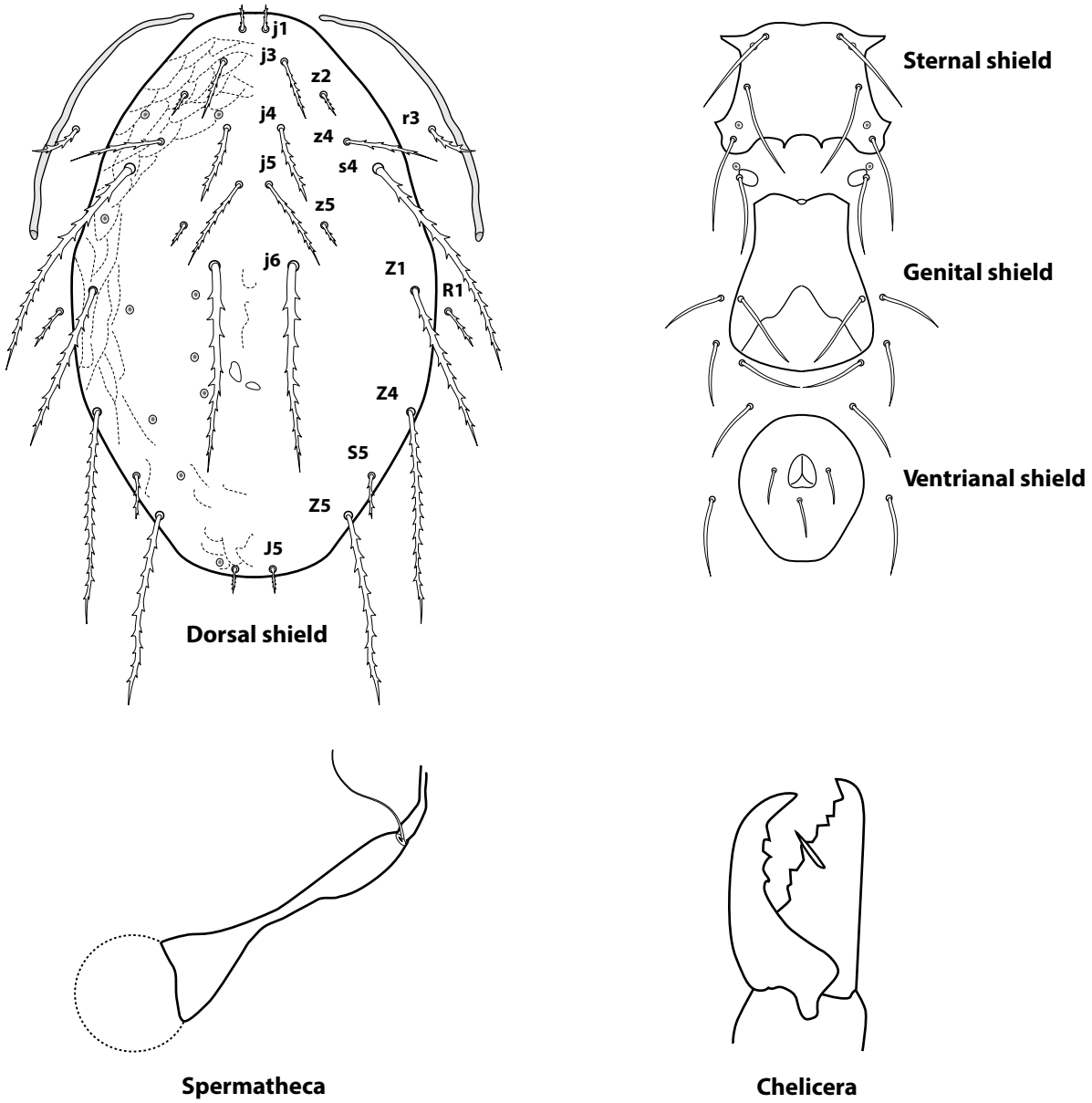



**Figure 10.** *Phytoseiulus persimilis* Athias-Henriot dorsal shield, ventral shields, spermatheca, and chelicera (Denmark and Schicha 1983).

## *Key to species of Euseius*

– Seta r3 on edge of dorsal shield . . . . . **2**

– Seta r3 on integument next to edge of dorsal shield . . . . . **3**

2. Dorsal shield lightly reticulated over entire surface, peritreme not extending as far as level of base of z2 or reaching level of coxa II (see fig. 11). . . . . ***obispensis*** Aponte & McMurtry

– Anterior portion of dorsal shield nearly smooth, peritreme extending to level of base of z2 or to middle of coxa II (see fig. 12) . . . . . ***tularensis*** Congdon*

3. Calyx of spermatheca short tube; macroseta on basitarsus IV with blunt tip (fig. 13). . . . . ***stipulatus*** (Athias-Henriot)

– Calyx of spermatheca long tube, often curved; macrosetae on basitarsus IV with sharp tip . . . . . **4**

4. Seta z4 usually nearly 2 times length of Z4 (see fig. 14). . . . . ***hibisci*** (Chant)

– Seta z4 not much (at most 1.5x) longer than Z4 . . . . . **5**

5. Macroseta on genu IV longer, ca. 58µ (51–64) Seta z4 short, length usually only about two-thirds of distance from its base to that of s4; Z4 short, <21µ (14–20) (see fig. 12) . . . . . ***tularensis****

– Macroseta on genu IV shorter, ca. 42µ (37–48). Seta z4 longer, length >two-thirds distance from its base to that of base of s4, usually extending nearly to base of s4; Z4 longer, usually >21µ (21–32) (see fig. 15) . . . . . ***quetzali*** McMurtry

*Occasional specimens of *tularensis* have r3 OFF the dorsal shield. Therefore, it may be necessary to use a microscope with the capability of measuring the length of setae to differentiate this species from *quetzali*.

### *Biology and distribution of Euseius species*

***Euseius* lifestyle – Type IV.** Phytoseiids in the genus *Euseius* feed on pollen, leaf sap, nonwebbing mites in the families Tetranychidae, Eriophyidae, and Tarsonemidae, as well as small insects such as thrips. Population increases are often more closely associated with pollen of crops and weeds, and growth or flush development of the host plant (indicating they feed on leaf sap), than with insect or mite prey. *Euseius* species are not associated with spider mite species that produce dense, heavily webbed colonies.

#### ***Euseius obispensis* (Aponte and McMurtry 1997)**

**California distribution:** known only from San Luis Obispo County.

**Recorded cultivated host plants in California:** avocado (Aponte and McMurtry 1997).

**Feeding habits:** not studied, but probably a generalist predator, typical of *Euseius* spp.

#### ***Euseius tularensis* (Congdon and McMurtry 1985)**

**California distribution:** widespread and common.

**Recorded cultivated host plants in California:** almond, avocado, citrus, grape, pear, and walnut (Congdon and McMurtry 1985, 1986; Grafton-Cardwell et al. 2020).

**Feeding habits:** nonwebbing tetranychid spider mites (citrus red mite *Panonychus citri* (McGregor)), thrips (citrus thrips *Scirtothrips citri* (Moulton)), pollen, and leaf sap.

#### ***Euseius stipulatus* (McMurtry 1977)**

**California distribution:** introduced to southern California citrus in 1971; native to the Mediterranean area (McMurtry 1977). Now widespread from interior and coastal southern California subtropical crops and blackberry and northward to nut crops in the San Joaquin and Sacramento valleys and grape in Sonoma County (McMurtry and Show 2012; Grafton-Cardwell et al. 2020).

**Recorded cultivated host plants in California:** almond, avocado, blackberry, cherimoya, citrus, grape, raspberry, strawberry, and walnut (McMurtry and Show 2012; Grafton-Cardwell et al. 2020).

**Feeding habits:** nonwebbing tetranychid mites (*P. citri*), eriophyid mites (citrus rust mite *Phyllocoptruta oleivora* (Ashmead)), thrips, and pollen.

#### ***Euseius hibisci* (Schuster and Pritchard 1963)**

**California distribution:** common in the coastal areas and southern interior areas and occasionally seen in the Central Valley.

**Recorded cultivated host plants in California:** almond, avocado, citrus, grape, stone fruit, strawberry, and walnut (Chant and Fleschner 1960; Schuster and Pritchard 1963; McMurtry and Johnson 1965, 1966; McMurtry et al. 1971; Oatman 1971; Rice et al. 1976; McMurtry and Flaherty 1977; Rice and Jones 1978; McMurtry et al. 1979; Congdon and McMurtry 1985, 1986; Tanigoshi et al. 1985; Grafton-Cardwell et al. 2020).

**Feeding habits:** nonwebbing tetranychid spider mites (*P. citri*, avocado brown mite *Oligonychus punicae* (Hirst), sixspotted spider mite *Eotetranychus sexmaculatus* (Riley)), eriophyid mites, tarsonemid mites (broad mite *Polyphagotarsonemus latus* (Banks)), thrips (*S. citri*), and pollen.

### ***Euseius quetzali*** **(McMurtry et al.** ***1985)***

**California distribution:** widespread and common.

**Recorded cultivated host plants in California:** almond, avocado, blackberry, cherimoya, citrus, grape, pear, raspberry, stone fruit, and walnut (McMurtry et al. 1985; Congdon and McMurtry 1986; Grafton-Cardwell et al. 2020).

**Feeding habits:** not studied, but probably a generalist predator, typical of *Euseius* spp.

## *Euseius obispensis*

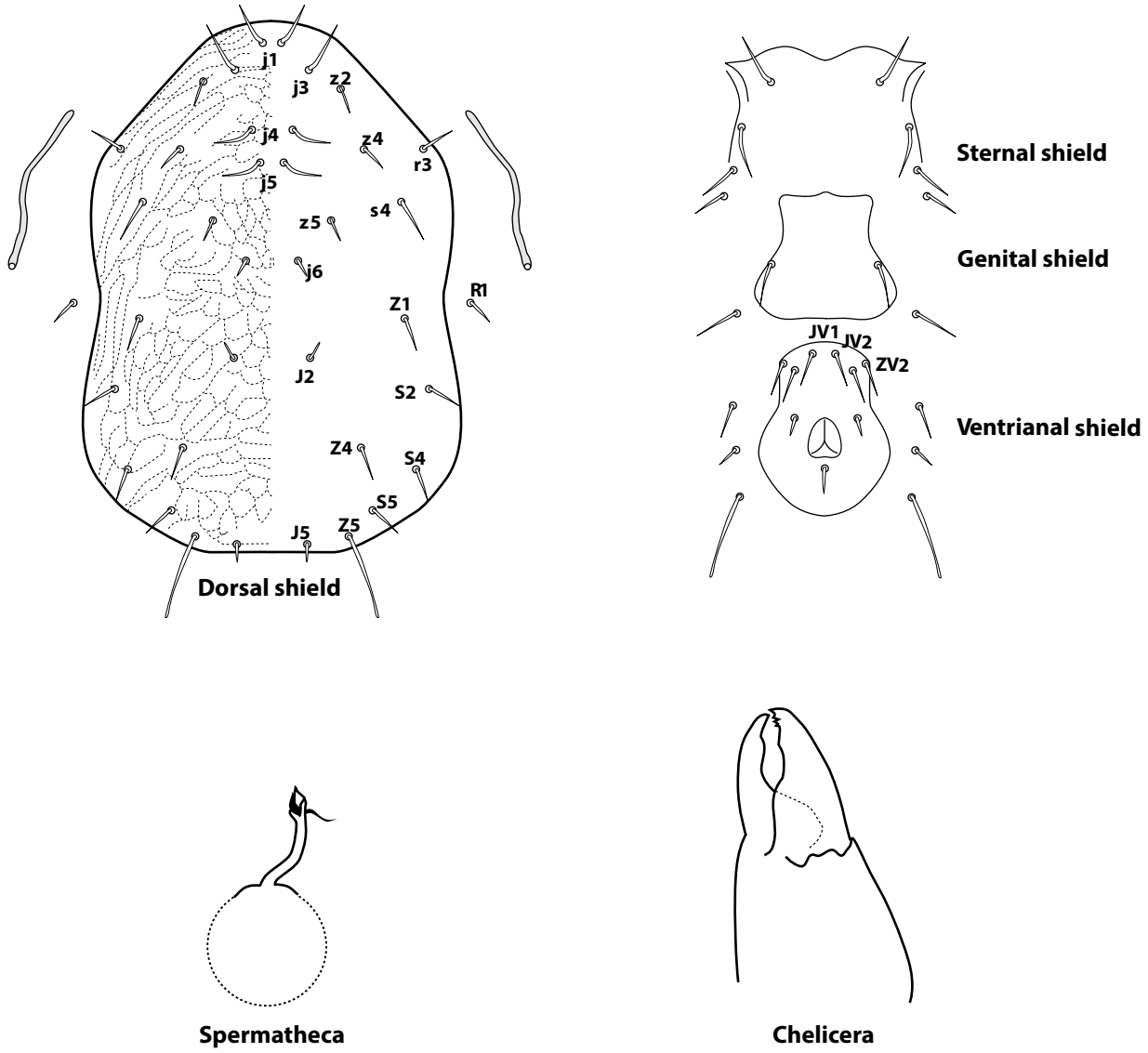



**Figure 11.** *Euseius obispensis* Aponte & McMurtry dorsal shield, ventral shields, spermatheca, and chelicera (Aponte and McMurtry 1997).

## *Euseius tularensis*

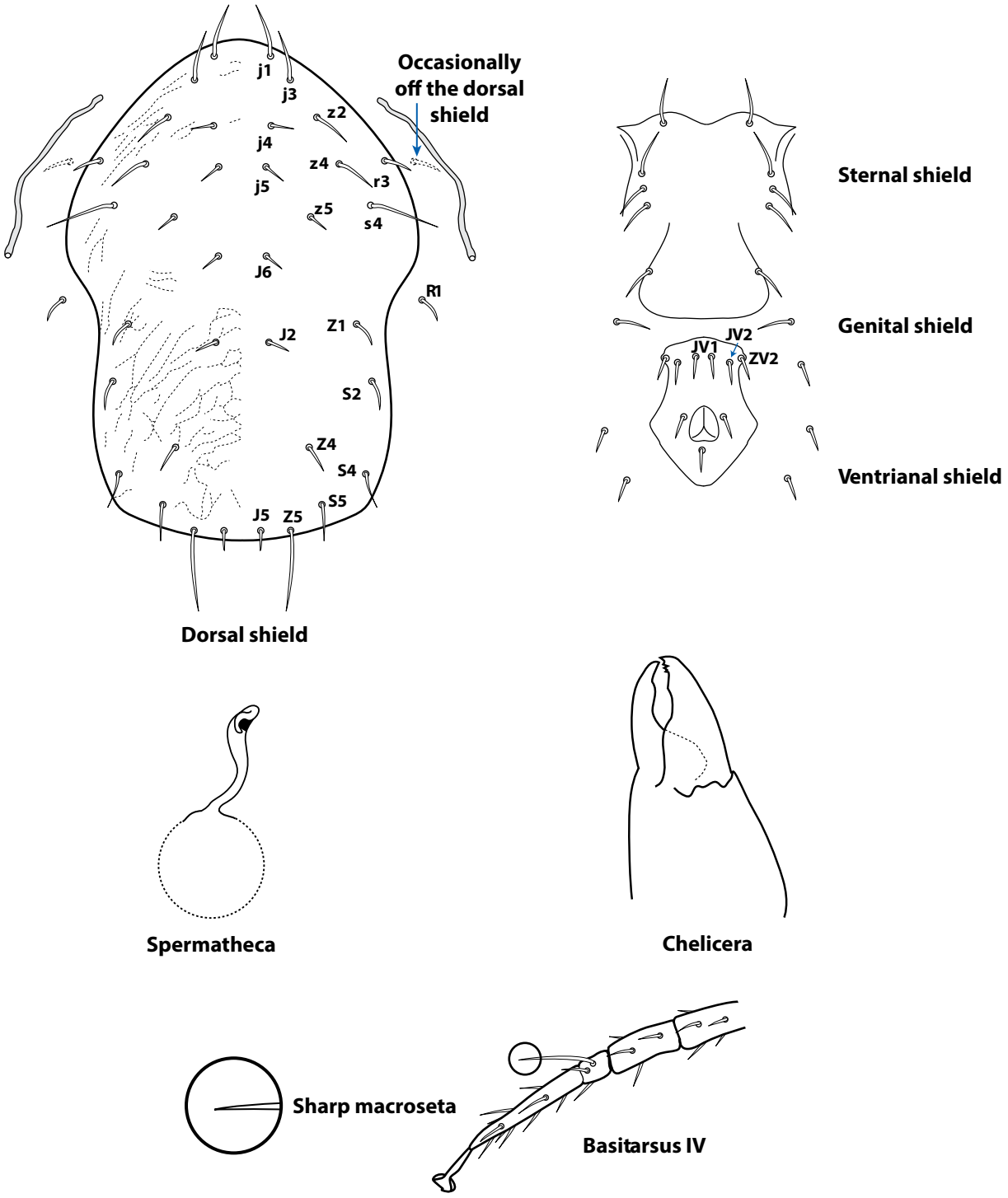



**Figure 12.** *Euseius tularensis* Congdon dorsal shield, ventral shields, spermatheca, chelicera, and basitarsus IV (Congdon and McMurtry 1985).

## *Euseius stipulatus*

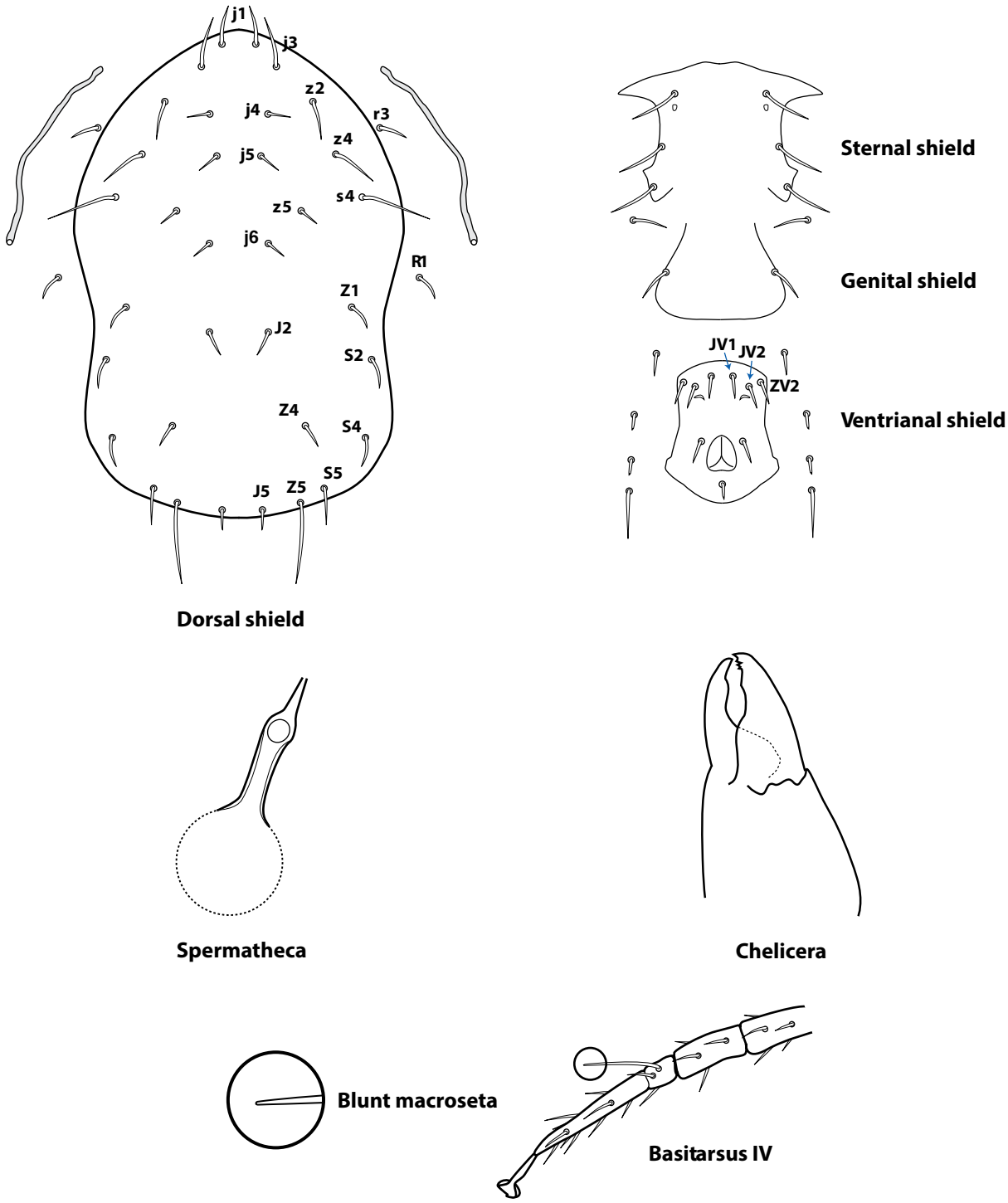
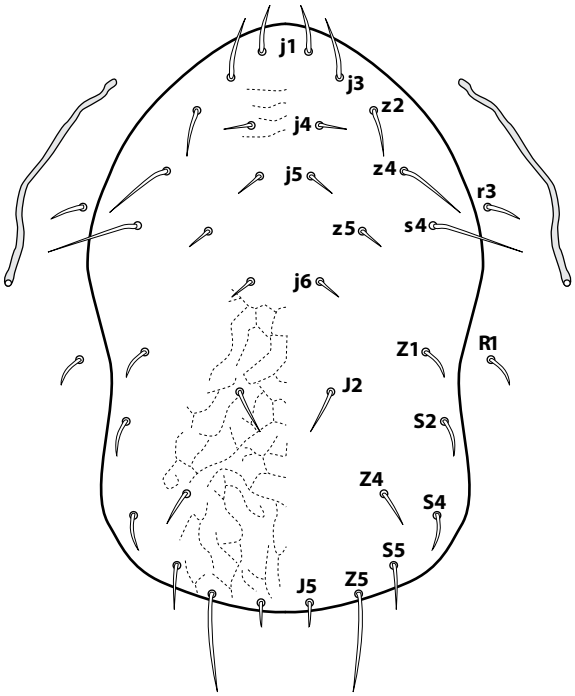
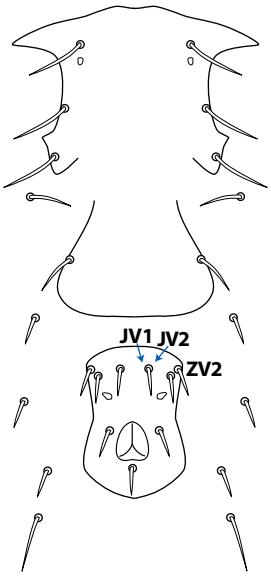



**Figure 13.** *Euseius stipulatus* (Athias-Henriot) dorsal shield, ventral shields, spermatheca, chelicera, and basitarsus IV (McMurtry 1977).

## *Euseius hibisci*



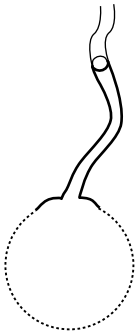

**Dorsal shield**



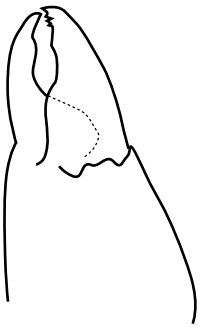

**Sternal shield**

**Genital shield**

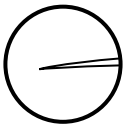
**Ventrianal shield**



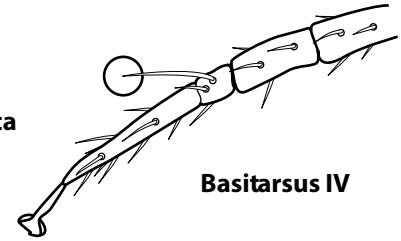
**Spermatheca**



**Chelicera**



**Sharp macroseta**



**Basitarsus IV**

**Figure 14.** *Euseius hibisci* (Chant) dorsal shield, ventral shields, spermatheca, chelicera, and basitarsus IV (Schuster and Pritchard 1963).

## *Euseius quetzali*

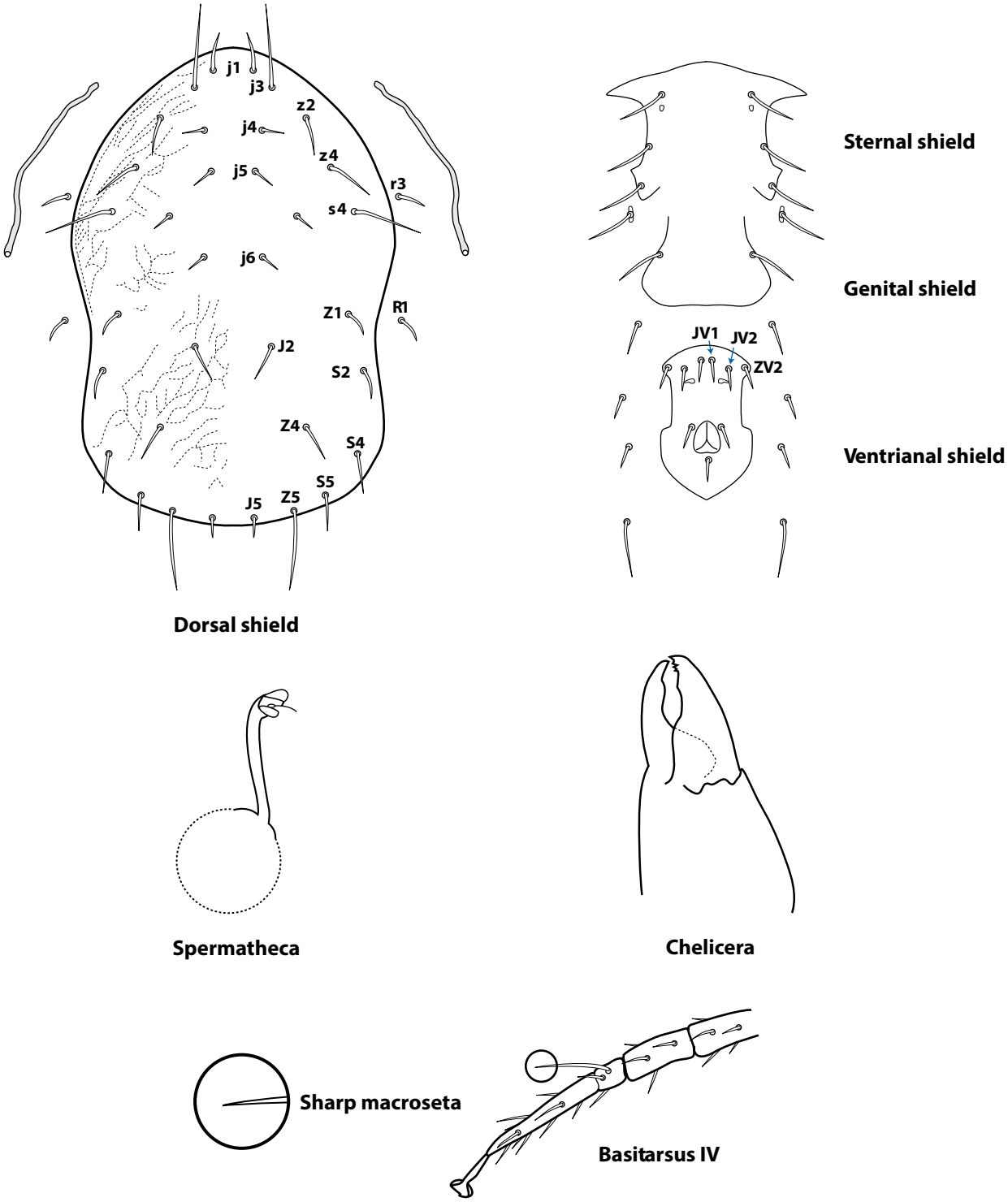



**Figure 15.** *Euseius quetzali* McMurtry dorsal shield, ventral shields, spermatheca, chelicera, and basitarsus IV (McMurtry et al. 1985).

## Species of *Amblydromalus*

### *Biology and Distribution of Amblydromalus species*

***Amblydromalus* lifestyle – Type III**: Generalists – broad feeding habits including mites, whiteflies, thrips and scale insects, as well as pollen

***Amblydromalus limonicus* (Schuster and Pritchard 1963)**

**California distribution:** coastal areas.

**Recorded cultivated host plants in California:** avocado, blackberry, cherimoya, citrus, grape, and walnut (Garman and McGregor 1956; Chant 1959; Chant and Fleschner 1960; Schuster and Pritchard 1963; McMurtry and Johnson 1966; McMurtry et al. 1971; McMurtry and Show 2012; Grafton-Cardwell et al. 2020).

**Feeding habits:** tetranychid spider mites (*O. punicae, P. citri*), scale crawlers, nectar, honeydew, and pollen. Produced commercially for use in greenhouses for western flower thrips *Frankliniella occidentalis* (Pergande) and greenhouse whitefly *Trialeurodes vaporariorum* (Westwood) control (LeBeck and Leppla 2021).

### *Amblydromalus limonicus*

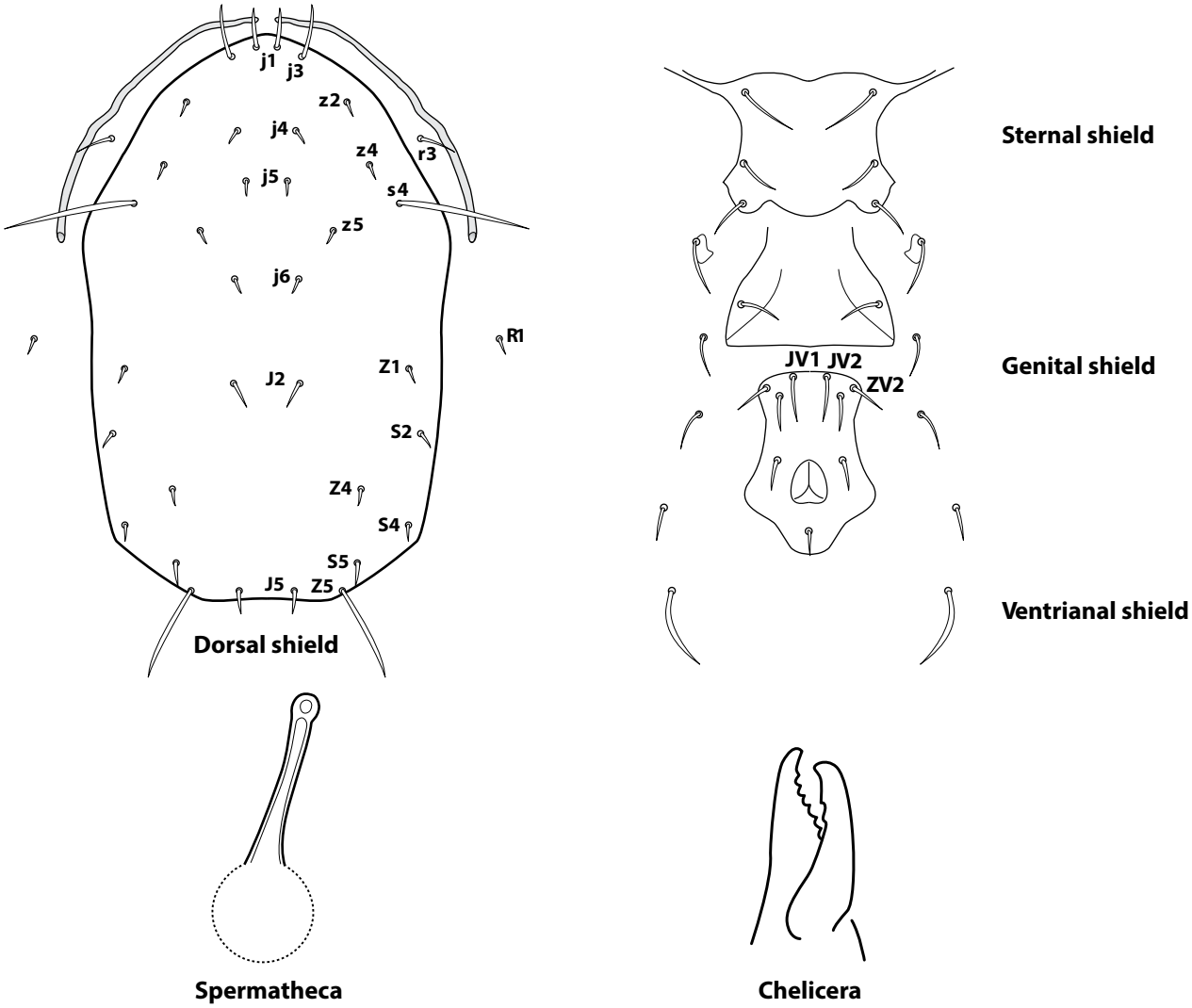



**Figure 16.** *Amblydromalus limonicus* (Garman and McGregor) dorsal shield, ventral shields, spermatheca, and chelicera (Schuster and Pritchard 1963). See p. 14 for the biology and distribution *A. limonicus*.

## Species of *Typhlodromalus*

### *Biology and Distribution of Typhlodromalus species*

***Typhlodromalus* lifestyle – Type III**. Generalists – broad feeding habits including mites, scales, pollen and fungi

***Typhlodromalus peregrinus* (Chant and McMurtry 2005b)**

**California distribution:** coastal areas.

**Recorded cultivated host plants in California:** citrus (Chant 1959) and a single record from grape (Grafton-Cardwell et al. 2020).

**Feeding habits:** Studies in Florida showed that a wide range of food was accepted, including spider mites, scale eggs and crawlers, pollen, honeydew and fungi.

### *Typhlodromalus peregrinus*

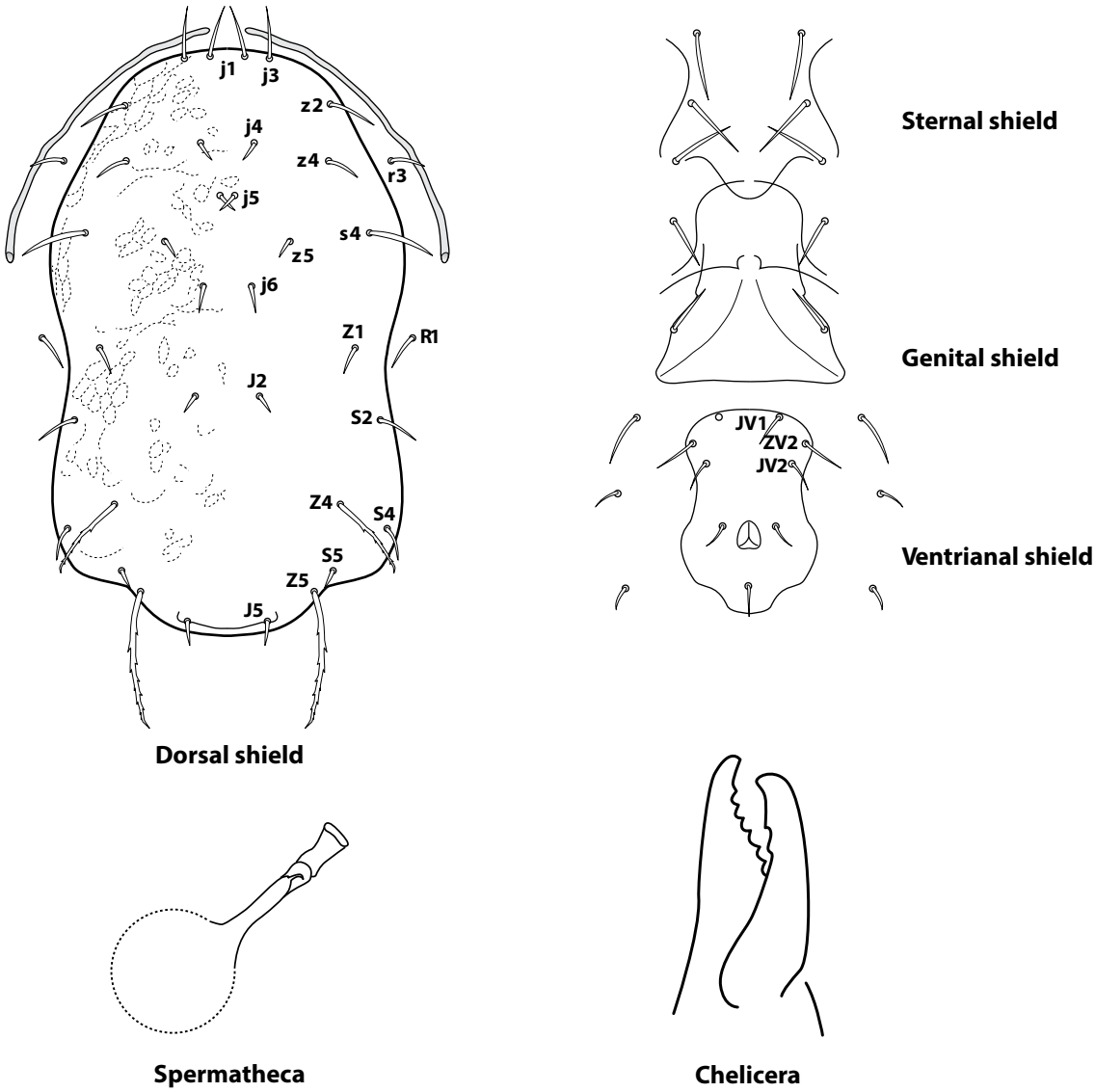



**Figure 17.** *Typhlodromalus peregrinus* (Muma) dorsal shield, ventral shields, spermatheca, and chelicera (Chant and McMurtry 2005b).

## *Key to species of Neoseiulus*

1. Calyx of spermatheca tubular or horn-shaped, length 3 or more times its greatest width; atrium as wide as or wider than base of calyx. . . . . **2**
– Calyx of spermatheca shaped like cup or tall glass, rarely more than 2 times its greatest width; atrium markedly narrower than base of calyx . . . . . **4**
2. Spermatheca distinctly constricted at juncture of atrium and calyx (fig. 18) . . . . . ***aurescens*** (Athias-Henriot)
– Spermatheca not distinctly constricted at juncture of atrium and calyx . . . . . **3**
3. Spermatheca tubular, but flaring outward at distal end (fig. 19). . . . . ***brevispinus*** (Kennett)
– Spermatheca horn-shaped, diameter gradually increasing distally (fig. 20) . . . . . ***barkeri*** Hughes [=mckenziei (Schuster & Pritchard)]
4. Setae J2 extending about two-thirds the distance to bases of setae Z4 (fig. 21) . . . . . ***fallacis*** (Garman)
– Setae J2 extending less than one-half the distance to bases of setae Z4. . . . . **5**
5. Ventrianal shield with large crescentic pores (fig. 22) . . . . . ***californicus*** (McGregor)
– Ventrianal shield with small, circular pores (fig. 23) . . . . . ***cucumeris*** (Oudemans)

### *Biology and distribution of Neoseiulus species*

***Neoseiulus* lifestyle – Type II–III**. Some Type II (preference for web-spinning spider mites); some Type III (generalists not preferring web-spinning spider mites). A number of these species are produced in insectaries and utilized in tree crops or greenhouses for spider mite or thrips control.

#### ***Neoseiulus aurescens* (Schuster and Pritchard 1963)**

**California distribution:** coastal areas.

**Recorded cultivated host plants in California:** blackberry, grape, pecan litter, strawberry, plum, and winter rye (Schuster and Pritchard 1963; McMurtry et al. 1971; Oatman 1971; McMurtry and Show 2012; Grafton-Cardwell et al. 2020).

**Feeding habits:** not well studied, probably Type III; tarsonemid mites (cyclamen mite *Phytonemus pallidus* (Banks)) and eriophyid mites.

#### ***Neoseiulus brevispinus* (Schuster and Pritchard 1963)**

**California distribution:** widespread.

**Recorded cultivated host plants in California:** grape and strawberry (Schuster and Pritchard 1963; McMurtry et al. 1971; Oatman 1971; Grafton-Cardwell et al. 2020).

**Feeding habits:** not studied, probably Type III.

#### ***Neoseiulus barkeri* (=*mckenziei*) (Schuster and Pritchard 1963)**

**California distribution:** widespread but uncommon.

**Recorded cultivated host plants in California:** strawberry, grape, and walnut (Schuster and Pritchard 1963; Grafton-Cardwell et al. 2020).

**Feeding habits:** Type III; tetranychid spider mites, tenuipalpid mites, eriophyid mites, tarsonemid mites, and thrips. Produced commercially for control of thrips (onion thrips *Thrips tabaci* Lindeman, western flower thrips) and tarsonemid mites (*P. latus*).

#### ***Neoseiulus fallacis* (Schuster and Pritchard 1963)**

**California distribution:** uncommon on crops.

**Recorded cultivated host plants in California:** kidney bean and soybean (Schuster and Pritchard 1963).

**Feeding habits:** Type II – mainly associated with web-spinning tetranychid spider mites (*T. urticae* and *T. pacificus*), but also known to feed on nonwebbing tetranychid mites (European red mite *P. ulmi (Koch))*, tarsonemid mites (*P. pallidus)*, and eriophyid mites (tomato russet mite *Aculops lycopersici* (Massee)). Produced commercially for twospotted spider mite, European red mite, and citrus red mite control (LeBeck and Leppla 2021).

### ***Neoseiulus californicus*** **(Schuster and Pritchard 1963)**

**California distribution:** widespread and common.

**Recorded cultivated host plants in California:** avocado, blackberry, citrus, grape, pear, pecan litter, raspberry, stone fruit, and walnut (Garman and McGregor 1956; Schuster and Pritchard 1963; McMurtry et al. 1971; Oatman 1971; McMurtry and Show 2012; Howell and Daugovish 2013; Grafton-Cardwell et al. 2020).

**Feeding habits:** Type II – mainly associated with web-spinning tetranychid spider mites (*T. urticae*, *Eotetranychus lewisi* (McGregor) and persea mite *Oligonychus perseae* (Tuttle, Baker, and Abbatiello), but also known to feed on tarsonemid mites (*P. pallidus*, *P. latus)*, insects, and pollen. Produced commercially for twospotted spider mite, broad mite, and cyclamen mite control (LeBeck and Leppla 2021).

### ***Neoseiulus cucumeris*** **(Schuster and Pritchard 1963)**

**California distribution:** coastal areas.

**Recorded cultivated host plants in California:** grape and strawberry (Schuster and Pritchard 1963; McMurtry et al. 1971; Oatman 1971; Grafton-Cardwell et al. 2020).

**Feeding habits:** Type III – tetranychid spider mites, tarsonemid mites (*P. latus*, *P. pallidus)*, thrips, and pollen. Produced commercially for twospotted spider mite, tarsonemid mite, and thrips (onion thrips and western flower thrips) control in greenhouses (LeBeck and Leppla 2021).

## *Neoseiulus aurescens*

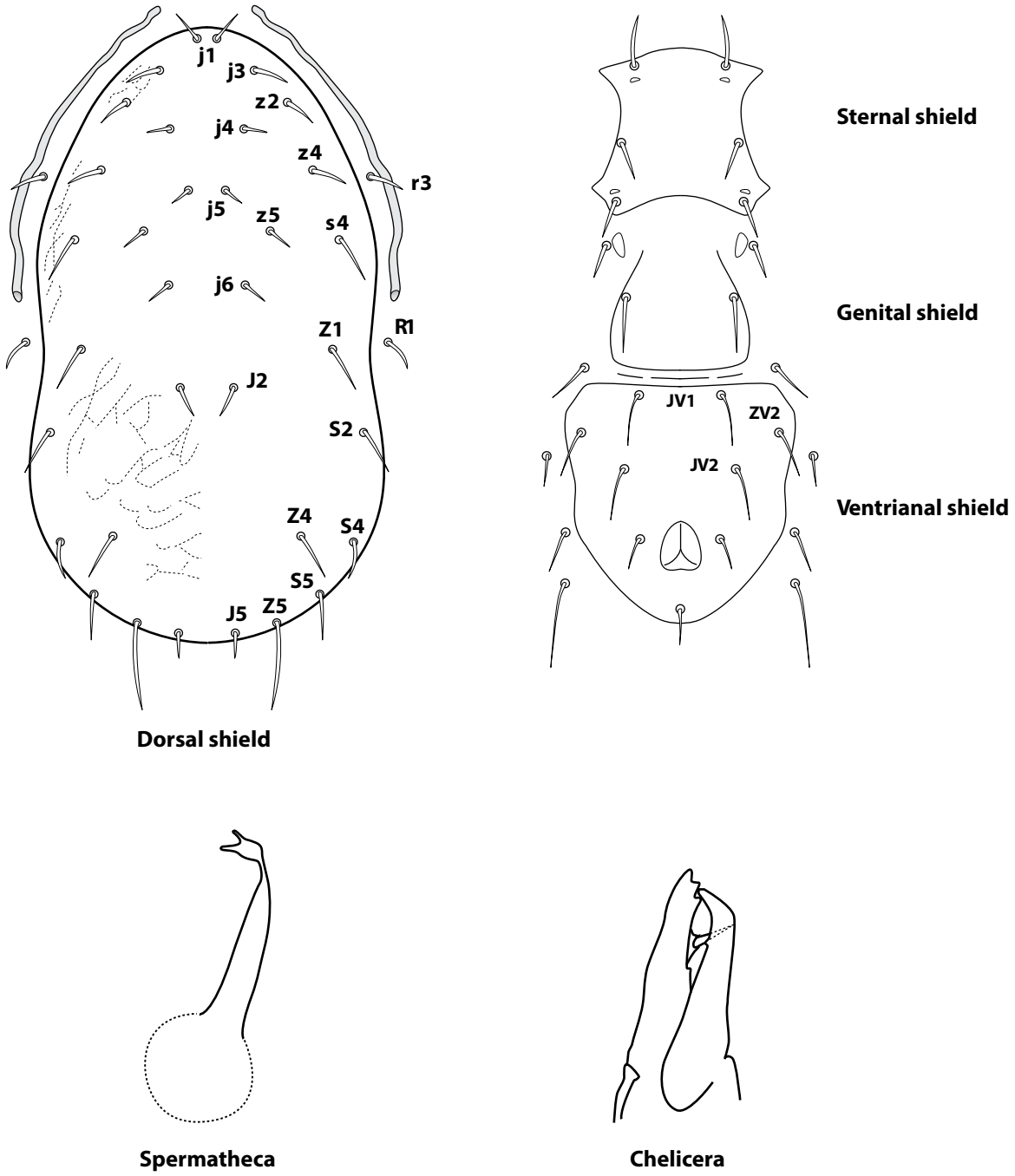



**Figure 18.** *Neoseiulus aurescens* (Athias-Henriot) dorsal shield, ventral shields, spermatheca, and chelicera (Schuster and Pritchard 1963).

## *Neoseiulus brevispinus*

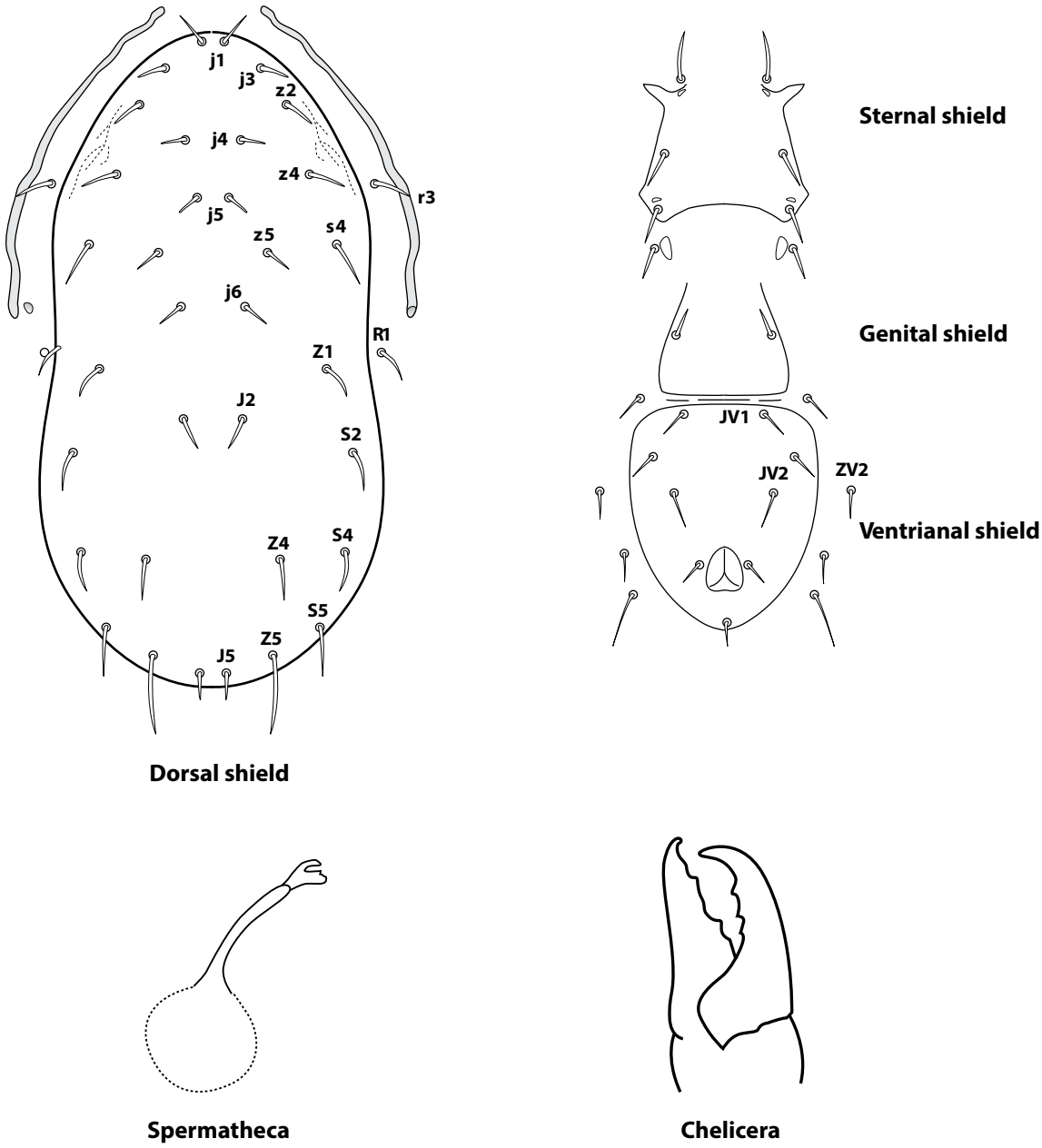



**Figure 19.** *Neoseiulus brevispinus* (Kennett) dorsal shield, ventral shields, spermatheca, and chelicera (Schuster and Pritchard 1963).

## *Neoseiulus barkeri*

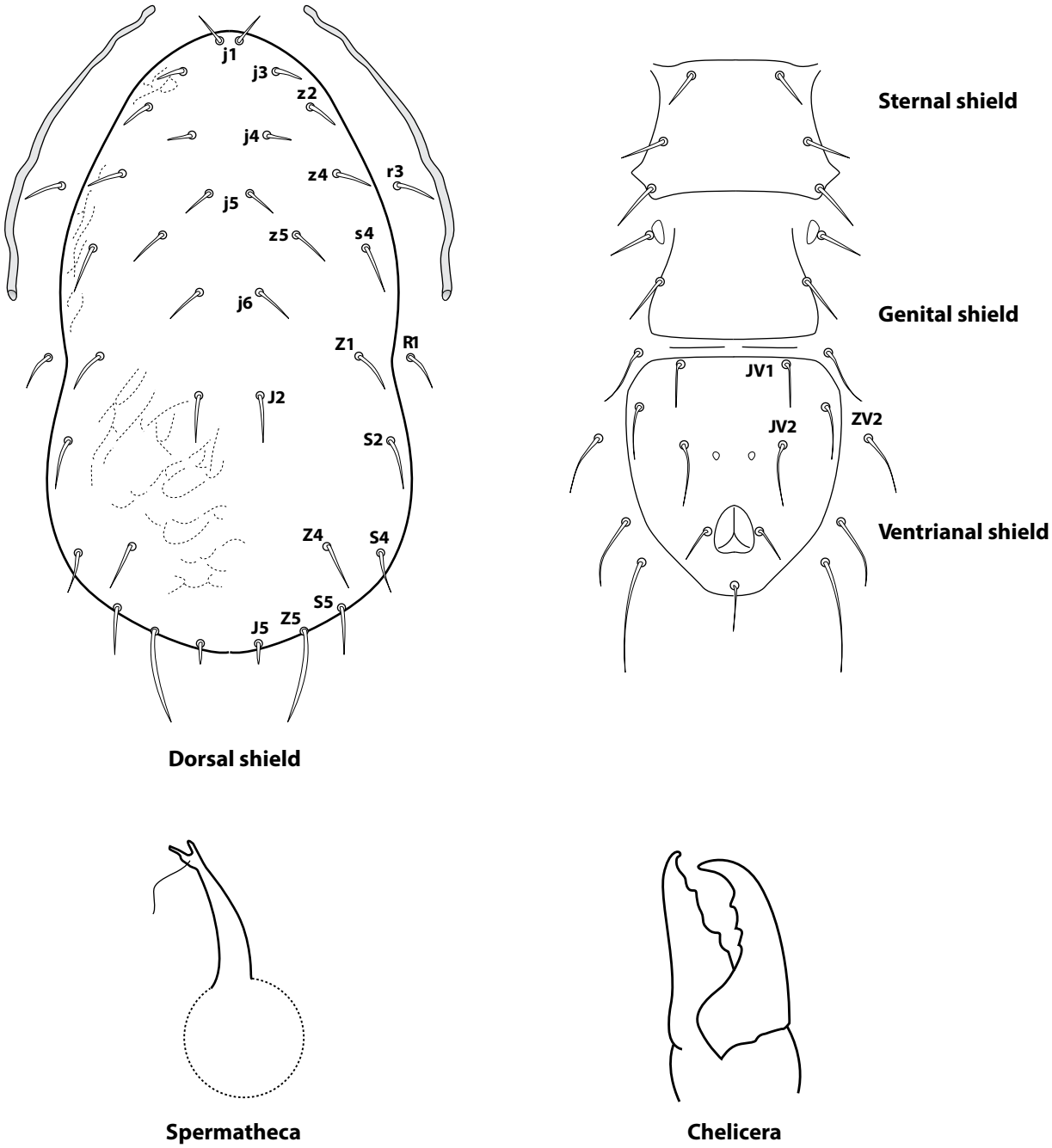
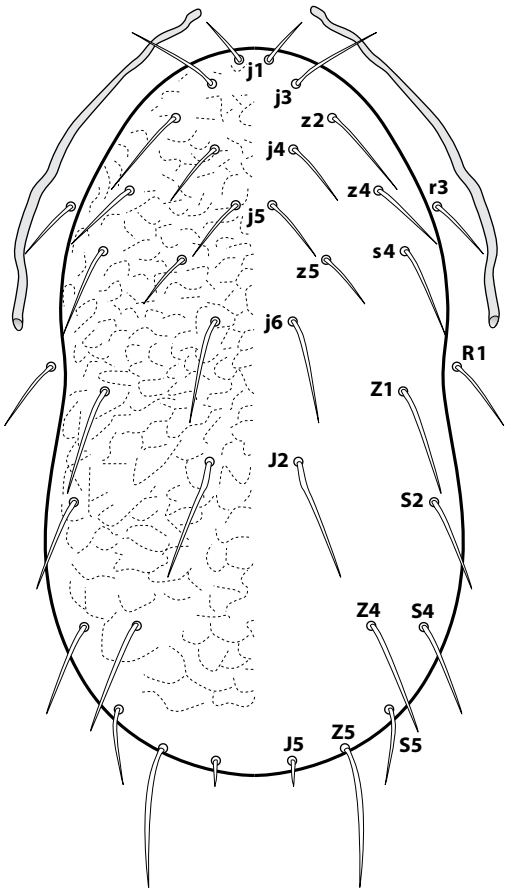
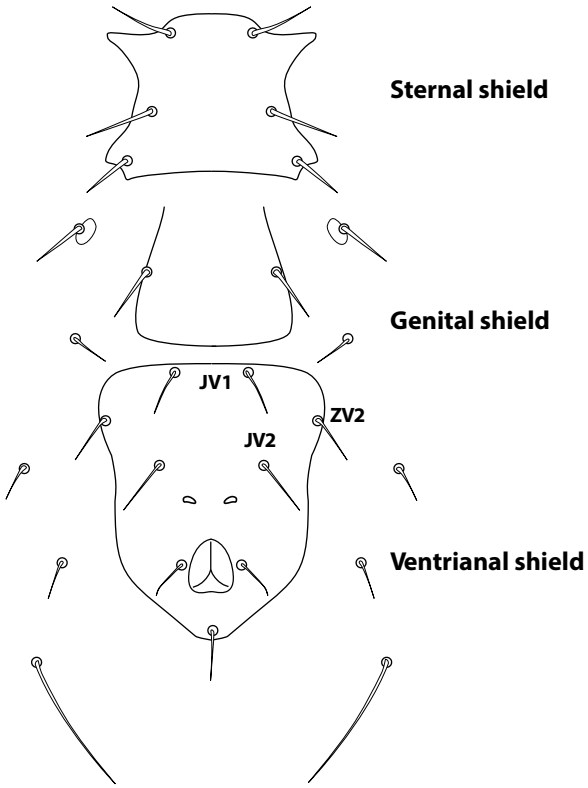


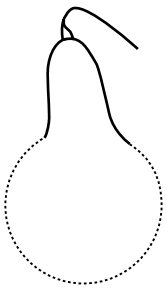

**Figure 20.** *Neoseiulus barkeri* Hughes[=mckenziei (Schuster and Pritchard)] dorsal shield, ventral shields, spermatheca, and chelicera (Schuster and Pritchard 1963).

## *Neoseiulus fallacis*




**Dorsal shield**



**Spermatheca**

**Chelicera**

**Figure 21.** *Neoseiulus fallacis* (Garman) dorsal shield, ventral shields, spermatheca, and chelicera (Schuster and Pritchard 1963).

## *Neoseiulus californicus*

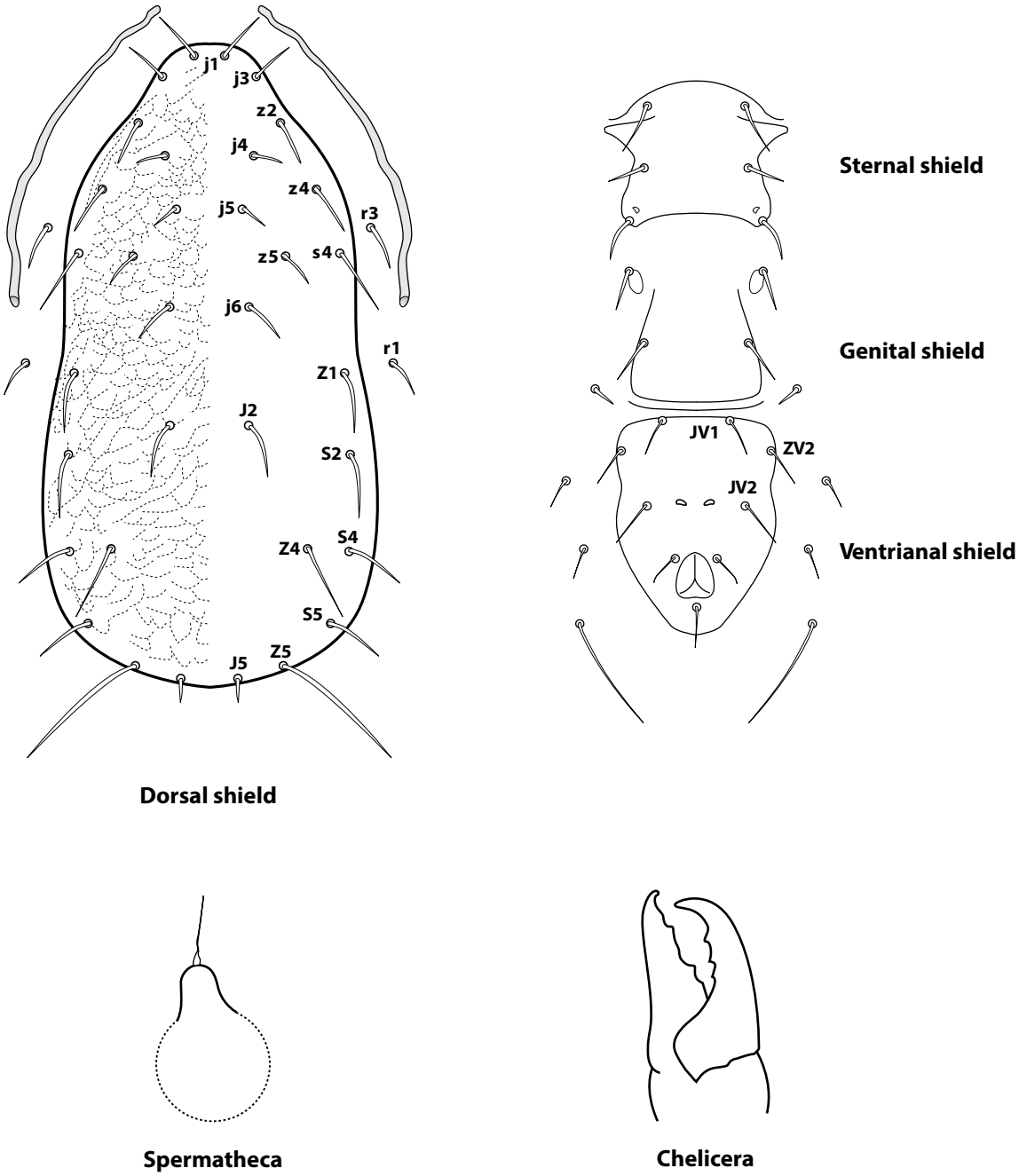



**Figure 22.** *Neoseiulus californicus* (McGregor) dorsal shield, ventral shields, spermatheca, and chelicera (Schuster and Pritchard 1963).

## *Neoseiulus cucumeris*

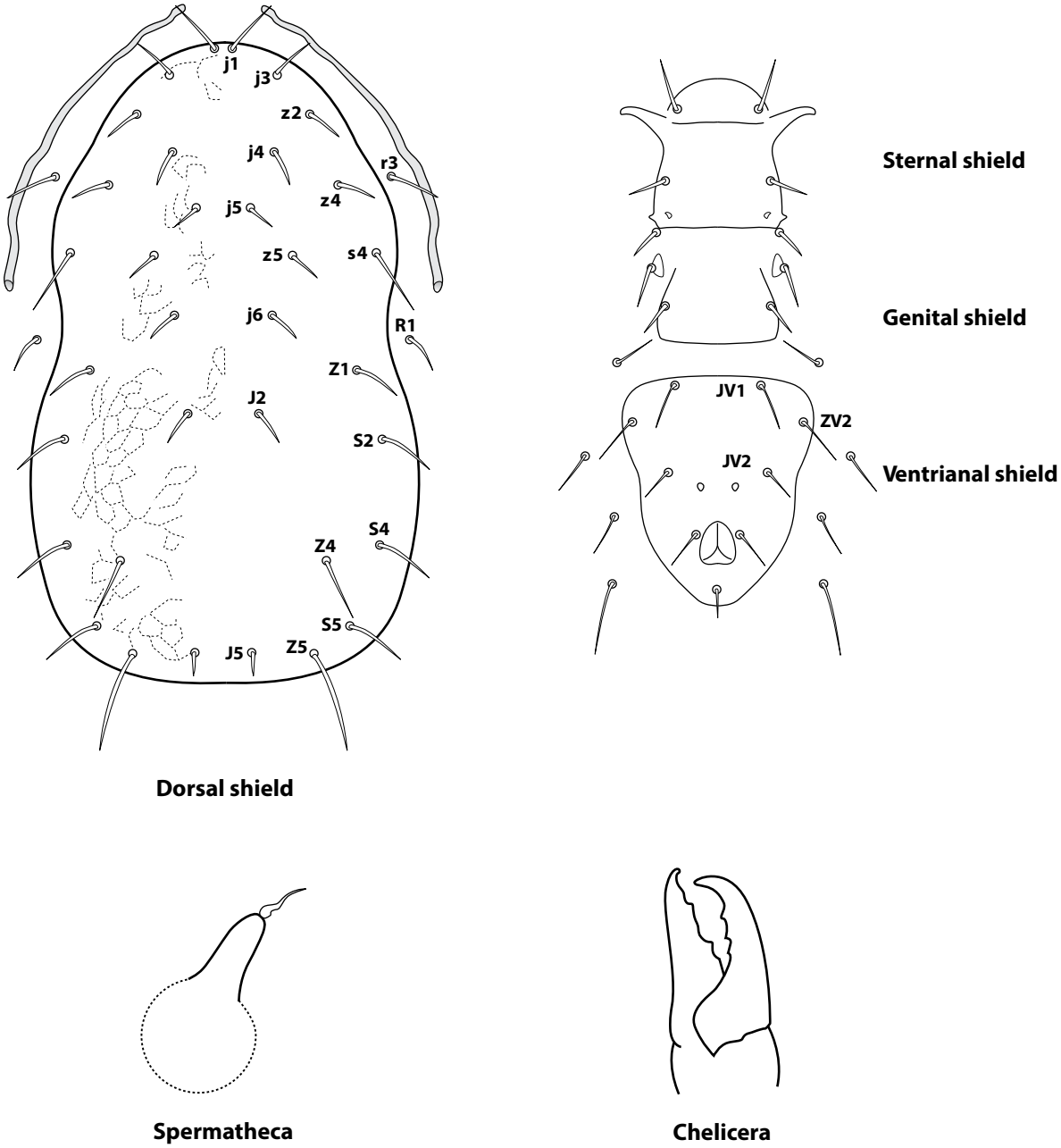



**Figure 23.** *Neoseiulus cucumeris* (Oudemans) dorsal shield, ventral shields, spermatheca, and chelicera (Schuster and Pritchard 1963).

## *Key to species of Proprioseiopsis*

1. Calyx of spermatheca shallow, cup-shaped (fig. 24) . . . . . ***asetus*** (Chant)
– Calyx of spermatheca saccular . . . . . **2**
2. Setae S2 much longer than Z1 . . . . . **3**
– Setae S2 short, subequal to Z1 . . . . . **4**
3. Ventrianal shield as wide as long, reticulated (fig. 25) . . . . . ***fragariae*** (Kennett)
– Ventrianal shield longer than wide, smooth (fig. 26) . . . . . ***exopodalis*** (Kennett)
4. Setae z2 more than twice the length of z4 (fig. 27) . . . . . ***lindquisti*** (Schuster & Pritchard)
– Setae z2 less than twice the length of z4 (fig. 28) . . . . . ***ovatus*** (Garman)

### *Biology and distribution of Proprioseiopsis species*

***Proprioseiopsis* lifestyles – Type III**. Generalists. There have been only few studies conducted on this genus, but development and reproduction has been confirmed on spider mites, eriophyid mites, and pollen. The reproductive potential of this group was low in the studies reported. Many species occur primarily in soil/humus/litter habitats. The five species listed below are the most likely to be found on crops.

#### ***Proprioseiopsis asetus* (Schuster and Pritchard 1963)**

**California distribution:** known from Riverside, Imperial, and Solano counties.

**Recorded cultivated host plants in California:** pecan litter (Schuster and Pritchard 1963).

**Feeding habits:** tetranychid spider mites (*T. urticae*, citrus brown mite *E. orientalis*), thrips (*F. occidentalis*, *T. tabaci)*, and pollen.

#### ***Proprioseiopsis fragariae* (Schuster and Pritchard 1963)**

**California distribution:** widespread but uncommon on crops.

**Recorded cultivated host plants in California:** leaf litter of alfalfa, grape, and strawberry (Schuster and Pritchard 1963; Grafton-Cardwell et al. 2020).

**Feeding habits:** not studied.

#### ***Proprioseiopsis exopodalis* (Schuster and Pritchard 1963)**

**California distribution:** widespread but uncommon on crops.

**Recorded cultivated host plants in California:** no cultivated hosts recorded. Bermudagrass, litter of oak, and ice plant (Schuster and Pritchard 1963).

**Feeding habits:** not studied.

#### ***Proprioseiopsis lindquisti* (Schuster and Pritchard 1963)**

**California distribution:** central and southern areas.

**Recorded cultivated host plants in California:** harvested hay, pear, and strawberry (Schuster and Pritchard 1963; McMurtry et al. 1971; Oatman 1971; Chant and Yoshida-Shaul 1984c; Grafton-Cardwell et al. 2020).

**Feeding habits:** not studied.

#### ***Proprioseiopsis ovatus* (Schuster and Pritchard 1963)**

**California distribution:** known only from Plumas County.

**Recorded cultivated host plants in California:** no cultivated hosts recorded; grass and soil (Schuster and Pritchard 1963).

**Feeding habits:** not studied.

## *Proprioseiopsis asetus*

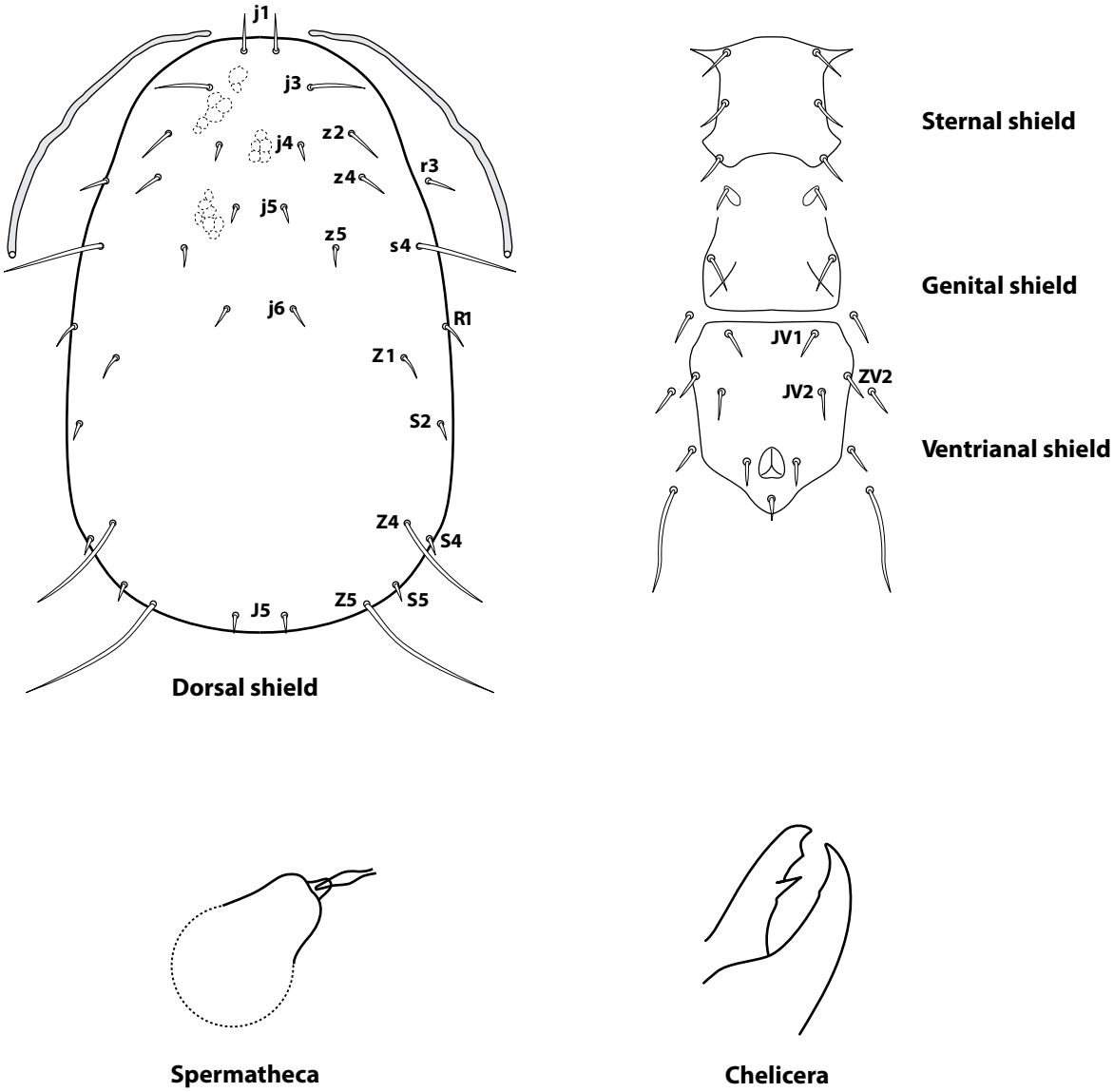



**Figure 24.** *Proprioseiopsis asetus* (Chant) dorsal shield, ventral shields, spermatheca, and chelicera (Schuster and Pritchard 1963).

## *Proprioseiopsis fragariae*

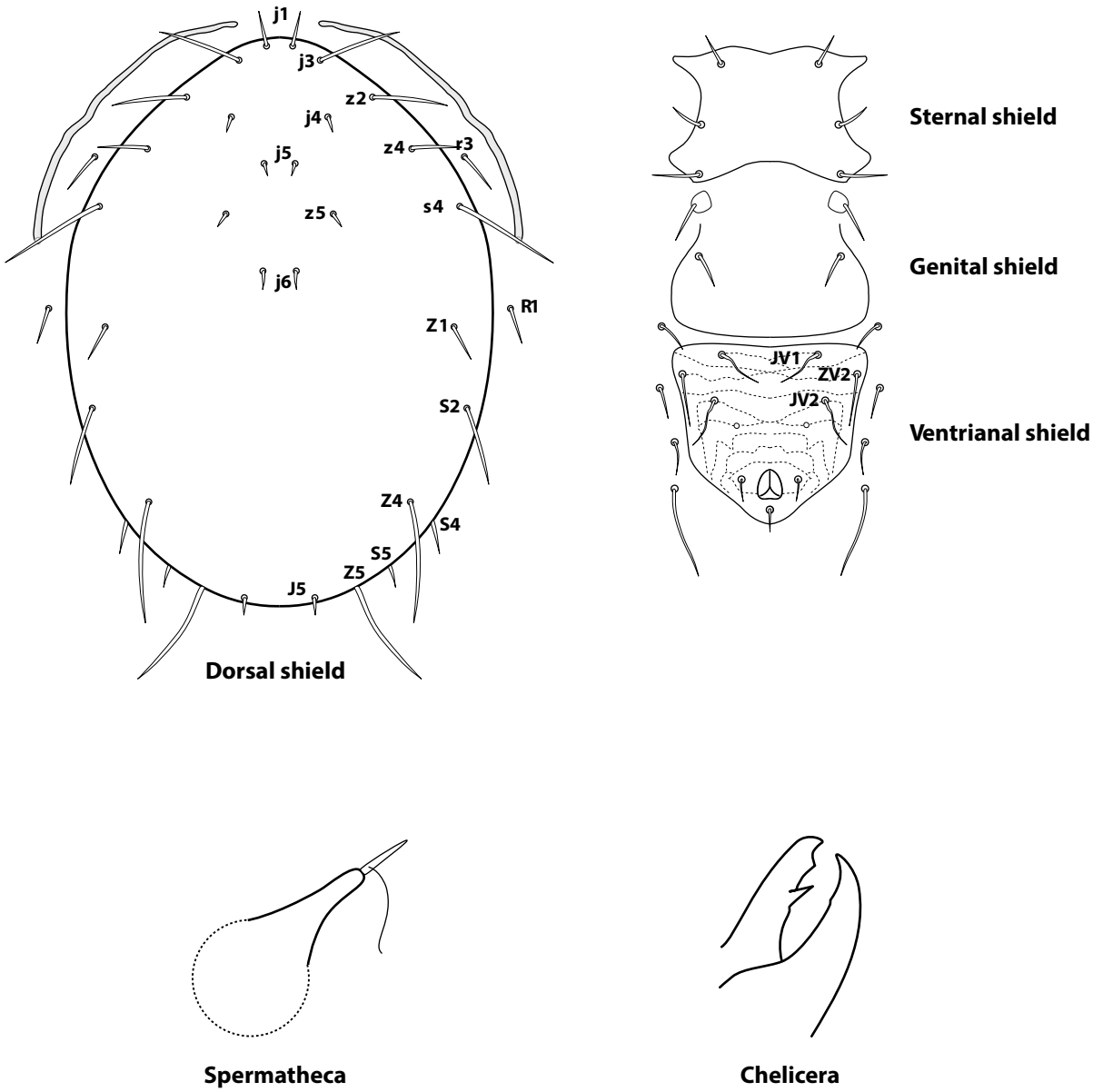



**Figure 25.** *Proprioseiopsis fragariae* (Kennett) dorsal shield, ventral shields, spermatheca, and chelicera (Schuster and Pritchard 1963).

## *Proprioseiopsis exopodalis*

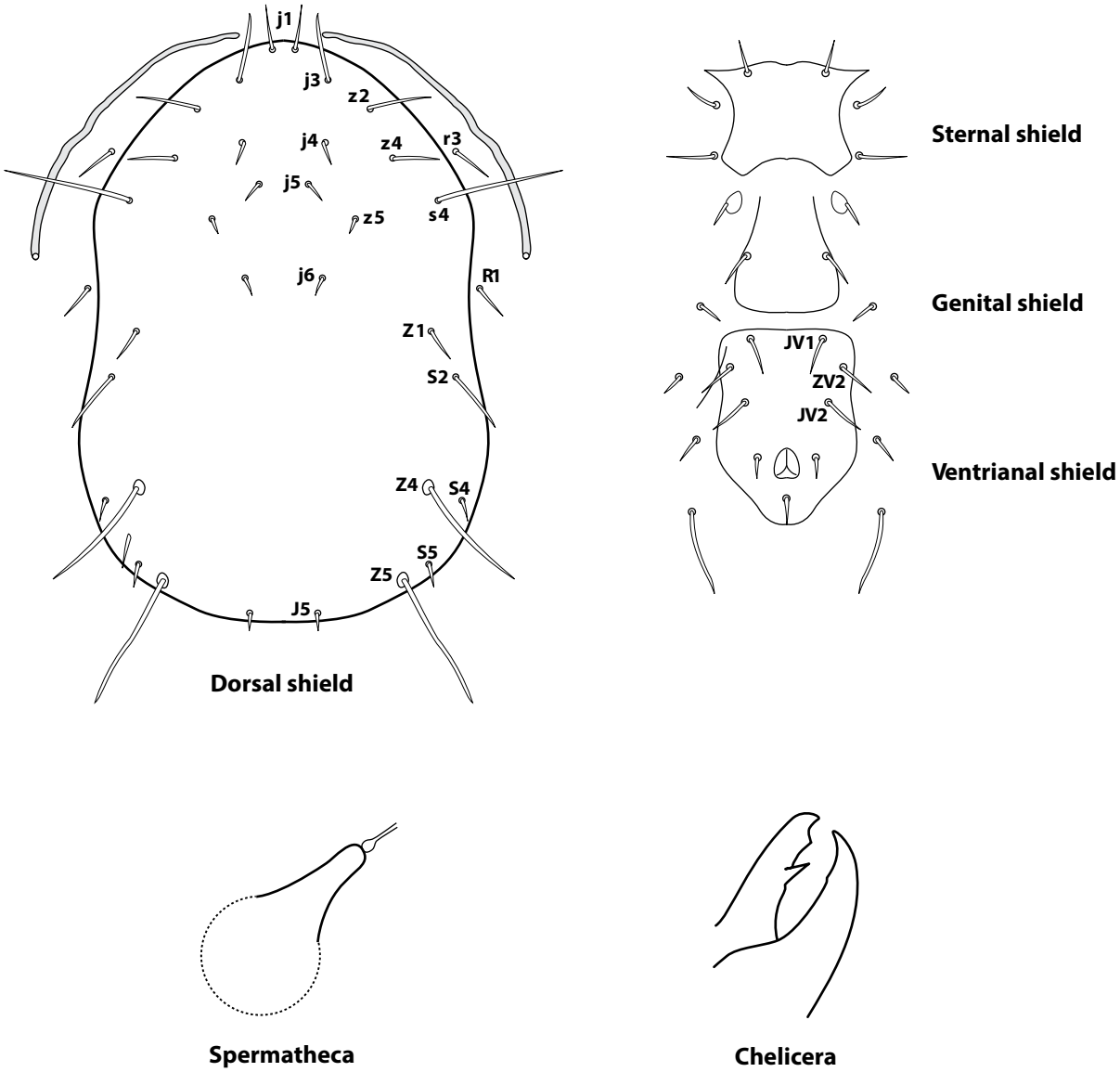



**Figure 26.** *Proprioseiopsis exopodalis* (Kennett) dorsal shield, ventral shields, spermatheca, and chelicera (Schuster and Pritchard 1963).

## *Proprioseiopsis lindquisti*

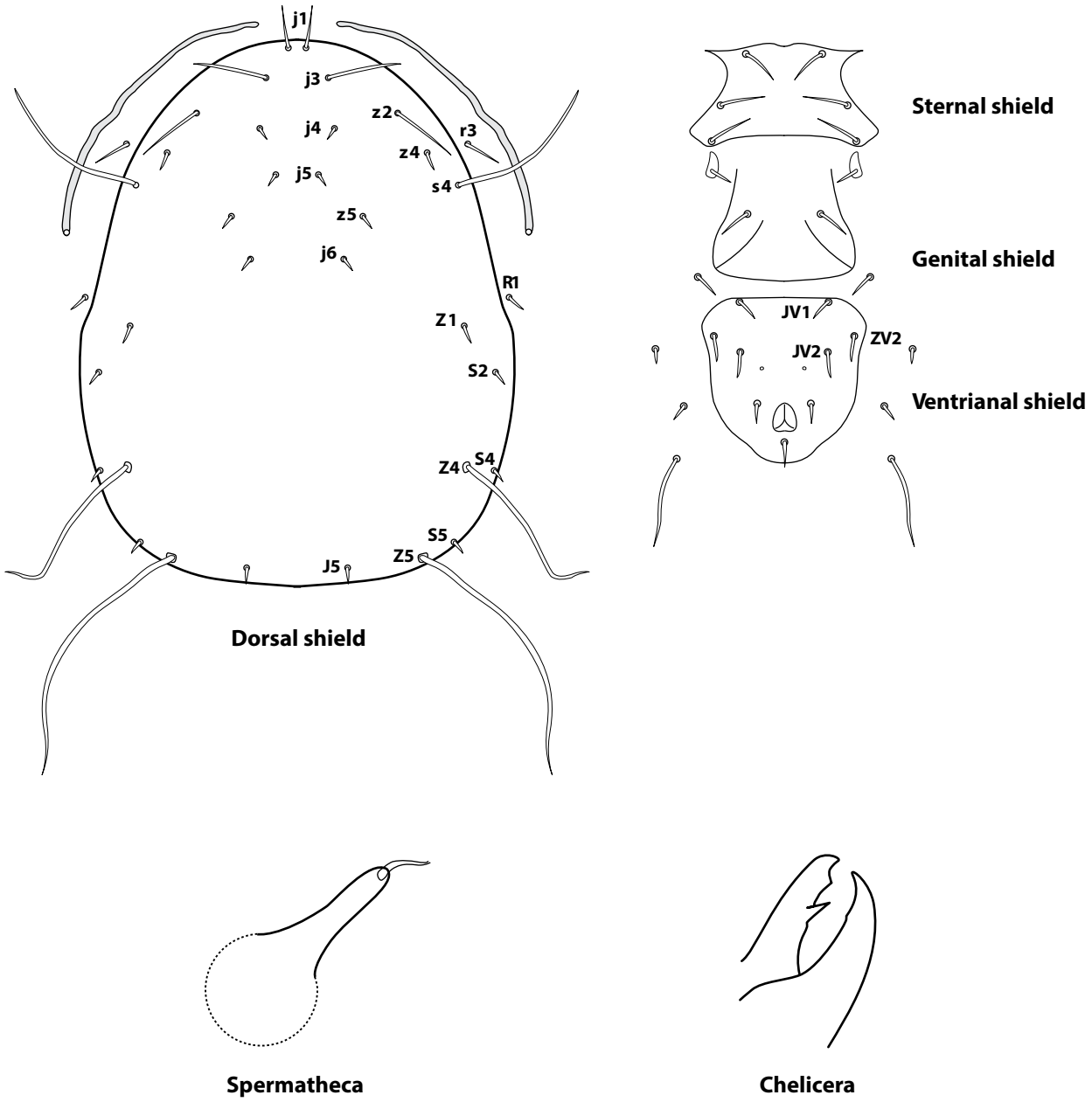



**Figure 27.** *Proprioseiopsis linquisti* (Schuster and Pritchard) dorsal shield, ventral shields, spermatheca, and chelicera (Schuster and Pritchard 1963).

## *Proprioseiopsis ovatus*

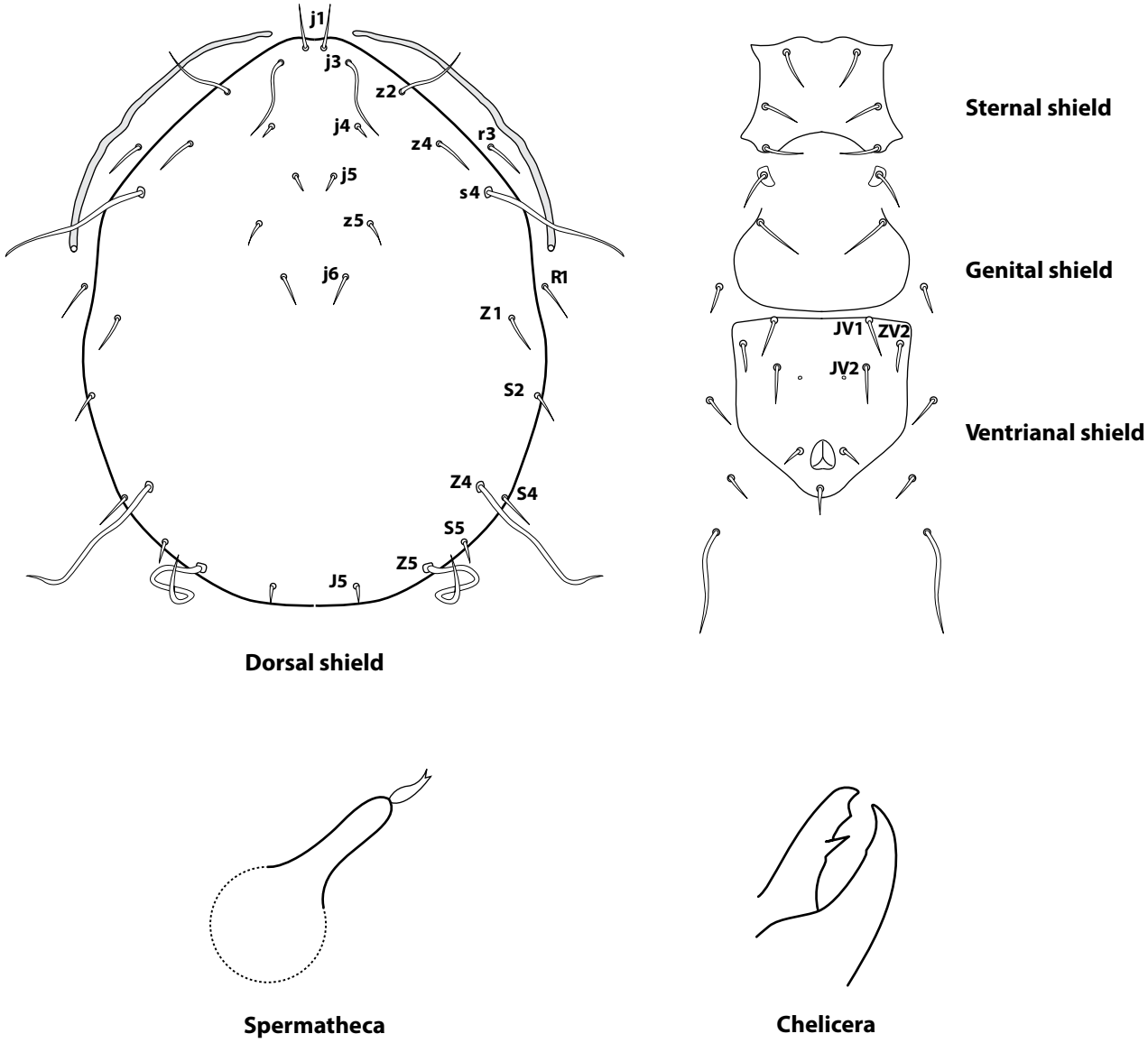



**Figure 28.** *Proprioseiopsis ovatus* (Garman) dorsal shield, ventral shields, spermatheca, and chelicera (Schuster and Pritchard 1963).

## Species of *Arrenoseius*

### *Biology and distribution of Arrenoseius species*

***Arrenoseius*** (=***Fundiseius***) lifestyle – likely Type III. Little known of the biology and feeding habits of species in this genus.

***Arrenoseius palustris*** **(Chant) (Schuster and Pritchard 1963)**

**California distribution:** widespread but uncommon on crops.

**Recorded cultivated host plants in California:** plum (Schuster and Pritchard 1963).

**Feeding habits:** not studied.

### *Arrenoseius palustris*

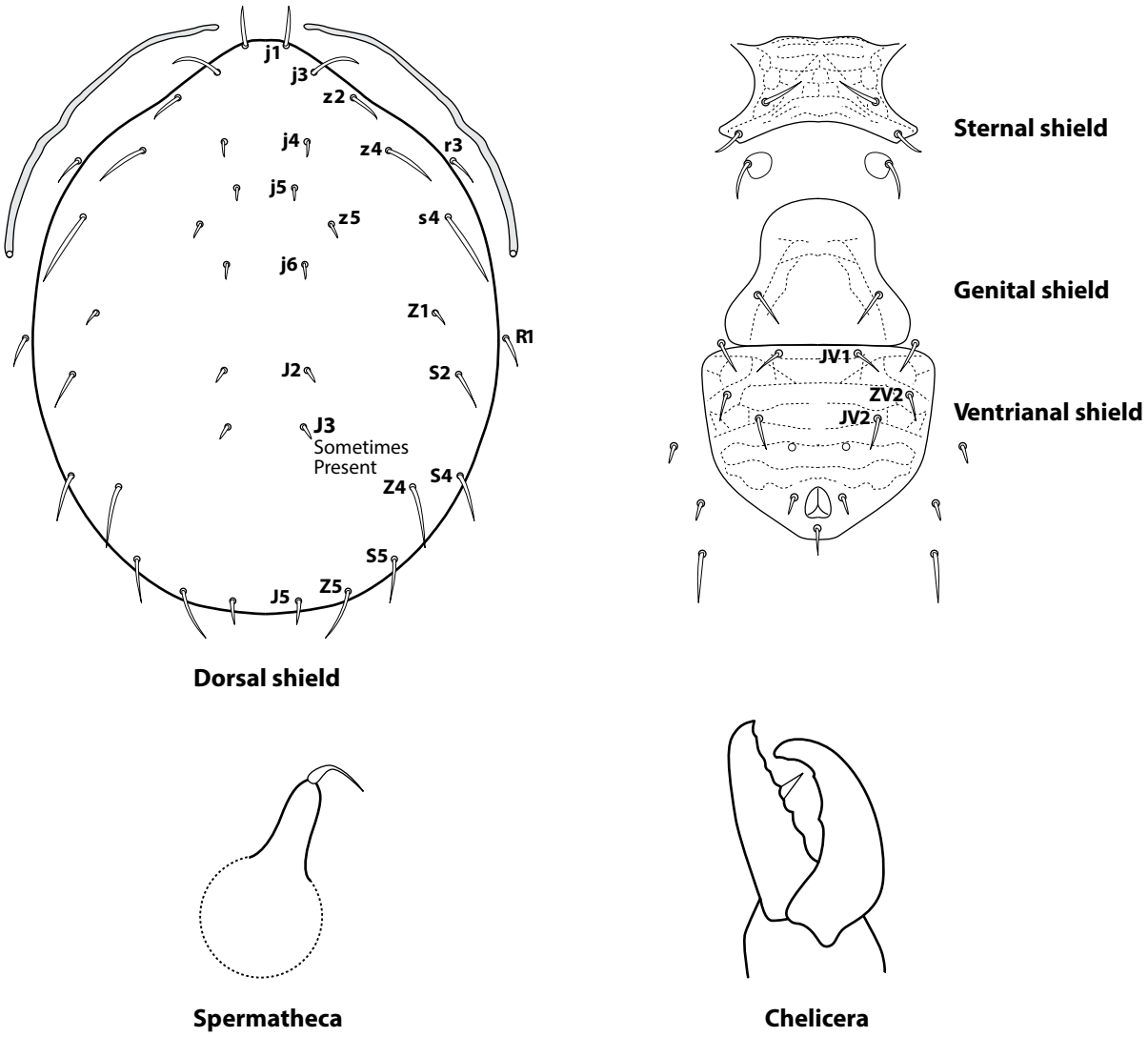



**Figure 29.** *Arrenoseius palustris* (Chant) dorsal shield, ventral shields, spermatheca, and chelicera (Schuster and Pritchard 1963).

## Species of *Graminaseius*

### *Biology and distribution of Graminaseius species*

***Graminaseius* lifestyle – likely Type III**. Feeding habits unknown.

***Graminaseius graminis* (Athias-Henriot 1961; Livshitz and Kuznetsov 1972; Doker et al. 2019)**

**California distribution:** coastal areas.

**Recorded cultivated host plants in California:** grape and strawberry (Grafton-Cardwell et al. 2020).

**Feeding habits:** not studied.

### *Graminaseius graminis*

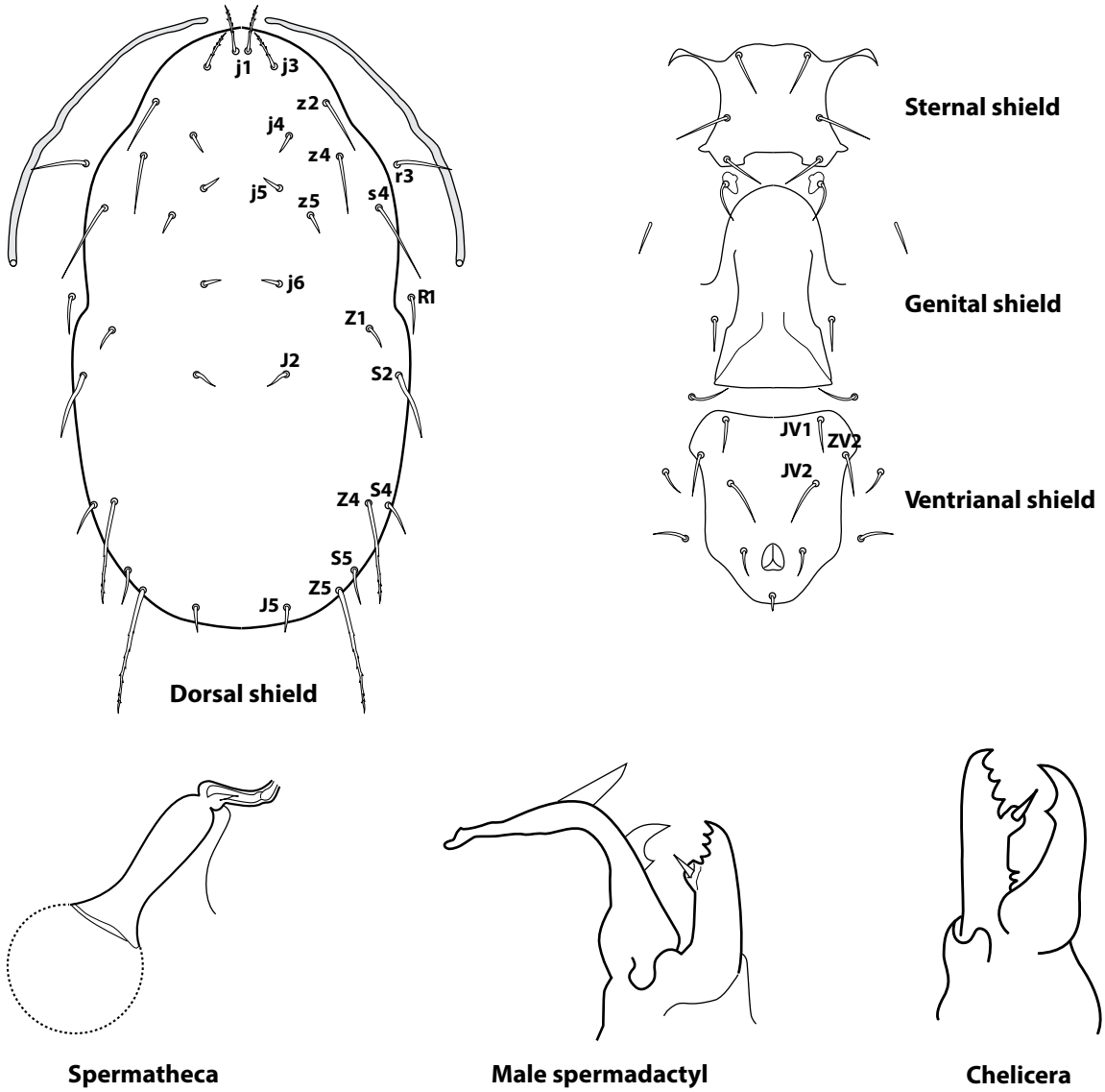



**Figure 30.** *Graminaseius graminis* (Chant) dorsal shield, ventral shields, spermatheca, chelicera, and spermadactyl (Athias-Henriot 1961; Livshits and Kuznetsov 1972; Doker et al. 2019).

## Species of *Transeius*

### *Biology and distribution of Transeius species*

***Transeius*** lifestyle – Type III. Known to feed on thrips, spider mites, and eriophyid mites.

***Transeius newelli*** **(Schuster and Pritchard 1963)**

**California distribution:** widespread.

**Recorded cultivated host plants in California: no cultivated hosts recorded;** foliage or litter of native trees (Schuster and Pritchard 1963).

**Feeding habits:** not studied.

### *Transeius newelli*

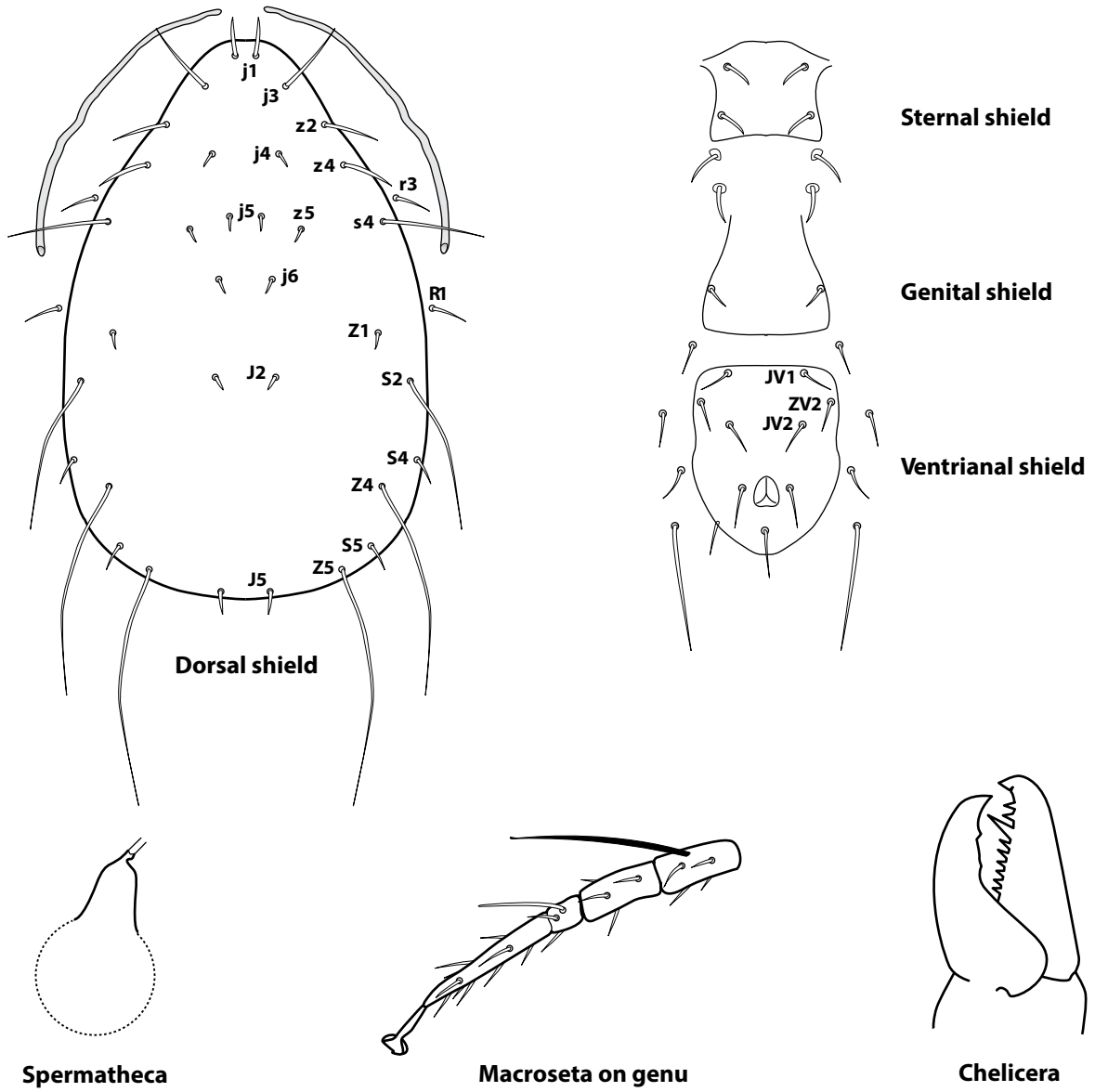



**Figure 31.** *Transeius newelli* (Chant) dorsal shield, ventral shields, spermatheca, chelicera, and macroseta on genu (Schuster and Pritchard 1963).

## *Key to species of Amblyseius*

1. Ventrianal shield vase-shaped, wider at level of anus than at anterior level (ZV-2) (fig. 32) . . . . . ***herbicolus*** (*Chant*) (=*largoensis Muma*)

– Ventrianal shield pentagonal, not wider at level of anus than at anterior level. . . . . **2**

2. Calyx of spermatheca cup or bell-shaped; setae z4 < one-third length of s4 (fig. 33) . . . . . ***andersoni*** (Chant)

– Calyx of spermatheca not bell-shaped; setae z4 > one-half length of s4 (fig. 34). . . . . ***similoides*** Buchelos & Pritchard

### *Biology and distribution of Amblyseius species*

***Amblyseius* lifestyle – Type III**. All species studied are generalist feeders of tetranychid spider mites, insects, and pollen.

#### *Amblyseius herbicolus* (=largoensis) (Schuster and Pritchard 1963)

**California distribution:** coastal areas.

**Recorded cultivated host plants in California:** avocado and walnut (Schuster and Pritchard 1963; McMurtry and Johnson 1966; McMurtry et al. 1971).

**Feeding habitats:** tetranychid spider mites, tarsonemid mites (*P. latus*), thrips, and pollen.

#### *Amblyseius andersoni* (Chant and Yoshida-Shaul 1990)

**California distribution:** known only from Mendocino County.

**Recorded cultivated host plants in California:** grape and pear (Grafton-Cardwell et al. 2020).

**Food habits:** tetranychid spider mites (*T. urticae*, *E. lewisi*, *P. ulmi*), eriophyid mites, tarsonemid mites (*P. pallidus)*, thrips (*F. occidentalis*, *T. tabaci*), and pollen. Produced commercially for spider mite, rust mite, and broad mite control (LeBeck and Leppla 2021).

#### *Amblyseius similoides* (Schuster and Pritchard 1963)

**California distribution:** widespread and common.

**Recorded cultivated host plants in California:** almond, avocado, blackberry, citrus, cherimoya, grape, pear, stone fruit, strawberry, and walnut (Buchelos and Pritchard 1960; Schuster and Pritchard 1963; McMurtry and Johnson 1966; McMurtry et al. 1971; Oatman 1971; McMurtry and Show 2012; Grafton-Cardwell et al. 2020).

**Feeding habits:** tetranychid spider mites (*T. pacificus, P. ulmi, O. punicae*), eriophyids, and pollen.

## *Amblyseius herbicolus*

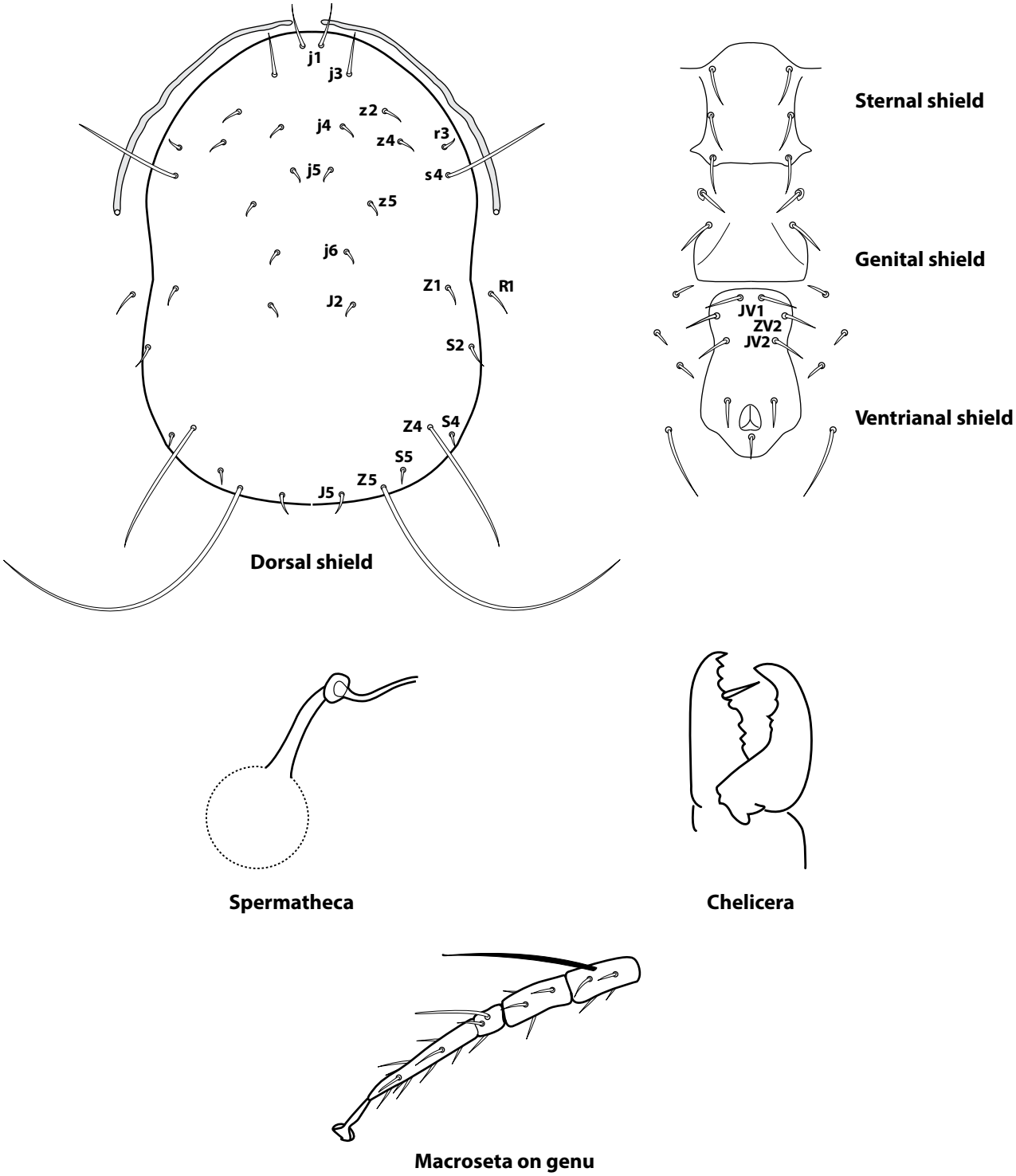



**Figure 32.** *Amblyseius herbicolus* (Chant) [=largoensis Muma] dorsal shield, ventral shields, spermatheca, chelicera, and macroseta on genu (Schuster and Pritchard 1963).

## *Amblyseius andersoni*

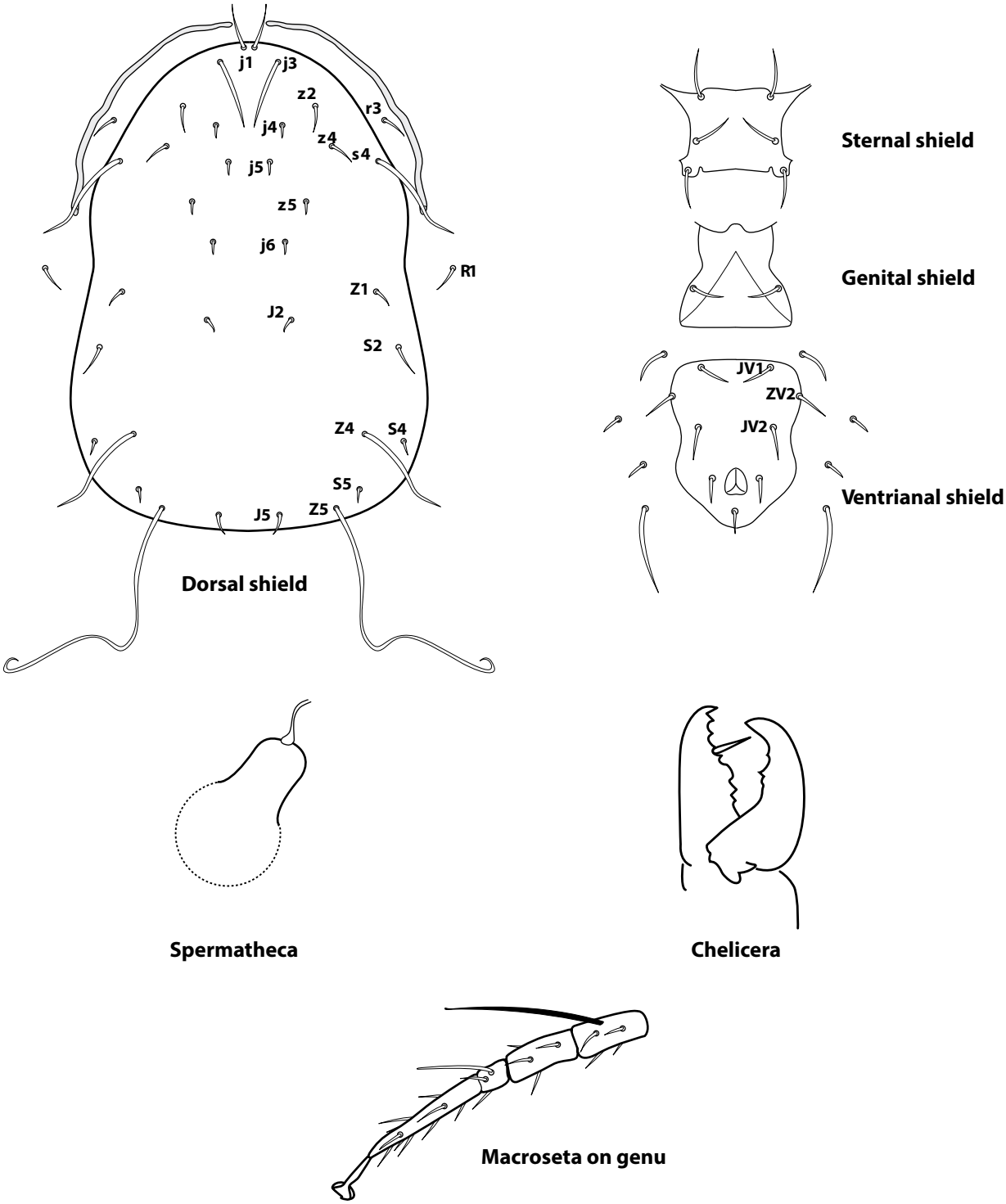
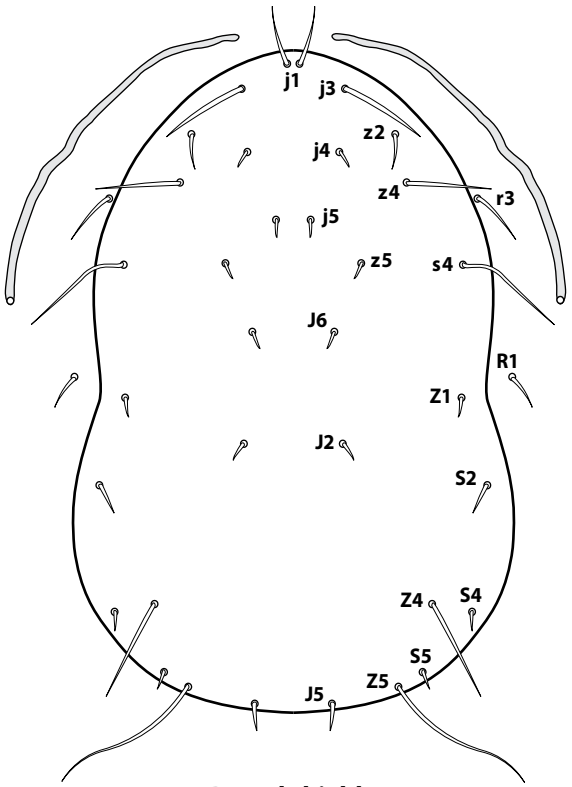
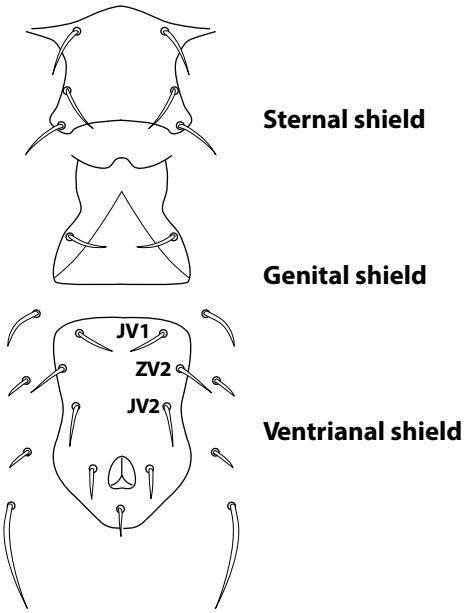



**Figure 33.** *Amblyseius andersoni* (Chant) dorsal shield, ventral shields, spermatheca, chelicera, and macroseta on genu (Chant and Yoshida-Shaul 1990).

## *Amblyseius similoides*



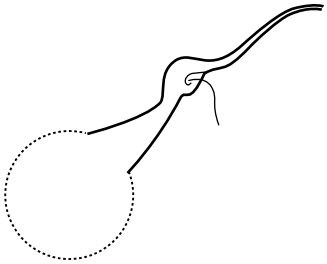

**Dorsal shield**




**Sternal shield**

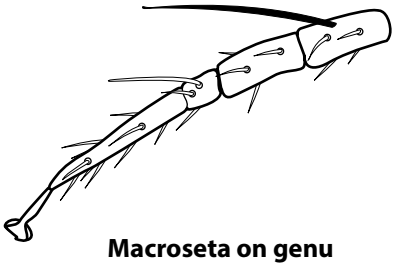
**Genital shield**

**Ventrianal shield**



**Spermatheca**

**Chelicera**



**Macroseta on genu**

**Figure 34.** *Amblyseius similoides* Buchelos and Pritchard dorsal shield, ventral shields, spermatheca, chelicera, and macroseta on genu (Schuster and Pritchard 1963).

## Species of *Phytoseius*

### *Biology and distribution of Phytoseius species*

***Phytoseius* lifestyle – Type III generalist feeders**. Often associated with eriophyoid mites (rust and bud mites), but effectiveness as biological control agents largely unknown. Small, laterally compressed, some thick, barbed, lateral setae. Often found on hairy leaves; their anatomy suggests behavior of crawling between leaf hairs.

***Phytoseius finitimus* (Schuster and Pritchard 1963)**

**California distribution:** known only from Sonoma County.

**Recorded cultivated host plants in California:** grape (Schuster and Pritchard 1963).

**Food habits:** not studied.

### *Phytoseius finitimus*

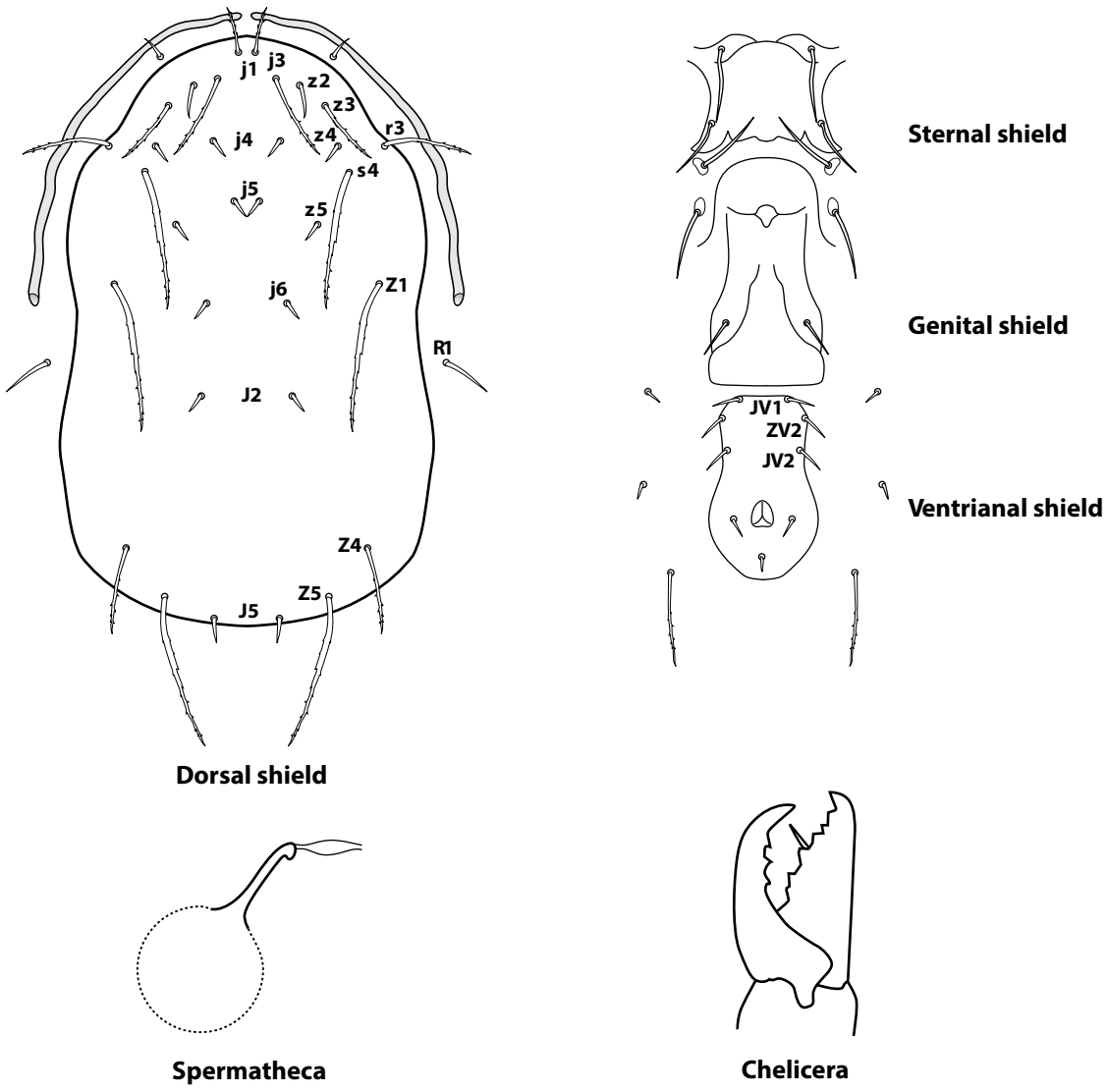



**Figure 35.** *Phytoseius finitimus* (Ribaga) dorsal shield, ventral shields, spermatheca, and chelicera (Schuster and Pritchard 1963).

## Species of *Paraseiulus*

### *Biology and distribution of Paraseiulus species*

***Paraseiulus* lifestyle – Type III.** Generalist feeders but showing a preference for and highest reproduction on eriophyid mites.

***Paraseiulus triporus* (Chant and Yoshida-Shaul 1982)**

**California distribution:** known only from Napa and San Joaquin counties.

**Recorded cultivated host plants in California:** plum and walnut (Schuster and Pritchard 1963).

**Feeding habits:** not studied.

### *Paraseiulus triporus*

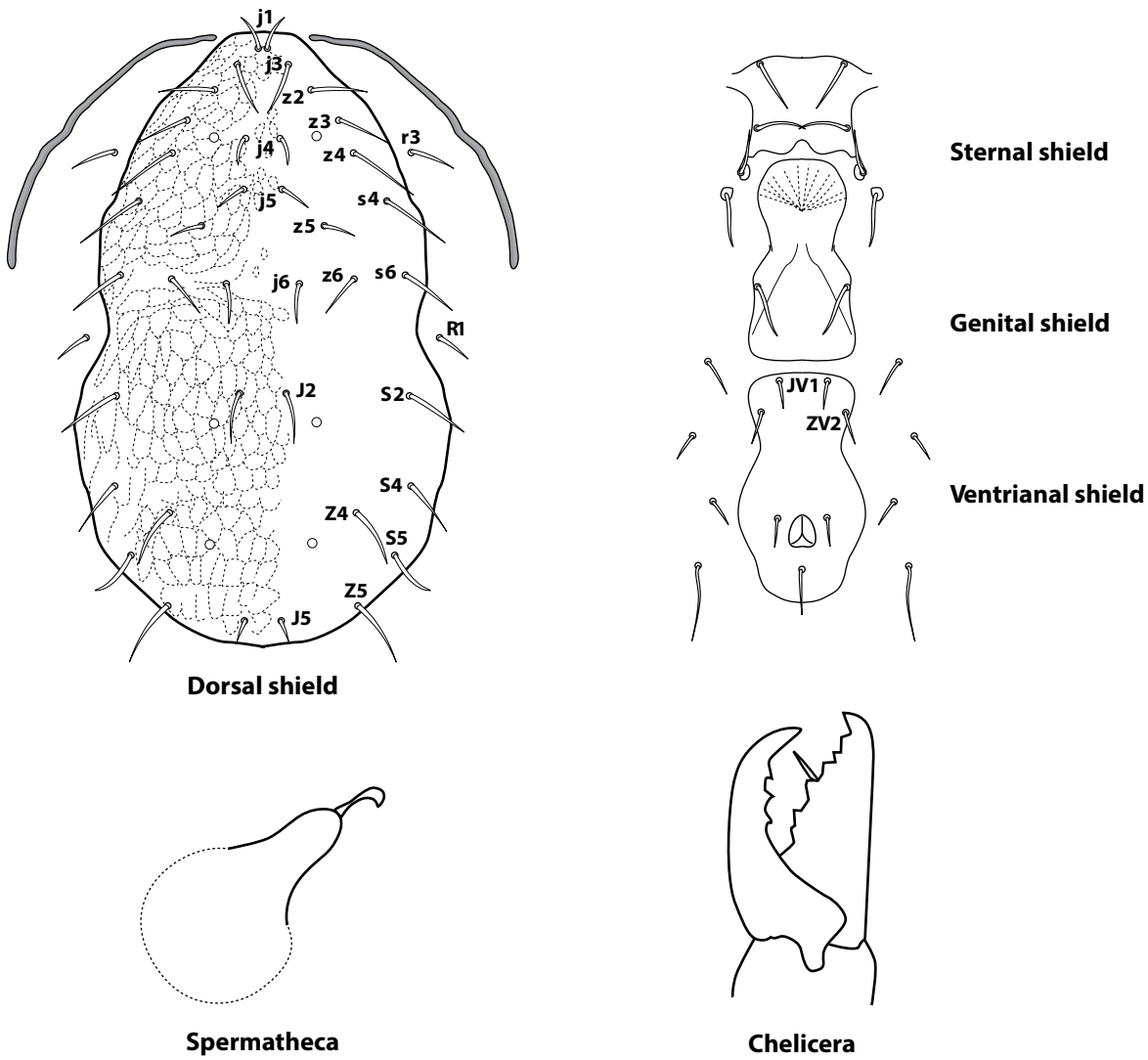



**Figure 36.** *Paraseiulus triporus* (Chant and Yoshida-Shaul) dorsal shield, ventral shields, spermatheca, and chelicera (Chant and Yoshida-Shaul 1982).

## *Key to Species of Galendromus*

1. Seta j4 much shorter than distance between its base and that of seta j5 (pinnatus group) . . . . . **2**
– Seta j4 as long as or longer than distance between its base and that of seta j5 (occidentalis group). . . . . .**3**
2. Dorsal shield with 4 pairs of large, distinct pores (fig. 37). . . . . ***reticulus*** Tuttle & Muma
– Dorsal shield without large, distinct pores (fig. 38) . . . . . ***pinnatus*** (Schuster & Pritchard)
3. Peritreme very short, only about as long as diameter of coxa III or IV (fig. 39). . . . . .***occidentalis*** (Nesbitt)
– Length of peritreme at least twice diameter of coxae III or IV . . . . . .**4**
4. Peritreme extending anteriorly at most to level of j3; z5 markedly shorter than j4, j5, and j6 (fig. 40) . . . . . ***helveolus*** (Chant)
– Peritreme extending anteriorly only to level of setae z3; z5 subequal to j4, j5, and j6 (fig. 41) . . . . . .***annectens*** (DeLeon)

### *Biology and distribution of Galendromus species*

***Galendromus* lifestyle – Type II**. All species show a strong preference for web-spinning tetranychid spider mites. *Galendromus occidentalis* is produced in insectaries and utilized in tree crops for spider mite and eriophyid mite control.

#### ***Galendromus reticulus* (Chant and Yoshida-Shaul 1984d)**

**California distribution:** uncommon.

**Recorded cultivated host plants in California:** no cultivated hosts recorded; willow and *Baccharis* (Chant and Yoshida-Shaul 1984d)

**Feeding habits:** not studied.

#### ***Galendromus pinnatus* (Chant and Yoshida-Shaul 1984d)**

**California distribution:** known only from Napa County.

**Recorded cultivated host plants in California:** plum (Schuster and Pritchard 1963; Chant and Yoshida-Shaul 1984d).

**Feeding habits:** not studied.

#### ***Galendromus occidentalis* (Chant and Yoshida-Shaul 1984b)**

**California distribution:** widespread and common.

**Recorded cultivated host plants in California:** almond, apple, avocado, blackberry, cherimoya, citrus, cotton, grape, pear, rhubarb, stone fruit, strawberry, and walnut (Schuster and Pritchard 1963; Flaherty and Huffaker 1970; McMurtry et al. 1971; Oatman 1971; Kinn and Doutt 1972; Rice et al. 1976; McMurtry and Flaherty 1977; Rice and Jones 1978; Hoy et al. 1979; Andrews and Barnes 1981; Hanna et al. 1997; Grafton-Cardwell et al. 2020).

**Feeding habits:** web-spinning tetranychid spider mites (*T. urticae, T. pacificus,* McDaniel spider mite *Tetranychus mcdanieli* McGregor, carmine spider mite *Tetranychus cinnabarinus* (Boisduval)), nonwebbing tetranychid spider mites (*E. willamette*i), and eriophyid (rust) mites. Produced commercially for spider mite and eriophyid mite control (LeBeck and Leppla 2021).

#### ***Galendromus helveolus* (Chant and Yoshida-Shaul 1984b)**

**California distribution:** introduced to California in 1991 on avocado against *O. perseae*, established in coastal areas.

**Recorded cultivated host plants in California:** avocado (Takano-Lee and Hoddle 2002).

**Feeding habits:** tetranychid spider mites (*O. perseae*, *E. sexmaculatus*, and rarely *O. punicae)*.

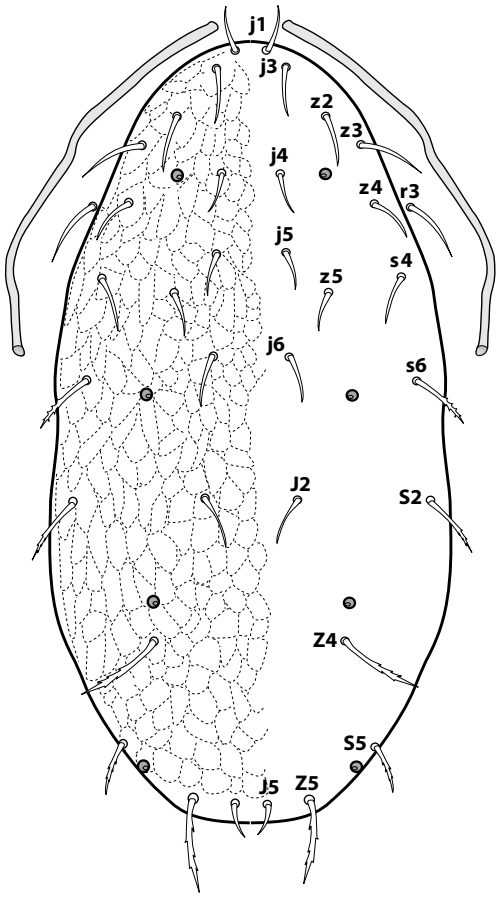
#### ***Galendromus annectens* (Chant and Yoshida-Shaul 1984b)**

**California distribution:** coastal and inland Southern California.

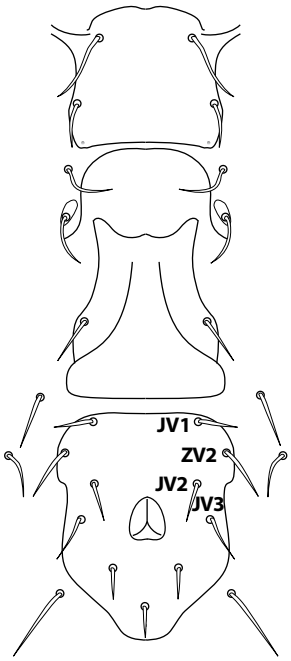
**Recorded cultivated host plants in California:** avocado and blackberry (McMurtry et al. 1971; McMurtry and Show 2012; Grafton-Cardwell et al. 2020).

**Feeding habits:** tetranychid spider mites (*O. perseae*, *O. punicae*, and *E. sexmaculatus*).

## *Galendromus reticulus*



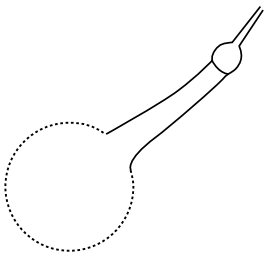

**Dorsal shield**




**Sternal shield**

**Genital shield**

**Ventrianal shield**



**Spermatheca**

**Chelicera**

**Figure 37.** *Galendromus reticulus* Tuttle and Muma dorsal shield, ventral shields, spermatheca, and chelicera (Chant and Yoshida-Shaul 1984d).

## *Galendromus pinnatus*

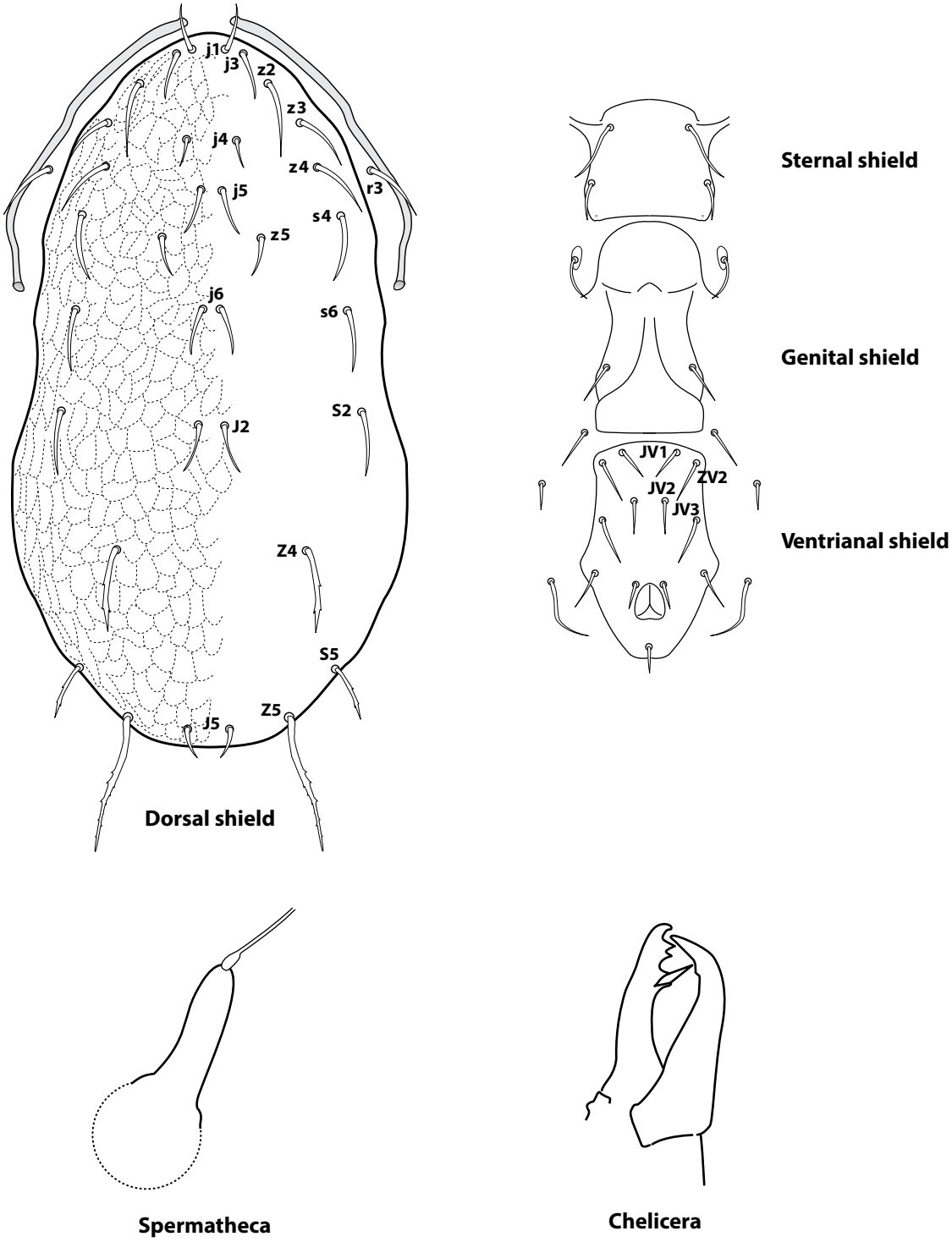
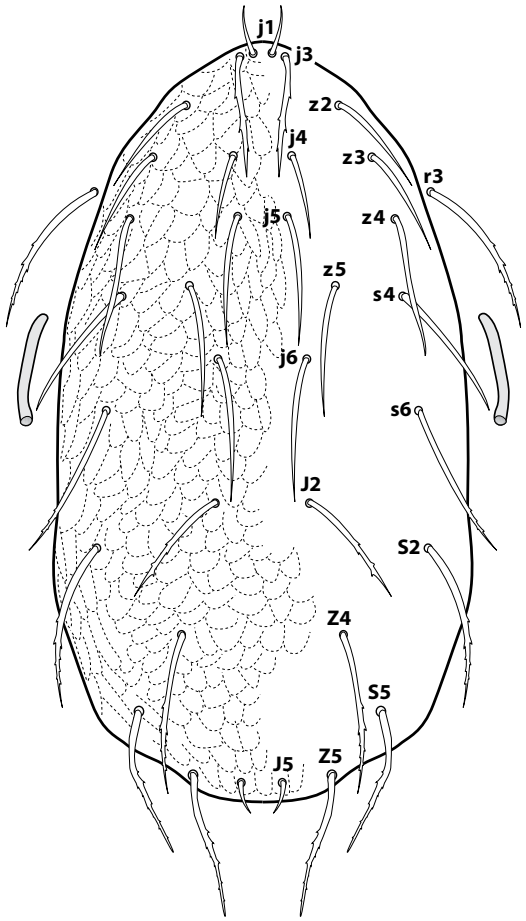
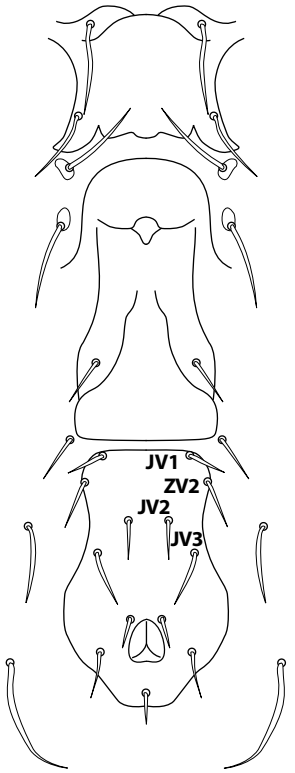



**Figure 38.** *Galendromus pinnatus* Tuttle and Muma dorsal shield, ventral shields, spermatheca, and chelicera (Chant and Yoshida-Shaul 1984d).

## *Galendromus occidentalis*



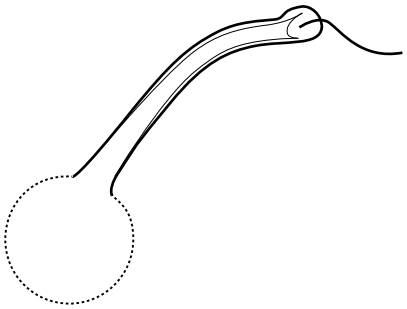

**Dorsal shield**




**Sternal shield**

**Genital shield**

**Ventrianal shield**

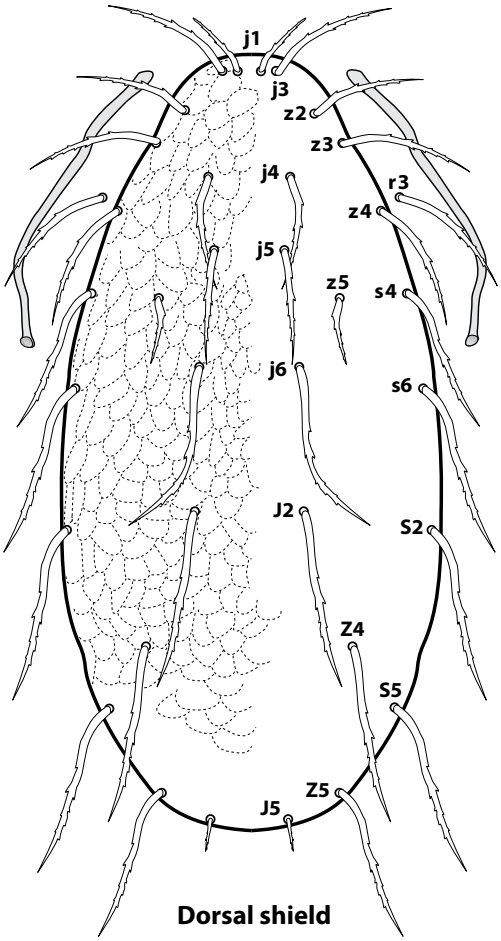


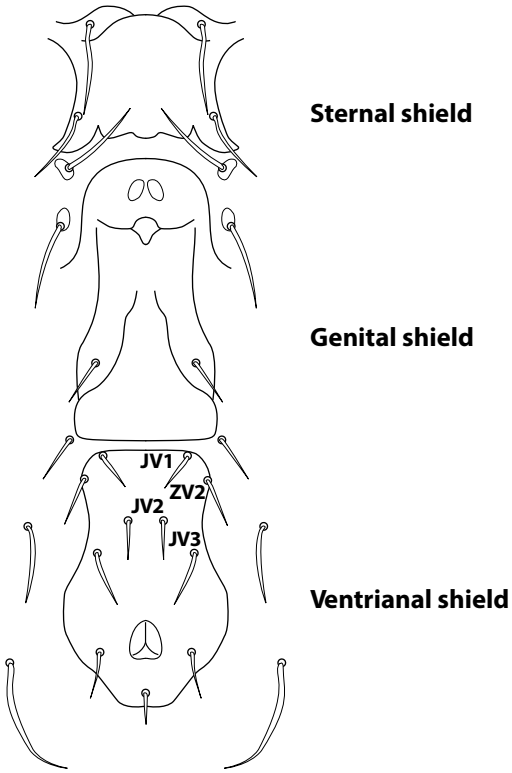
**Spermatheca**

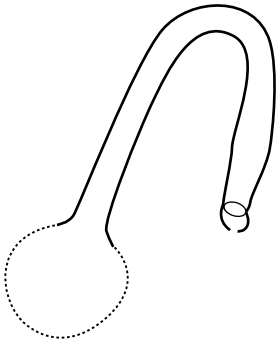
**Chelicera**

**Figure 39.** *Galendromus occidentalis* (Nesbitt) dorsal shield, ventral shields, spermatheca, and chelicera (Chant and Yoshida-Shaul 1984b).

## *Galendromus helveolus*



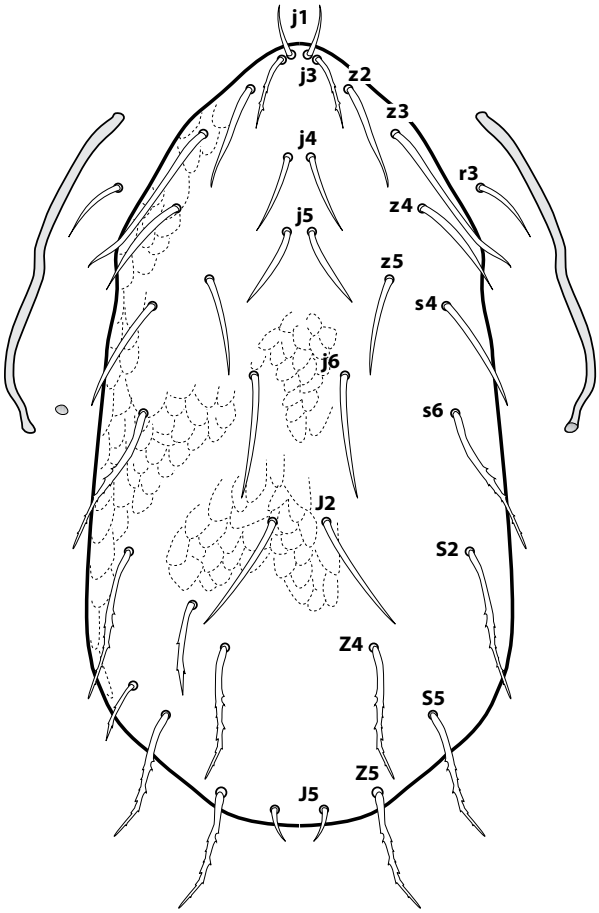



Spermatheca

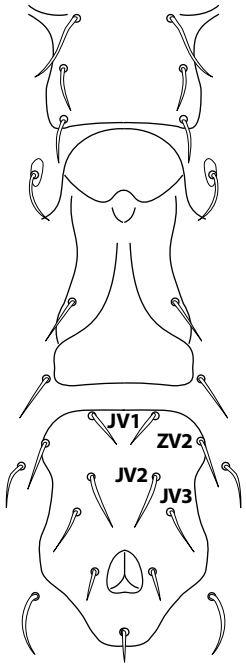
Chelicera

**Figure 40.** *Galendromus helveolus* (Chant) dorsal shield, ventral shields, spermatheca, and chelicera (Chant and Yoshida-Shaul 1984b).

## *Galendromus annectans*



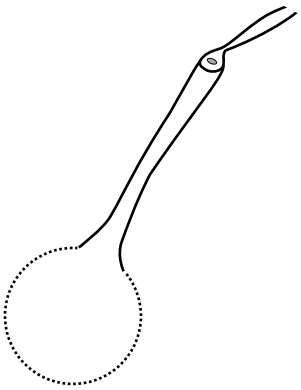

**Dorsal shield**




**Sternal shield**

**Genital shield**

**Ventrianal shield**



**Spermatheca**

**Chelicera**

**Figure 41.** *Galendromus annectans* (DeLeon) dorsal shield, ventral shields, spermatheca, and chelicera (Chant and Yoshida-Shaul 1984b).

## *Key to species of Typhlodromus*

1. Setae S5 absent (subgenus Typhlodromus) (fig. 42) . . . . . ***pyri*** (Scheuten)
– Setae S5 present (subgeneus Anthoseius) . . . . . **2**
2. Setae z2 and z4 short, j3, z3, s4 and s6 long, exceeding distances between bases (fig. 43) . . . . . ***rickeri*** Chant
– Setae z2 and z4 subequal to j3, z3, s4 and s6 . . . . . **3**
3. Basitarsus IV with long, knobbed macroseta; calyx of spermatheca usually bladder-shaped or saccular, occasionally with constriction or narrow neck next to atrium, then flaring outward gradually (fig. 44) . . . . . ***rhenanoides*** (Athias-Henriot)
– Basitarsus IV with short, inconspicuous macroseta; calyx of spermatheca a narrow tube for most of length (fig. 45) . . . . . ***caudiglans*** (Schuster)

### *Biology and distribution of Typhlodromus species*

***Typhlodromus* lifestyle – Type III**. Most species studied are generalists feeding on web-spinning tetranychid spider mites, red mites, rust mites, and pollen.

#### ***Typhlodromus pyri* (Chant and Yoshida-Shaul 1987)**

**California distribution:** known only from Napa and Sonoma counties.

**Recorded cultivated host plants in California:** grape (Schuster and Pritchard 1963; Grafton-Cardwell et al. 2020).

**Feeding habits:** tetranychid spider mites (*T. urticae*, *P. ulmi)*, eriophyid mites, and pollen.

#### ***Typhlodromus rickeri* (Chant 1960)**

**California distribution:** introduced to California from India in 1962 (McMurtry and Scriven 1964). Established (but rare) in Santa Barbara County and San Diego County.

**Recorded cultivated host plants in California: citrus** (McMurtry 1962)

**Feeding habits:** tetranychid spider mites (*T. pacificus*, *P. citri*, *E. lewisi*, *O. punicae*).

#### ***Typhlodromus rhenanoides* (Schuster and Pritchard 1963)**

**California distribution:** widespread.

**Recorded cultivated host plants in California:** avocado, blackberry, grape, plum, and raspberry (Schuster and Pritchard 1963; McMurtry and Show 2012; Grafton-Cardwell et al. 2020).

**Feeding habits:** tetranychid spider mites (*T. urticae*) and eriophyid mites.

#### ***Typhlodromus caudiglans* (Schuster and Pritchard 1963)**

**California distribution:** widespread and common.

**Recorded cultivated host plants in California:** stone fruit, pear, grape, walnut, and almond (Schuster and Pritchard 1963; Rice et al. 1976; McMurtry and Flaherty 1977; Rice and Jones 1978; Grafton-Cardwell et al. 2020).

**Feeding habits:** tetranychid spider mites (*P. ulmi*), eriophyid mites, and pollen.

## *Typhlodromus pyri*

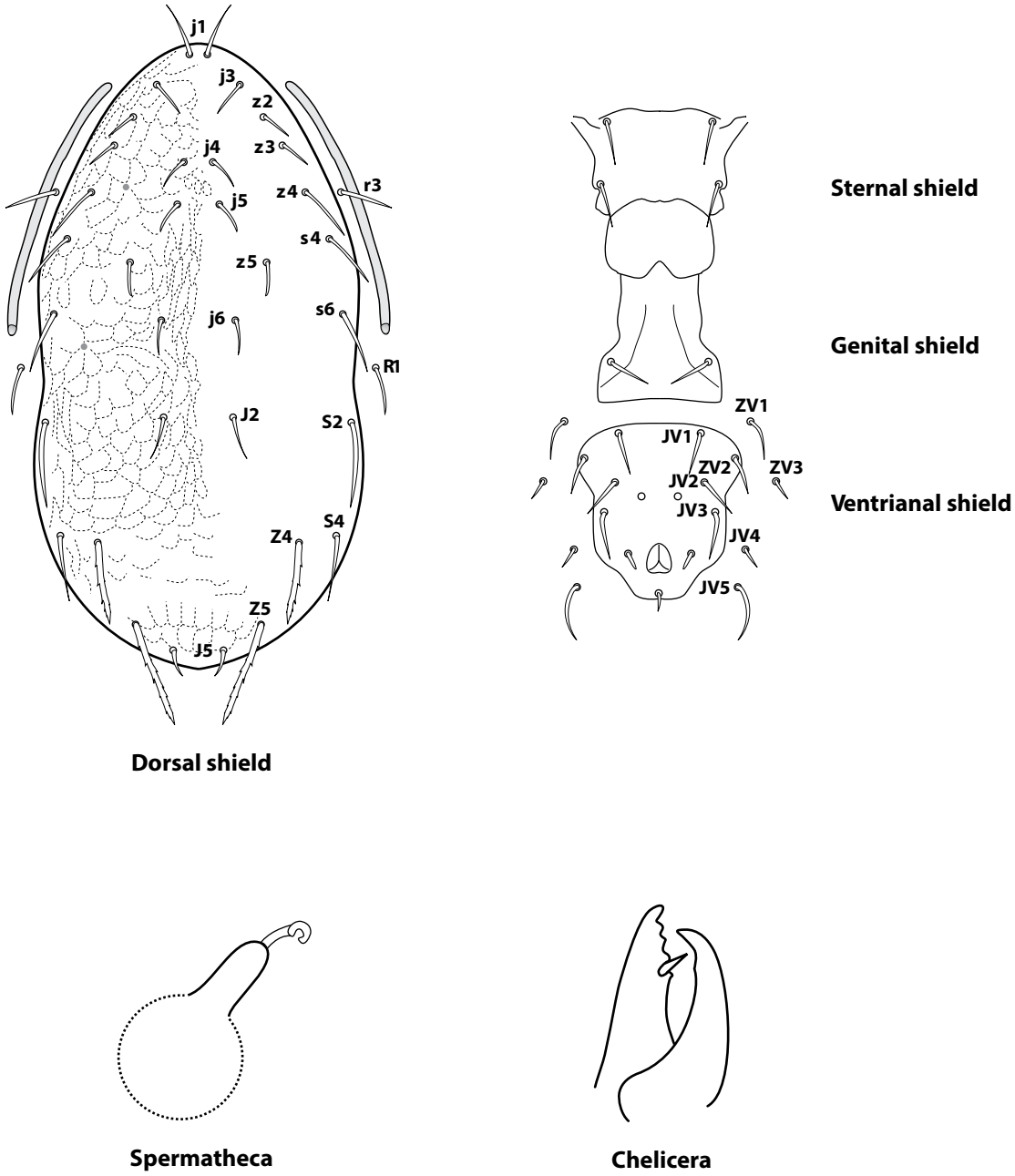



**Figure 42.** *Typhlodromus pyri* (Scheuten) dorsal shield, ventral shields, spermatheca, and chelicera (Chant and Yoshida-Shaul 1987).

## *Typhlodromus rickeri*

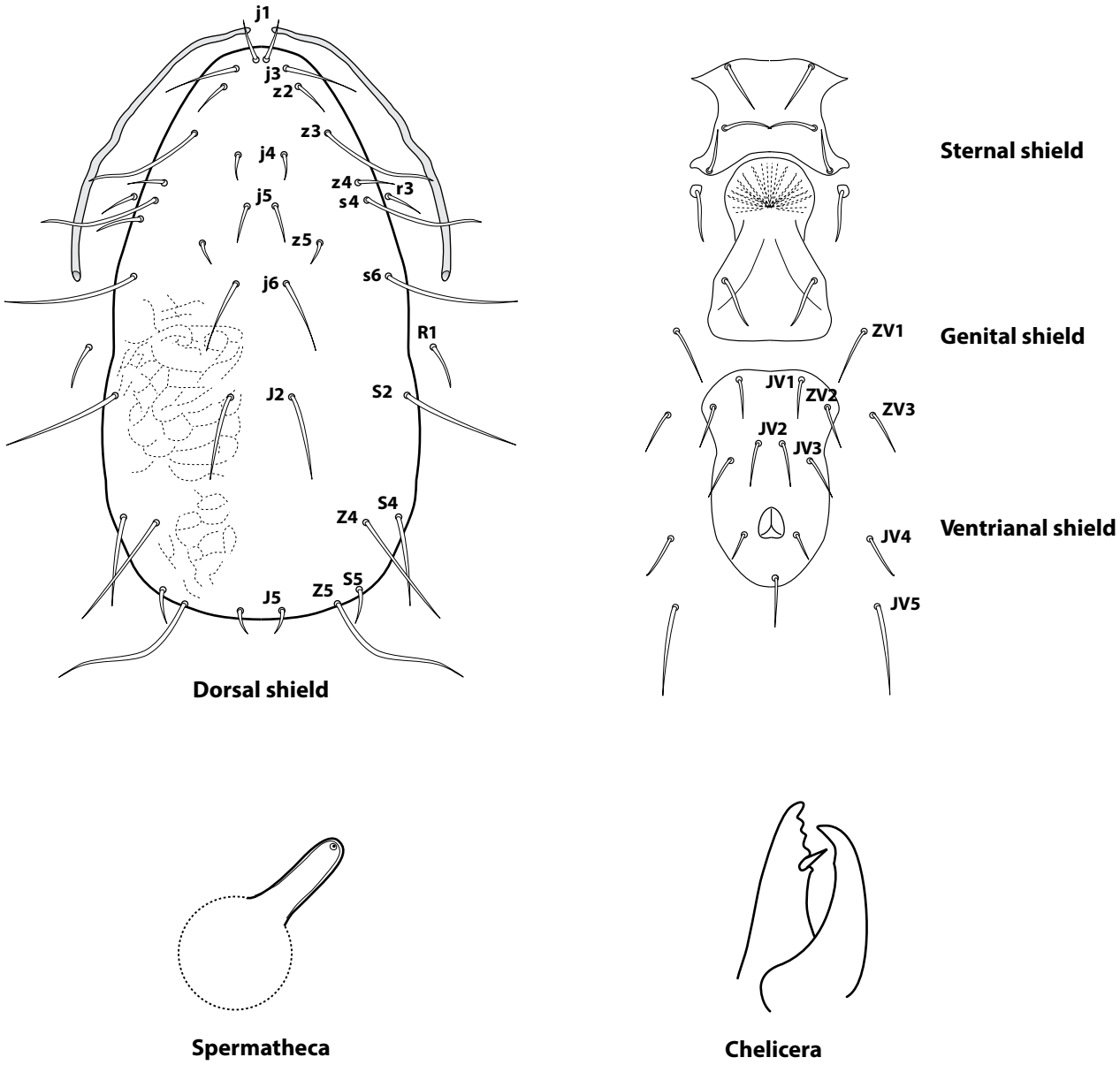



**Figure 43.** *Typhlodromus rickeri* Chant dorsal shield, ventral shields, spermatheca, and chelicera (Chant 1960).

## *Typhlodromus rhenanoides*

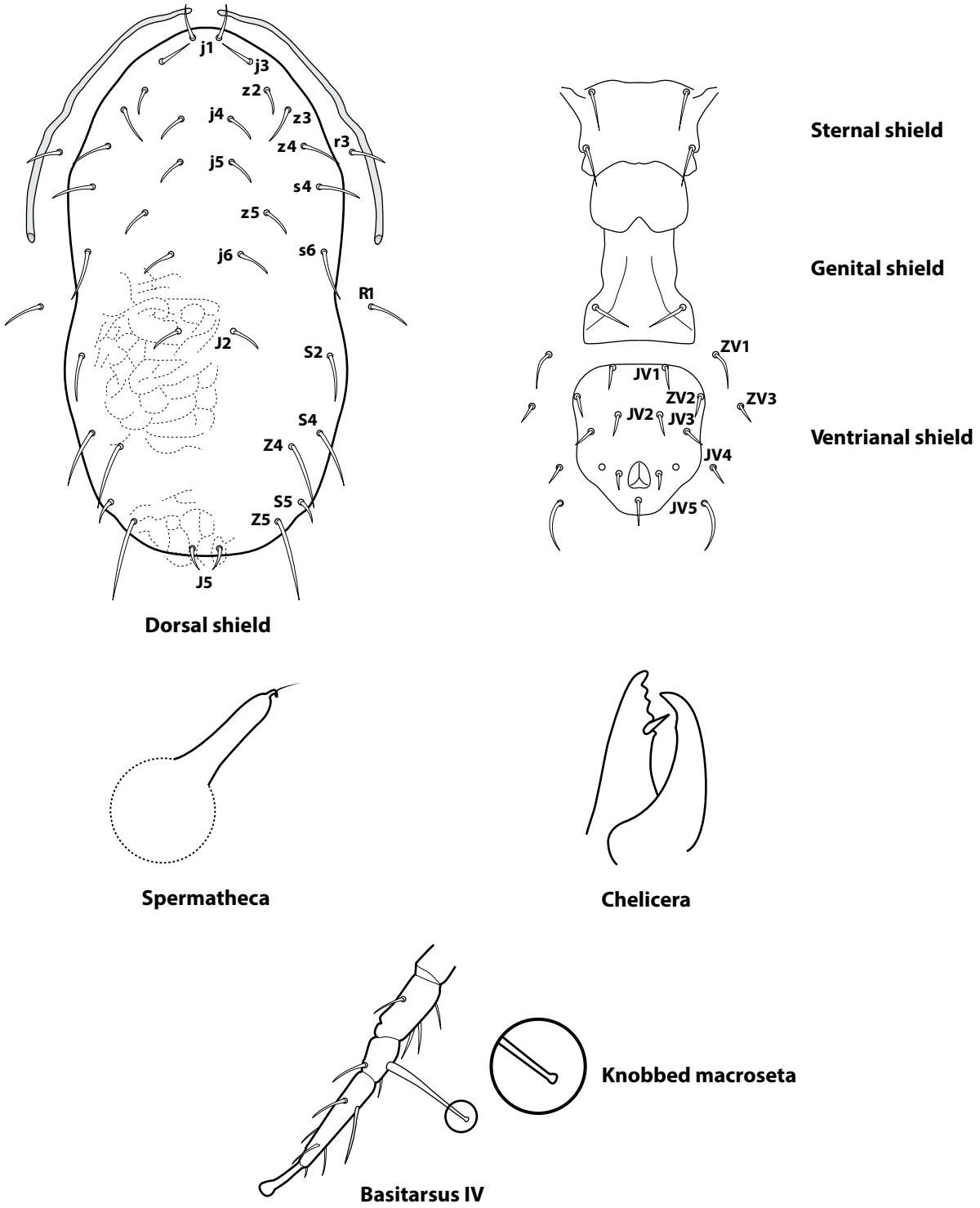



**Figure 44.** *Typhlodromus rhenanoides* (Athias-Henriot) dorsal shield, ventral shields, spermatheca, chelicera, and basitarsus (Schuster and Pritchard 1963).

## *Typhlodromus caudiglans*

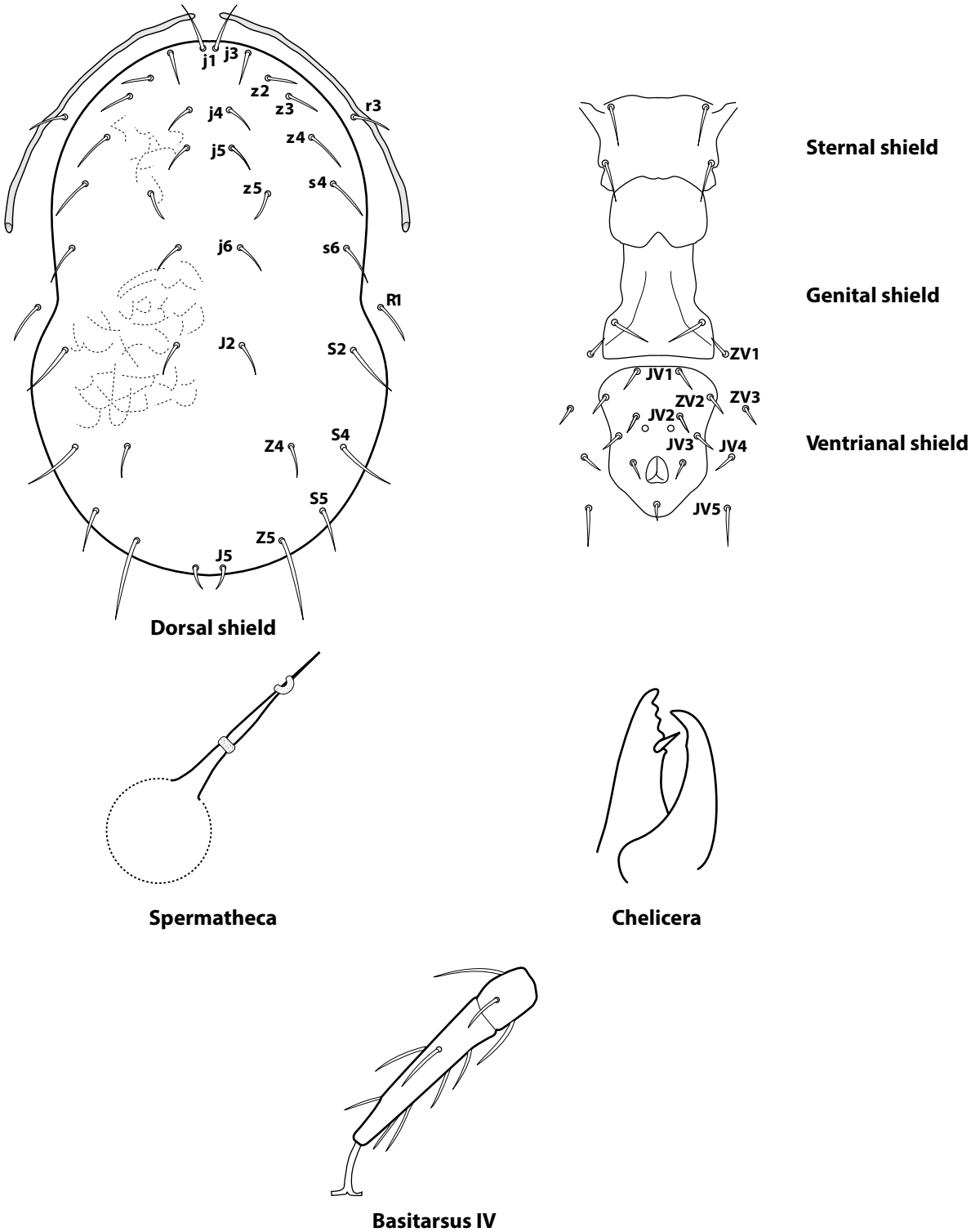



**Figure 45.** *Typhlodromus caudiglans* (Schuster) dorsal shield, ventral shields, spermatheca, chelicera, and basitarsus (Schuster and Pritchard 1963).

## Species of *Typhlodromina*

### *Biology and distribution of Typhlodromina species*

***Typhlodromina* lifestyle – not well studied, but probably Type III**, generalist feeders. A species in Florida was observed feeding on citrus red mite and sixspotted spider mite.

### ***Typhlodromina eharai* (Chant and Yoshida-Shaul 1983)**

**California distribution:** widespread but uncommon.

**Recorded cultivated host plants in California:** avocado, blackberry, citrus, grape, plum, and raspberry (McMurtry et al. 1971; Chant and Yoshida-Shaul 1983; McMurtry and Show 2012; Grafton-Cardwell et al. 2020).

**Feeding habits:** not well studied; observed to prey on tydeid mites on avocado foliage.

### *Typhlodromina eharai*

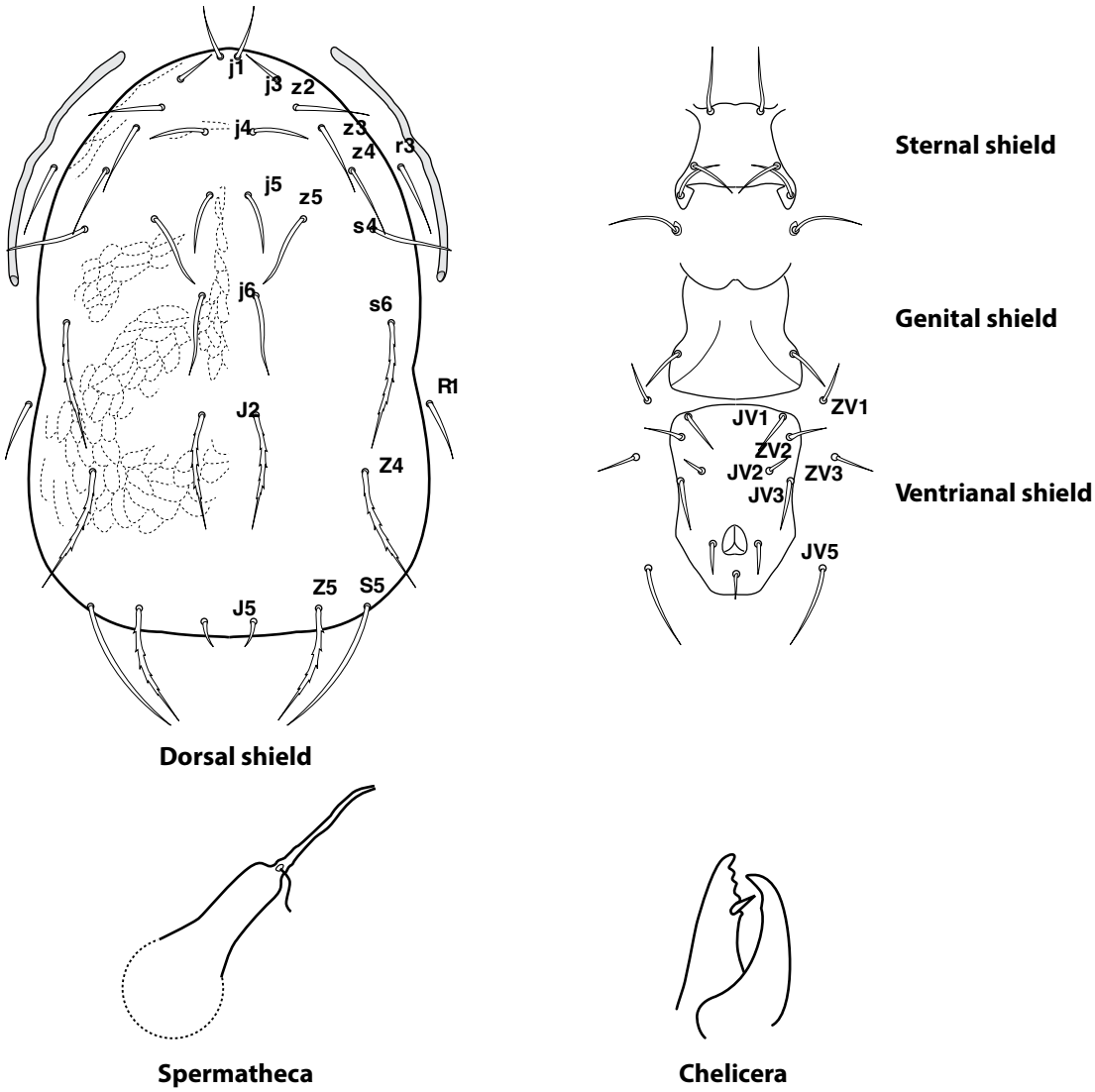



**Figure 46.** *Typhlodromina eharai* Muma and Denmark dorsal shield, ventral shields, spermatheca, and chelicera (Chant and Yoshida-Shaul 1983).

## *Key to Species of Metaseiulus*

1. Setae R1 inserted on dorsal shield. . . . . ***pomi*** group **2**
– Setae R1 inserted on integument near margin of dorsal shield.... . . . . ***pini*** group **4**
2. Ventrianal shield with 3 pairs of preanal setae (JV 3 absent) (fig. 47)..... . . . . ***validus*** (Chant)
– Ventrianal shield with 4 pairs of preanal setae. . . . . **3**
3. Ventrianal shield vase-shaped. Seta ZV3 absent (fig. 48). . . . . ***flumenis*** (Chant) [=*mcgregori* (Chant)]
– Ventrianal shield pentagonal, with only slight "waist," seta ZV3 present (fig. 49) . . . . . ***pomoides*** (Schuster & Pritchard)
4. Ventrianal shield with 2 pairs of preanal setae (JV2 and JV3) (fig. 50) . . . . . ***smithi*** (Schuster)
– Ventrianal shield with 4 pairs of preanal setae. . . . . **5**
5. With 2 pairs of "ventrolateral" setae, ZV1 and JV5 (fig. 51)..... . . . . ***citri*** (Garman & McGregor)
– With 3 pairs of "ventrolateral" setae, ZV1, ZV3, and JV5 . . . . . **6**
6. Setae Z4 no more than half distance between its base and that of S5 (fig. 52) . . . . . ***pini*** (Chant)
– Setae Z4 almost as long as distance between its base and that of S5 . . . . . **7**
7. Calyx of spermatheca narrow, only slightly flared at distal end; ratio of seta Z5 to s6 greater than 2.0 (fig. 53) . . . . . ***johnsoni*** (Mahr)
– Calyx of spermatheca wider, distinctly flared outward at distal end; ratio of seta Z5 to s6 less than 1.8 (fig. 54) . . . . . ***arboreus*** (Chant)

### *Biology and distribution of Metaseiulus species*

***Metaseiulus* lifestyle – Type III**. All species studied are generalist feeders (McMurtry and Croft 1997; Croft et al. 2004). No close correlations observed between *Metaseiulus* spp. and abundance of spider mites.

#### ***Metaseiulus validus* (Schuster and Pritchard 1963)**

**California distribution:** widespread but uncommon on crops.

**Recorded cultivated host plants in California:** no cultivated host plants recorded; pine, juniper, and sumac (Schuster and Pritchard 1963).

**Feeding habits:** tetranychid spider mites (*T. pacificus, P. citri, O. punicae*).

#### ***Metaseiulus flumenis* (=*mcgregori*) (Chant and Yoshida-Shaul 1984c)**

**California distribution:** widespread.

**Recorded cultivated host plants in California:** almond, apple, avocado, citrus, grape, and walnut (Schuster and Pritchard 1963; McMurtry et al. 1971; Andrews and Barnes 1981; Grafton-Cardwell et al. 2020).

**Feeding habits:** tetranychid spider mites (*T. pacificus, P. citri*), tenuipalpid mites, eriophyid mites, insects, and pollen.

#### ***Metaseiulus pomoides* (Chant and Yoshida-Shaul 1984c)**

**California distribution:** known only from Yolo, Butte, and San Bernardino counties.

**Recorded cultivated host plants in California: apple and** grape (Schuster and Pritchard 1963; McMurtry et al. 1971).

**Feeding habits:** not well studied; observed feeding on tetranychid spider mites.

#### ***Metaseiulus smithi* (Chant and Yoshida-Shaul 1984a)**

**California distribution:** widespread but uncommon.

**Recorded cultivated host plants in California:** grape (Schuster 1957; Schuster and Pritchard 1963; Chant and Yoshida-Shaul 1984a) and a single record from walnut in the Sacramento Valley (Grafton-Cardwell et al. 2020).

**Feeding habits:** not well studied; observed feeding on eriophyid mites.

### *Metaseiulus citri* (Chant and Yoshida-Shaul 1984a)

**California distribution:** widespread and common.

**Recorded cultivated host plants in California:** almond, apple, blackberry, citrus, grape, pear, stone fruit, and walnut (Garman and McGregor 1956; Schuster and Pritchard 1963; McMurtry et al. 1971; Rice et al. 1976; McMurtry and Flaherty 1977; Rice and Jones 1978; Chant and Yoshida-Shaul 1984a; McMurtry and Show 2012; Grafton-Cardwell et al. 2020).

**Feeding habits:** tetranychid spider mites (*T. urticae, T. pacificus*), eriophyid (rust mites), and pollen.

### *Metaseiulus pini* (Chant and Yoshida-Shaul 1984a)

**California distribution:** widespread but uncommon on crops.

**Recorded cultivated host plants in California:** no cultivated host plant recorded; pine and some nonconifers (Chant and Yoshida-Shaul 1984a).

**Feeding habits:** not well studied; tetranychid spider mites and pollen.

### *Metaseiulus johnsoni* (Chant and Yoshida-Shaul 1984a)

**California distribution:** widespread.

**Recorded cultivated host plants in California: apple,** avocado, blackberry, citrus, grape, raspberry, strawberry, and walnut (Chant and Yoshida-Shaul 1984a; McMurtry and Show 2012; Grafton-Cardwell et al. 2020).

**Feeding habits:** not studied.

### *Metaseiulus arboreus* (Chant and Yoshida-Shaul 1984a)

**California distribution:** coastal and southern interior areas.

**Recorded cultivated host plants in California:** apple, avocado, blackberry, citrus, grape, rhubarb, strawberry, and walnut (Schuster and Pritchard 1963; McMurtry et al. 1971; Oatman 1971; McMurtry and Show 2012; Grafton-Cardwell et al. 2020).

**Feeding habits:** tetranychid spider mites (*T. urticae*), eriophyid mites (*S. pallidus*), tarsonemid mites, and pollen.

## *Metaseiulus validus*

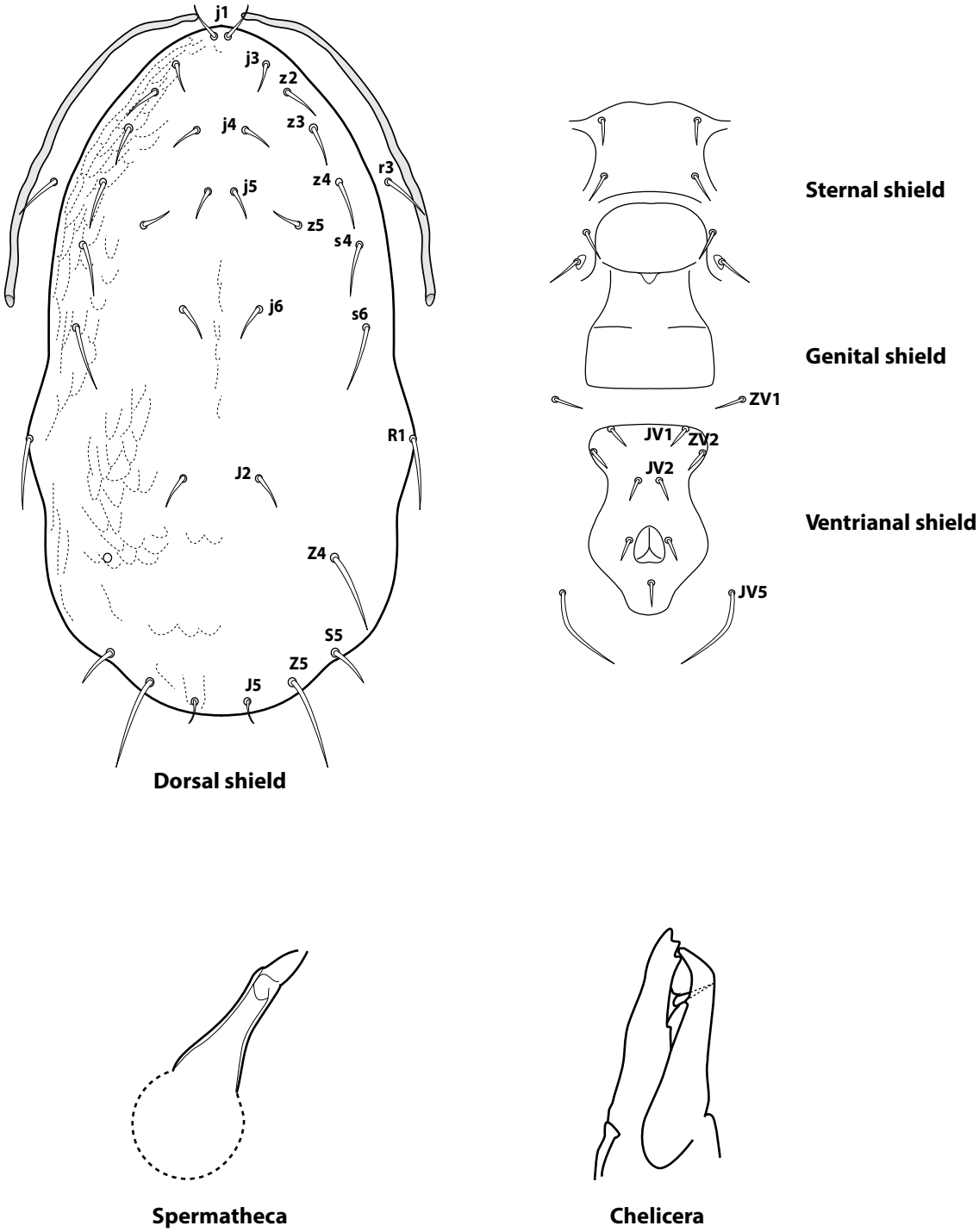
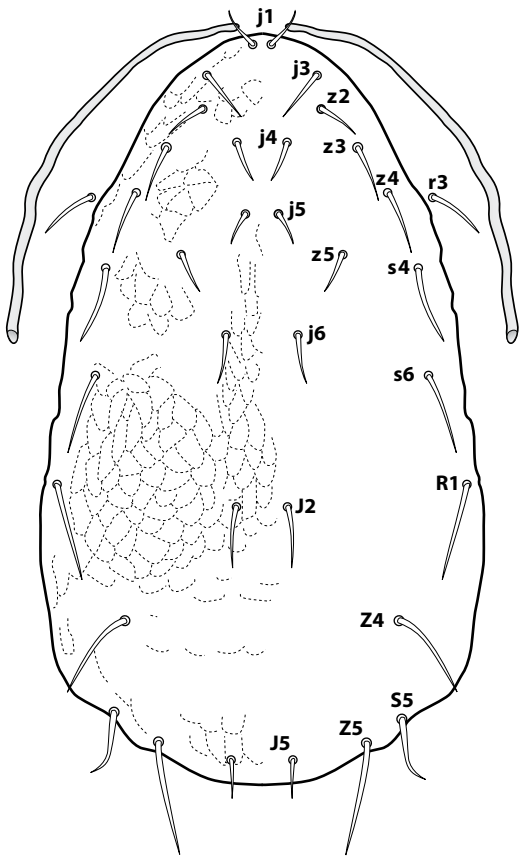
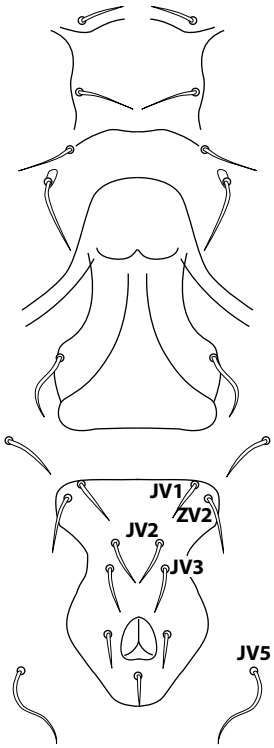



**Figure 47.** *Metaseiulus validus* (Chant) dorsal shield, ventral shields, spermatheca, and chelicera (Schuster and Pritchard 1963).

## *Metaseiulus flumenis*



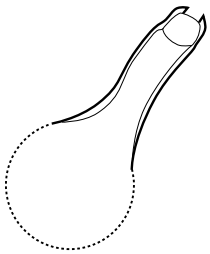

**Dorsal shield**




**Sternal shield**

**Genital shield**

**Ventrianal shield**



**Spermatheca**

**Chelicera**

**Figure 48.** *Metaseiulus flumenis* (Chant) [=mcgregori (Chant)] dorsal shield, ventral shields, spermatheca, and chelicera (Chant and Yoshida-Shaul 1984c).

## *Metaseiulus pomoides*

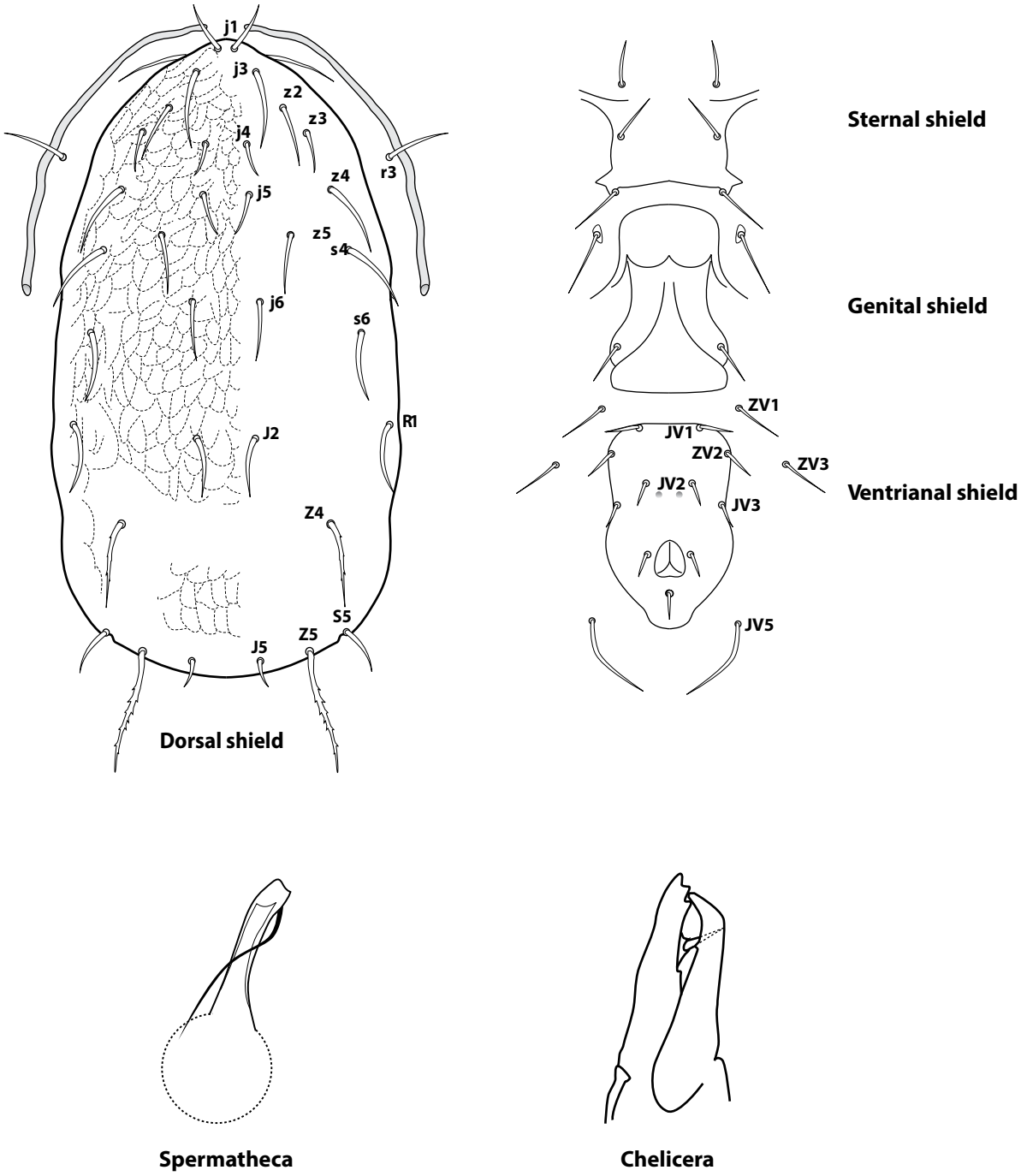



**Figure 49.** *Metaseiulus pomoides* (Schuster and Pritchard) dorsal shield, ventral shields, spermatheca, and chelicera (Chant and Yoshida-Shaul 1984c).

## *Metaseiulus smithi*

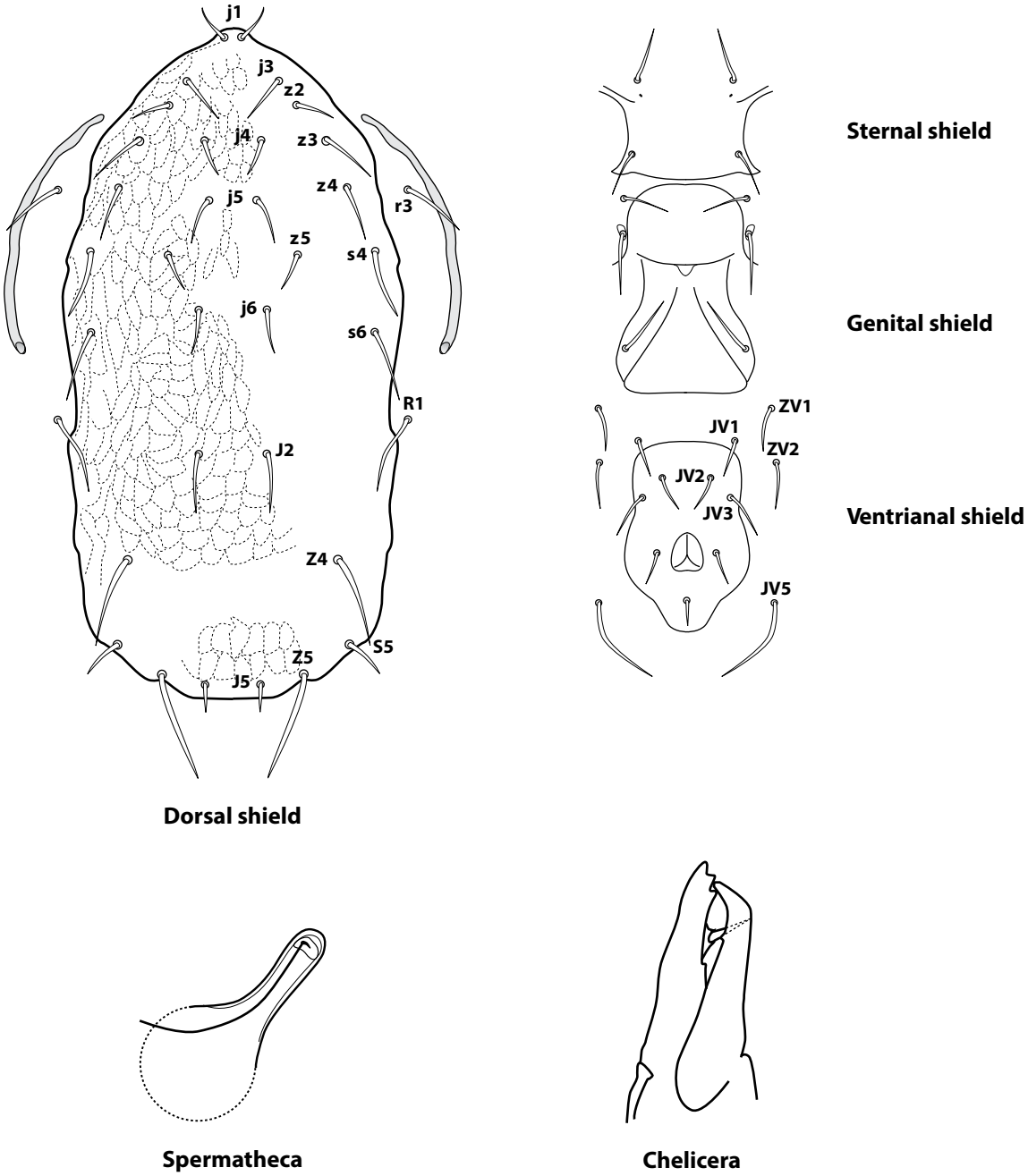



**Figure 50.** *Metaseiulus smithi* (Schuster) dorsal shield, ventral shields, spermatheca, and chelicera (Chant and Yoshida-Shaul 1984a).

## *Metaseiulus citri*

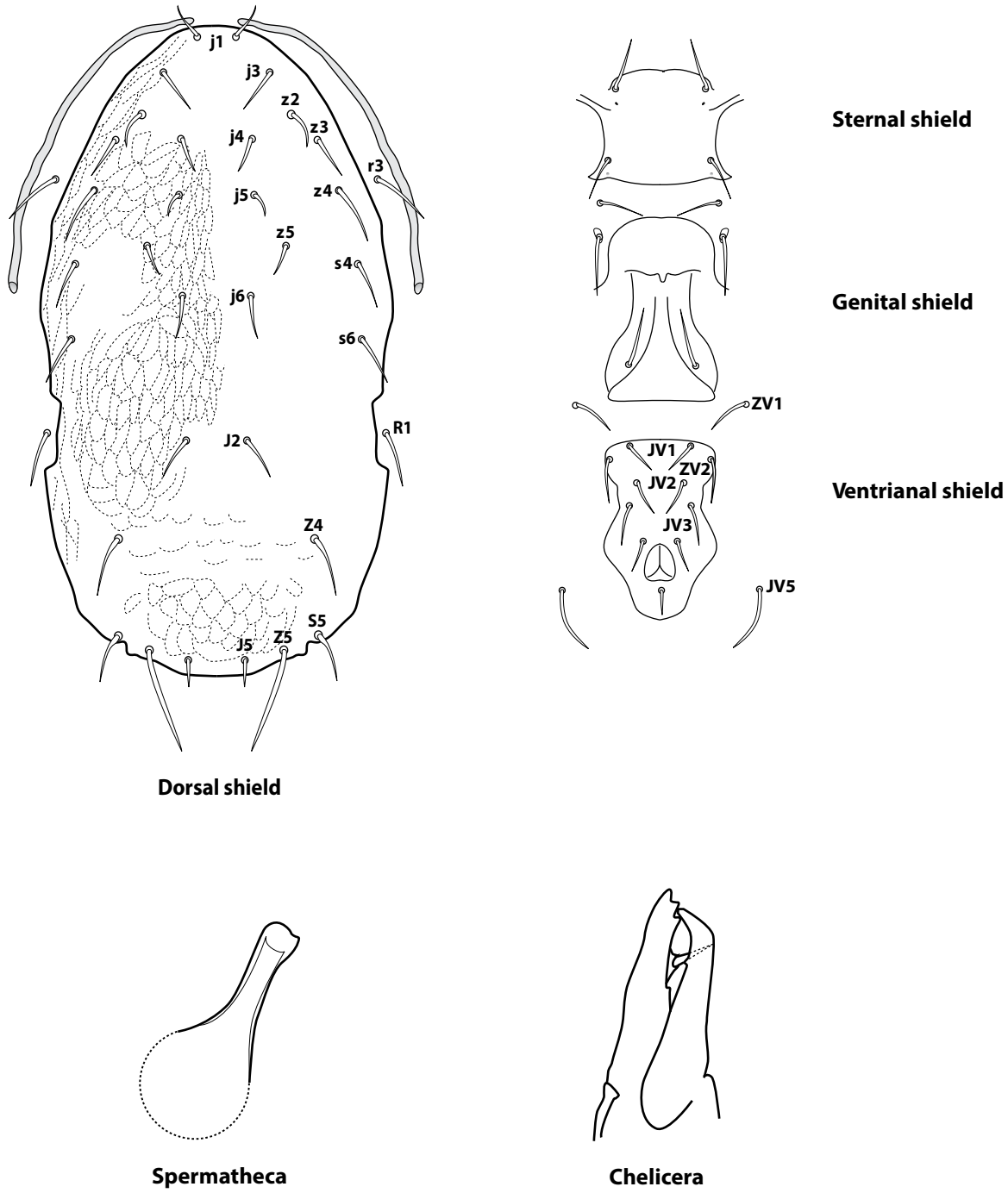
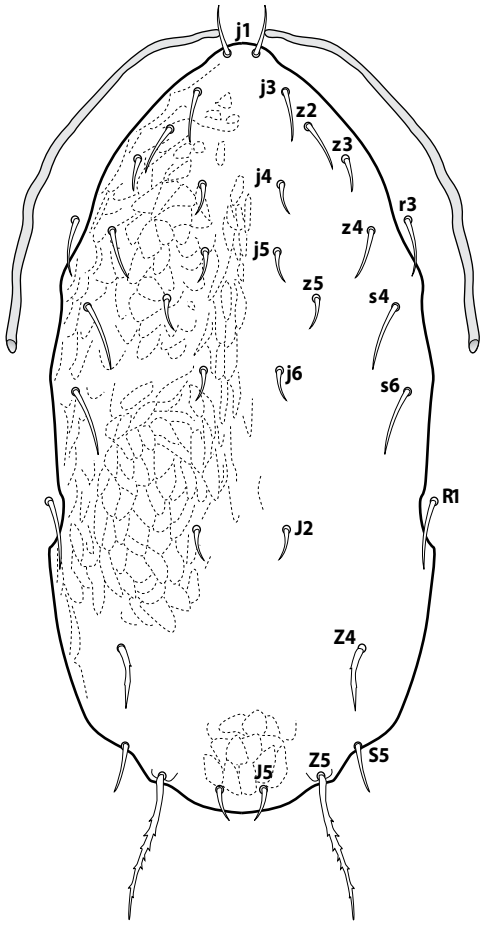
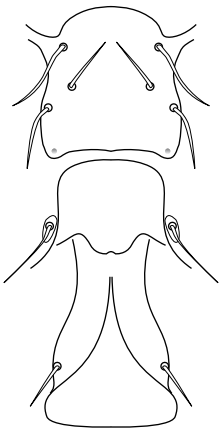



**Figure 51.** *Metaseiulus citri* (Garman and McGregor) dorsal shield, ventral shields, spermatheca, and chelicera (Chant and Yoshida-Shaul 1984a).

## *Metaseiulus pini*

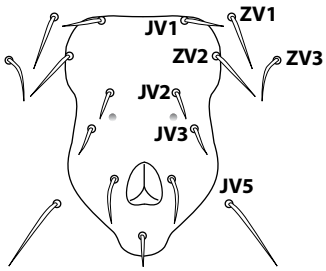



**Dorsal shield**

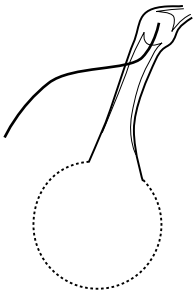


**Sternal shield**

**Genital shield**




**Ventrianal shield**



**Spermatheca**

**Chelicera**

**Figure 52.** *Metaseiulus pini* (Chant) dorsal shield, ventral shields, spermatheca, and chelicera (Chant and Yoshida-Shaul 1984a).

## *Metaseiulus johnsoni*

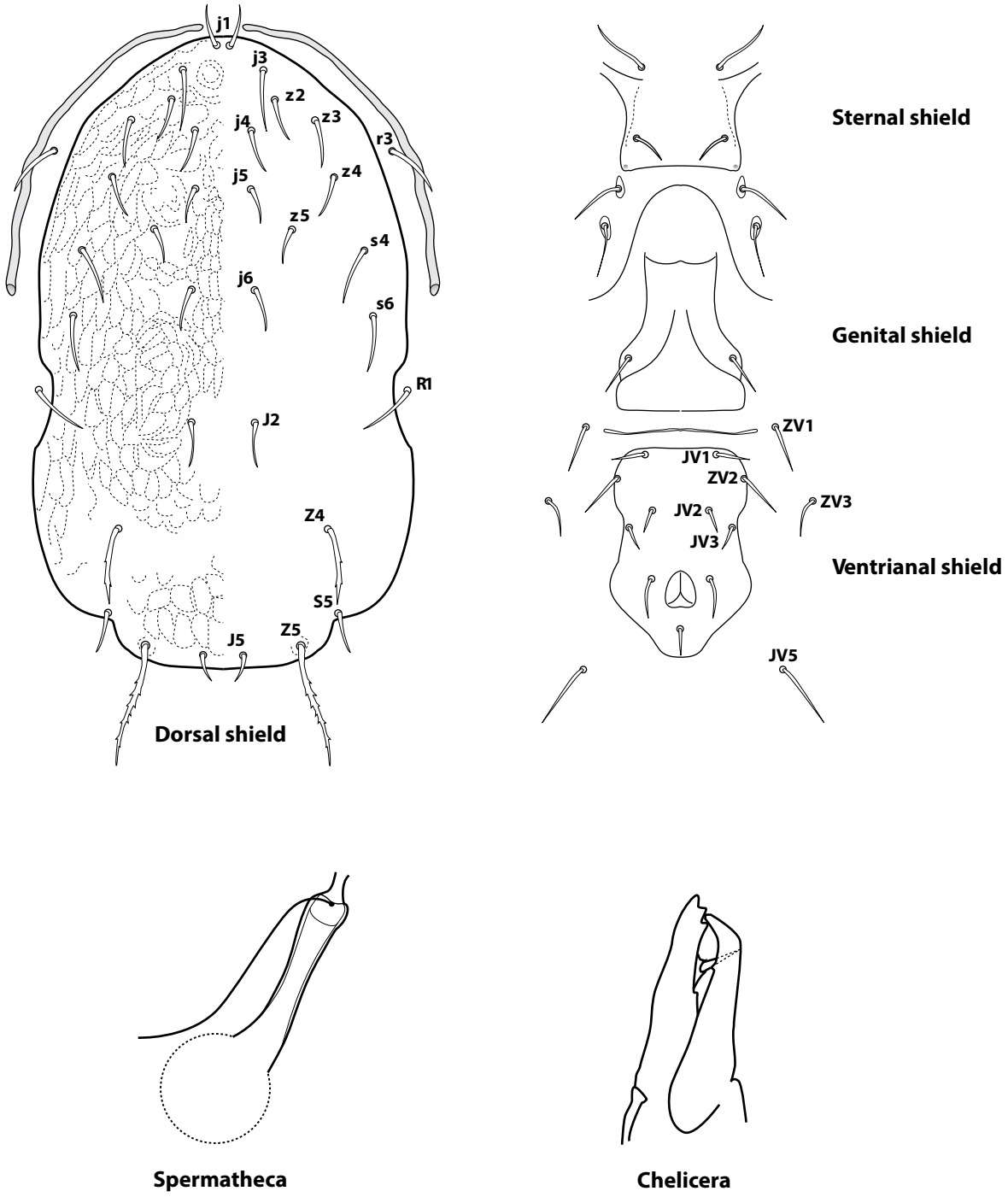
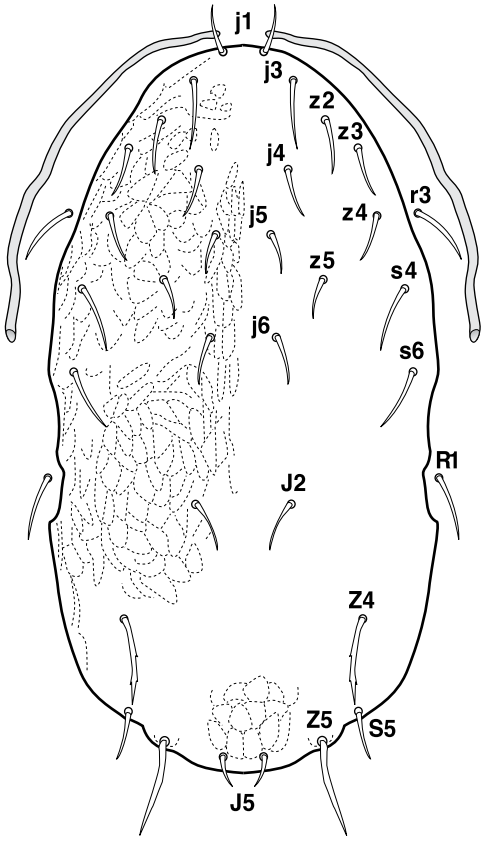
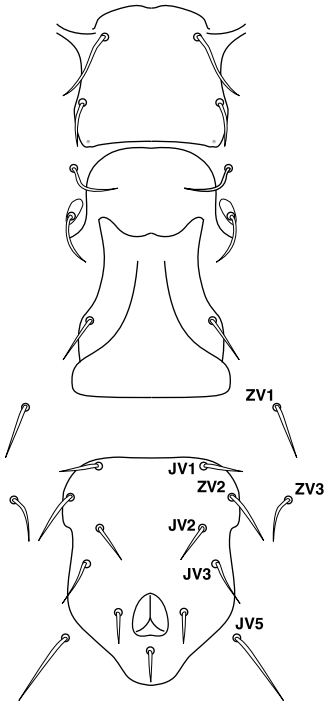



**Figure 53.** *Metaseiulus johnsoni* (Mahr) dorsal shield, ventral shields, spermatheca, and chelicera (Chant and Yoshida-Shaul 1984a).

## *Metaseiulus arboreus*



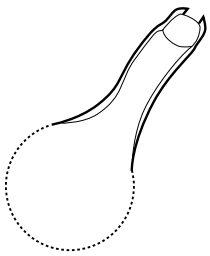

**Dorsal shield**




**Sternal shield**

**Genital shield**

**Ventrianal shield**



**Spermatheca**

**Chelicera**

**Figure 54.** *Metaseiulus arboreus* (Chant) dorsal shield, ventral shields, spermatheca, and chelicera (Chant and Yoshida-Shaul 1984a).

## References


Athias-Henriot, C. 1961. Mesostigmates (Urop. Excl.) edaphiques Mediterraneens (Acaromorpha, Anactinotrichida). Acarologia 3:381–509.

Andrews, K. L., and M. M. Barnes. 1981. Spider mites on almond in the southern San Joaquin Valley of California. Environmental Entomology 10:6–9. https://doi.org/10.1093/ee/10.1.6

Aponte, O., and J. A. McMurtry. 1997. Description of *Euseius obispensis* N. Sp. (Acari: Phytoseiidae) from avocado in California. International Journal of Acarology 23:21–25. https://doi.org/10.1080/01647959708684115

Buchelos, T. C., and A. E. Pritchard. 1960. *Amblyseius similoides*, a new predacious mite from California (Acarina: Phytoseiidae). Pan-Pacific Entomologist 36:179–182.

Chant, D. A. 1959. Phytoseiid mites (Acarina: Phytoseiidae) Part II. A taxonomic review of the family Phytoseiidae, with descriptions of 38 new species. Canadian Entomologist 91, Suppl. 12:45–164.

———. 1960. Descriptions of five new species of mites from India Roman for (Acarina: Phytoseeiidae, Aceosejidae). Canadian Entomologist 92(1):58–65. https://www.cambridge.org/core/journals/canadian-entomologist/article/abs/descriptions-of-five-new-species-of-mites-from-india-acarina-phytoseiidae-aceosejidae/C744B764D420726F276EF4474D74CF2A

Chant, D.A, and C.A. Fleschner. 1960. Some observations of the ecology of Phytoseiid mites (Acarina: Phytoseiidae) in California. Entomophaga 5:131–139. https://link.springer.com/article/10.1007/BF02374401

Chant, D. A., and J. A. McMurtry. 1994. A review of the subfamilies Phytoseiinae and Typhlodrominae (Acari: Phytoseiidae). International Journal of Acarology 20:223–310. https://doi.org/10.1080/01647959408684022

———. 2003. A review of the subfamily Amblyseiinae Muma (Acari: Phytoseiidae): Part I. Neoseiulini new tribe. International Journal of Acarology 29(1):3–46. https://www.researchgate.net/publication/296806695_A_revision_of_the_subfamily_Amblyseiinae_Muma_Acari_Phytoseiidae_Part_I_Neoseiulini_new_tribe

———. 2004a. A review of the subfamily Amblyseiinae Muma (Acari: Phytoseiidae): Part III. The tribe Amblyseiini Wainstein, Subtribe Amblyseiina n. Subtribe. International Journal of Acarology 30(3):171–228. https://www.tandfonline.com/doi/abs/10.1080/01647950408684388

———. 2004b. A review of the subfamily Amblyseiinae Muma (Acari: Phtyoseiidae): Part IV. Tribe Amblyseiini Wainstein, subtribe Arrenoseiina Chant and McMurtry. International Journal of Acarology 30(4):291–312. https://www.tandfonline.com/doi/abs/10.1080/01647950408684399

———. 2005a. A review of the subfamily Amblyseiinae Muma (Acari: Phytoseiidae): Part V. Tribe Amblyseiini, subtribe Proprioseiopsina Chant and McMurtry. International Journal of Acarology 31(1):3–22. https://www.tandfonline.com/doi/abs/10.1080/01647950508684412

———. 2005b. A review of the subfamily Amblyseiinae Muma (Acari: Phytoseiidae): Part VI. The tribe Euseiini n. tribe, subtribes Typhlodromalina n. subtribe, Euseiina n. subtribe, and Ricoseiina n. subtribe. International Journal of Acarology 31(3):187–224. https://doi.org/10.1080/01647950508684424

———. 2006. A review of the subfamily Amblyseiinae Muma (Acari: Phytoseiidae): Part VIII. The tribes Macroseiini Chant, Denmark and Baker, Phytoseiulini n. tribe, Afroseiulini n. tribe and Indoseiulini Ehara and Amano. International Journal of Acarology 32(1):13–25. https://doi.org/10.1080/01647950608684439

———. 2007. Illustrated keys and diagnoses for the genera and subgenera of the Phytoseiidae of the world (Acari: Mesostigmata). West Bloomfield, MI: Indira Publishing House.

Chant, D. A., and E. Yoshida-Shaul. 1982. A world review of the soleiger species group in the genus *Typhlodromus* Scheuten (Acarina: Phytoseiidae). Canadian Journal of Zoology 60(12):3021–3032. https://doi.org/10.1139/z82-385

———. 1983. A world review of five similar species groups in the genus *Typhlodromus* Scheuten. Part II. The *conspicuous* and *cornus* groups (Acarina: Phytoseiidae). Canadian Journal of Zoology 61(5):1041–1057. https://doi.org/10.1139/z83-138

———. 1984a. A world review of five similar species groups in the genus *Typhlodromus* Scheuten. Part III. The *pini* group (Acarina: Phytoseiidae). Canadian Journal of Zoology 62(2):276–290. https://doi.org/10.1139/z84-045

———. 1984b. A world review of the *occidentalis* species group in the genus *Typhlodromus* Scheuten (Acarina: Phytoseiidae). Canadian Journal of Zoology 62(9):1860–1871. https://doi.org/10.1139/z84-272

———. 1984c. A world review of the *pomi* species group in the genus *Typhlodromus* Scheuten (Acarina: Phytoseiidae). Canadian Journal of Zoology 62(12):2610–2630. https://doi.org/10.1139/z84-382

———. 1984d. A world review of four species groups in the genus *Typhlodromus* Scheuten (Acarina: Phytoseiidae): *brevicollis*, *luculentis*, *carinulatus* and *pinnatus*. Canadian Journal of Zoology 62(12):2631–2642. https://doi.org/10.1139/z84-383

———. 1987. A world review of the *pyri* species group in the genus *Typhlodromus* Scheuten (Acarina: Phytoseiidae). Canadian Journal of Zoology 65(7):1770–1804. https://doi.org/10.1139/z87-272

———. 1990. The identities of *Amblyseius andersoni* (Chant) and *A. potentillae* (Garman) in the family Phytoseiidae (Acari: Gamasina). International Journal of Acarology 16(1):5–12. https://doi.org/10.1080/01647959008683857

Congdon, B. D. 2002. The family Phytoseiidae (Acari) in western Washington State with descriptions of three new species. International Journal of Acarology 28(1):3–27. https://doi.org/10.1080/01647950208684275

Congdon, B. D., and J. A. McMurtry. 1985. Biosystematics of *Euseius* on California citrus and avocado with the description of a new species (Acari: Phytoseiidae). International Journal of Acarology 11(1):23–30. https://doi.org/10.1080/01647958508683391

———. 1986. The distribution and taxonomic relationships of *Euseius quetzali* McMurtry in California (Acari: Phytoseiidae). International Journal of Acarology 12(1):7–11. https://doi.org/10.1080/01647958608683433

Croft, B. A., J. S. Blackwood, and J. A. McMurtry. 2004. Classifying life-style types of phytoseiid mites: diagnostic traits. Experimental and Applied Acarology 33(4):247–260. https://doi.org/10.1023/b:appa.0000038622.26584.82

Demite, P. R., G. J. de Moraes, J. A. McMurtry, H. A. Denmark, and R. C. Castilho. 2020. Phytoseiidae database. www.lea.esalq.usp.br/phytoseiidae

Denmark, H. A., and G. A. Evans. 2011. Phytoseiidae of North America and Hawaii (Acari: Mesostigmata). West Boomfield, MI: Indira Publishing House.

Denmark, H. A., and E. Schicha. 1983. Revision of the genus *Phytoseiulus* Evans (Acarina: Phytoseiidae). International Journal of Acarology 9:27–35. https://doi.org/10.1080/01647958308683308

Di Palma, A., and G. Alberti. 2001. Fine structure of the female genital system in phytoseiid mites with remarks on egg nutrimentary development, sperm-access system, sperm transfer, and capacitation (Acari, Gamasida, Phytoseiidae). Experimental and Applied Acarology 25(7):525–591. https://doi.org/10.1023/a:1014741808835

Doker, I., C. Kazak, and K. Karut. 2019. The genus *Graminaseius* Chant & McMurtry (Acari: Phytoseiidae) in Turkey with descriptions of two new species and re-description of *Graminaseius graminis* (Chant). Systematics and Applied Acarology 24(5):731–741. https://www.biotaxa.org/saa/article/view/saa.24.5.2

Flaherty, D. L., and C. B. Huffaker. 1970. Biological control of Pacific mites and Willamette mites in San Joaquin Valley vineyards. I. Role of *Metaseiulus occidentalis*. Hilgardia 40(10):267–308. http://hilgardia.ucanr.edu/Abstract/?a=hilg.v40n10p267

Garman, P., and E. A. McGregor. 1956. Four new predaceous mites (Acarina, Phytoseiidae). Bulletin of the Southern California Academy of Sciences 55:7–13.

Gerson, U., R. L. Smiley, and R. Ochoa. 2003. Mites (Acari) for pest control. Oxford, UK: Blackwell Publishing.

Grafton-Cardwell, E. E., W. J. Bentley, M. L. Bianchi, F. E. Cave, R. B. Elkins, L. Godfrey, P. Gu, D. R. Haviland, D. Headrick, M. Hoddle, J. McMurtry, M. E. Murrietta, N. J. Mills, Y. Ouyang, C. Pickel, S. Rill, M. C. Stavrinides, and L. G. Varela. 2020. Surveys of 12 California crops for phytoseiid predatory mites show changes compared to earlier studies. California Agriculture. https://doi.org/10.3733/ca.2020a0010

Hanna, R., L. T. Wilson, F. G. Zalom, and D. L. Flaherty. 1997. Effects of predation and competition on the population dynamics of *Tetranychus pacificus* on grapevines. Journal of Applied Ecology 34(4):878–888. https://doi.org/10.2307/2405279

Howell, A. D., and O. Daugovish. 2013. Biological control of *Eotetranychus lewisi* and *Tetranychus urticae* (Acari: Tetranychidae) on strawberry by four phytoseiids (Acari: Phytoseiidae). Journal of Economic Entomology 106(1):80–85. https://doi.org/10.1603/EC12304

Hoy, M. A. 1982. Aerial dispersal and field efficacy of a genetically improved strain of the spider mite predator *Metaseiulus occidentalis*. Entomologia Experimentalis et Applicata 32(3): 205–212. https://doi.org/10.1111/j.1570-7458.1982.tb03207.x

———. 2011. The Phytoseiidae: Effective natural enemies. In: M. A. Hoy, Agricultural Acarology: Introduction to Integrated Mite Management. Boca Raton, FL: CRC Press.

Hoy, M. A., R. T. Roush, K. B. Smith, and L. W. Barclay. 1979. Spider mites and predators in San Joaquin Valley almond orchards. California Agriculture 33:11–13. http://calag.ucanr.edu/download_pdf.cfm?article=ca.v033n10p11

Hughes, A. M. 1962. The Genus *Calvolia* Oudemans, 1911 (Acari: Sarcoptiformes). Acarologia 4(1):48–63. https://www1.montpellier.inrae.fr/CBGP/acarologia/export_pdf.php?id=3952&typefile=1

Kinn, D. N., and R. L. Doutt. 1972. Natural control of spider mites on wine grape varieties in Northern California. Environmental Entomology 1(4):513–518. https://doi.org/10.1093/ee/1.4.513

Krantz G. W., and D. E. Walter, eds. 2009. A manual of acarology. Lubbock, TX: Texas Tech University Press.

LeBeck, L. M., and N. C. Leppla. 2021. Guidelines for purchasing and using commercial natural enemies and biopesticides in North America. University of Florida IFAS Extension IPM-146. https://edis.ifas.ufl.edu/in849

Lindquist, E. E., and G. O. Evans. 1965. Taxonomic concepts in the Ascidae, with a modified setal nomenclature for the idiosoma of the Gamasina (Acarina: Mesostigmata). The Memoirs of the Entomological Society of Canada 97(S47). https://doi.org/10.4039/entm9747fv

Livshits, I. Z., and N. N. Kuznetsov. 1972. Phytoseiid mites from the Crimea (Parasitiformes: Phytoseiidae). Trudy Akad. Nauk Nikitskii Botanicheskii Sad, Yalta 61:13–64.

McMurtry, J. A. 1962. Fighting pest mites with predaceous mites. California Citrograph 47:361–362.

McMurtry, J. A. 1977. Some predaceous mites [Phytoseiidae] on citrus in the Mediterranean region. Entomophaga 22:19–30. https://link.springer.com/article/10.1007/BF02372986

McMurtry, J. A., and B. A. Croft. 1997. Life-styles of phytoseiid mites and their roles in biological control. Annual Review of Entomology 42:291–321. https://doi.org/10.1146/annurev.ento.42.1.291

McMurtry, J. A., and D. L. Flaherty. 1977. An ecological study of phytoseiid and tetranychid mites on walnut in Tulare County, California. Environmental Entomology 6(2):287–292. https://doi.org/10.1093/ee/6.2.287

McMurtry, J. A., and H. G. Johnson. 1965. Some factors influencing the abundance of the predaceous mite *Amblyseius hibisci* in Southern California (Acarina: Phytoseiidae). Annals of the Entomological Society of America 58(1):49–56. https://doi.org/10.1093/aesa/58.1.49

———. 1966. An ecological study of the spider mite *Oligonychus punicae* (Hirst) and its natural enemies. Hilgardia 37(11):363–402. https://doi.org/10.3733/hilg.v37n11p363

McMurtry, J. A., and G. T. Scriven. 1964. Biology of the predaceous mite *Typhlodromus rickeri* (Acarina: Phytoseiidae). Annals of the Entomological Society of America 57(3):362–367. https://doi.org/10.1093/aesa/57.3.362

McMurtry, J. A., and E. D. Show. 2012. Phytoseiidae on blackberry in Central California. Systematic and Applied Acarology 17(4):384–387. https://doi.org/10.11158/saa.17.4.6

McMurtry, J. A., M. H. Badii, and B. D. Congdon. 1985. Studies on a *Euseius* complex on avocado in Mexico and Central America, with a description of a new species (Acari: Phytoseiidae). Acarologia 26(2):107–116. https://www1.montpellier.inra.fr/CBGP/acarologia/article.php?id=2680

McMurtry, J. A., G. J. de Moraes, and N. F. Sourassou. 2013. Revision of the lifestyles of phytoseiid mites (Acari: Phytoseiidae) and implications for biological control strategies. Systematic and Applied Acarology 18(4):297–320. https://doi.org/10.11158/saa.18.4.1

McMurtry, J. A., J. G. Morse, and H. G. Johnson. 1992. Studies of the impact of *Euseius* species (Acari: Phytoseiidae) on citrus mites using predator exclusion and predator release experiments. Experimental and Applied Acarology 15:233–248. https://doi.org/10.1007/BF01246565

McMurtry, J. A., E. R. Oatman, and C. A. Fleschner. 1971. Phytoseiid mites on some tree and row crops and adjacent wild plants in Southern California. Journal of Economic Entomology 64(2):405–408. https://doi.org/10.1093/jee/64.2.405

McMurtry, J. A., E. R. Oatman, P. A. Phillips, and C. W. Wood. 1978. Establishment of *Phytoseiulus persimilis* (Acari: Phytoseiidae) in Southern California. Entomophaga 23(2):175-179. https://doi.org/10.1007/BF02371725

McMurtry, J. A., J. G. Shaw, and H. G. Johnson. 1979. Citrus red mite populations in relation to virus disease and predaceous mites in Southern California. Environmental Entomology 8(1):160–164. https://doi.org/10.1093/ee/8.1.160

McMurtry, J. A., N. F. Sourassou, and P. R. Demite. 2015. The Phytoseiidae (Acari: Mesostigmata) as biological control agents. In D. Carrillo, G. de Moraes, and J. Pena, eds., Prospects for Biological Control of Plant Feeding Mites and Other Harmful Organisms. Progress in Biological Control 19. Cham, Switzerland: Springer. https://doi.org/10.1007/978-3-319-15042-0_5

Oatman, E. R. 1971. Mite species on strawberry in Southern California. Journal of Economic Entomology 64(5):1313–1314. https://doi.org/10.1093/jee/64.5.1313

Oatman, E. R., and J. A. McMurtry. 1966. Biological control of the two-spotted spider mite on strawberry in Southern California. Journal of Economic Entomology 59(2):433–439. https://doi.org/10.1093/jee/59.2.433

Oatman, E. R., F. E. Gilstrap, and F. Voth. 1976. Effect of different release rates of *Phytoseiulus persimilis* (Acarina: Phytoseiidae) on the twospotted spider mite on strawberry in Southern California. Entomophaga 21: 269–273.

Oatman, E. R., J. A. McMurtry, F. E. Gilstrap, and V. Voth. 1977. Effect of releases of *Amblyseius californicus*, *Phytoseiulus persimilis* and *Typhlodromus occidentalis* on the twospotted spider mite on strawberry in southern California. Journal of Economic Entomology 70: 45–47. https://doi.org/10.1007/BF02371761

Oatman, E. R., J. A. McMurtry, H. H. Shorey, and V. Voth. 1967. Studies on integrating *Phytoseiulus persimilis* releases, chemical applications, cultural manipulations, and natural predation for control of the two-spotted spider mite on strawberry in Southern California. Journal of Economic Entomology. 60(5):1344–1351. https://doi.org/10.1093/jee/60.5.1344

Oatman, E. R., J. A. McMurtry, and V. Voth. 1968. Suppression of the two-spotted spider mite on strawberry with mass releases of *Phytoseiulus persimilis*. Journal of Economic Entomology 61:1517–1521. https://doi.org/10.1093/jee/61.6.1517

Rice, R., and R. A. Jones. 1978. Mites in almonds and stone fruits. California Agriculture 32(4):20–21. http://calag.ucanr.edu/Archive/?article=ca.v032n04p20

Rice, R. E., R. A. Jones, and M. L. Hoffman. 1976. Seasonal fluctuations in phytophagous and predaceous mite populations on stonefruits in California. Environmental Entomology 5(3):557–564. https://doi.org/10.1093/ee/5.3.557

Rowell, H. J., D. A. Chant, and R. I. C. Hansell. 1978. The determination of setal homologies and setal patterns on the dorsal shield in the family Phytoseiidae (Acarina: Mesostigmata). Canadian Entomologist 110(8):859–876. https://doi:10.4039/Ent110859-8

Schuster, R. O. 1957. A new species of *Typhlodromus* from California (Phytoseiidae: Acarina). Pan Pacific Entomologist. 33:203–205.

Schuster, R. O., and A. E. Pritchard. 1963. Phytoseiid mites of California. Hilgardia 34(7):191–198. http://hilgardia.ucanr.edu/Abstract/?a=hilg.v34n07p191

Takano-Lee, M., and M. S. Hoddle. 2002. *Oligonychus perseae* (Acari: Tetranychidae) population responses to cultural control attempts in an avocado orchard. Florida Entomologist 85(1):216–226. https://doi.org/10.1023/A:1020949531639

Tanigoshi, L. K., J. Fargerlund, J. Y. Nishio-Wong, and H. J. Griffiths. 1985. Biological control of citrus thrips, *Scirtothrips citri* (Thysanoptera: Thripidae), in Southern California citrus groves. Environmental Entomology 14(6):733–741. https://doi.org/10.1093/ee/14.6.733

## Glossary

**Line drawings showing the majority of structures can be found in figures 2–8.**

**Acaridida:** A taxonomic term previously used for the Astigmata.

**Actinedida:** A taxonomic term previously used for the Prostigmata.

**Amblyseiinae:** A subfamily of the Phytoseiidae with only four pairs of anterolateral setae.

**Ameroseiidae:** A family of mites in the Mesostigmata that inhabits soil, nests, or stored products.

**anal setae:** Setae lateral to and just posterior to the anus.

**anterior:** Front of the body nearer the head.

**anterodorsal:** Front and top.

**anterolateral:** Front and outer edges.

**anteromedial:** Front and middle area.

**apotele:** The ending segment of an appendage (palp or tarsus).

**arthropod:** Including insects and mites.

**Ascidae:** A family of mites in the Mesostigmata that inhabits soil, humus, litter, foliage, bark, flowers, and nests.

**Astigmata:** The suborder of mites that has no apparent stigmatal openings. Many species are pests in stored products.

**atrium:** A valve-like structure at the basal end of the spermatheca that connects the calyx (cervix) to the major duct, and gives rise to the minor duct.

**basitarsus:** The basal portion of the tarsus.

**calyx (=cervix):** A narrow, often tubelike structure surrounding the base of the vesicle of the spermatheca.

**chelate:** Pincerlike.

**chelicerae:** The most anterior pair of limbs. The primary organs for mite feeding and adapted for chewing, piercing, tearing, or sucking.

**constricted:** Narrowed, restricted.

**convex:** A surface that is curved or rounded outward.

**corniculus (pl. corniculi):** A ventral, hornlike process on the anterior tip of the gnathosoma.

**coxa:** The basal leg segment, between the body wall and the trochanter.

**crescentic pores:** Crescent-shaped openings.

**dentate:** Toothlike.

**detritus:** Break-down products, waste.

**deutonymph:** Second nymphal stage of mites.

**digit:** End segment of the chelicera.

**dorsal or dorsum:** The upper surface.

**dorsal shield:** A shield covering the majority of the dorsal surface of the mite.

**dorsolateral:** Above and outside.

**equidistant:** Equally spaced.

**eriophyid:** Mites in the family Eriophyidae, some of which are pests of crops—for example, rust mites and bud mites.

**femur:** The third leg segment, between the trochanter and the genu.

**fungivore:** Feeding on fungi.

**Gamasida:** A previous taxonomic term for Mesostigmata.

**genital shield:** A ventral shield covering the genital opening, between the sternal and ventrianal shields.

**genu:** The fourth leg segment, between the femur and the tibia.

**gnathosoma:** The anterior-most portion of the mite body, consisting of the segments where the chelicerae and palps originate.

**honeydew:** The sugary substance excreted by some insects, such as whiteflies, aphids, soft scales, and psyllids.

**humeral:** Shoulder area.

**humus:** Decomposed plant matter in the soil.

**idiosoma:** The main body of a mite, not including the appendages or the gnathosoma.

**idiosomal venter:** The main shield found on the lower side of the mite.

**integument:** Fleshy skin; not hardened or sclerotized.

**lateral:** Referring to the side, or away from the midline.

**legs I, II, III, and IV:** Legs one through four, counted from the anterior (front leg = leg I; coxa IV = coxa on the hind leg).

**lobe:** Protrusion.

**macrosetae:** Enlarged setae, usually longer and thicker than the other setae.

**margin:** Edge.

**mechanoreceptor:** A sense organ or cell that responds to mechanical stimuli such as touch or sound.

**medial:** Midline of the body.

**Mesotigmata:** The order of mites characterized by stigmatal openings in the middle (meso) of the body. They are primarily free-living predators in soil, on vegetation, as vertebrate parasites, in flowers, or feeding on fungi.

**morphology:** The form and structure of an organism.

**nodular:** A small, rounded shape or swelling.

**opisthonotal:** The dorsal portion of the region behind the legs.

**opisthosoma:** The most posterior body region (=abdomen), behind the legs.

**Oribatida:** The suborder that includes the moss or beetle mites that are primarily soil-dwellers, feeding on detritus and microorganisms.

**palp (pl. palpi):** The second pair of limbs, between the chelicerae and the first pair of legs. Serve as platforms for chemosensory and thigmotactic sensory receptors, like the antennae of insects and to manipulate prey.

**palptarsal claw:** A clawlike structure on the palp. The palp tarsal apotele in the Mesostigmata is a tined structure below the terminus of the palp; may serve a role in prey manipulation.

**pentagonal:** Shaped like a pentagon (five-sided).

**peritreme:** A surface groove that connects the stigmatal opening to the front of the body; in Phytoseiidae, it runs laterally along the coxae and is important for respiration.

**phase contrast:** A type of microscopy that translates differences in the phase of the light transmitted through or reflected by the object into differences of intensity in the image.

**phytoseiid:** A member of the family Phytoseiidae; predatory mites, many of which are important biological control agents (such as the western predatory mite).

**Phytoseiinae:** A subfamily of the Phytoseiidae that has 5 to 6 pairs of anterolateral setae; r3 setae is inserted on the dorsal shield and all S setae are absent.

**pilus dentilis:** A hairlike structure on the chelicerae that acts as a mechanoreceptor that informs the mite it is gripping something.

**podonotal:** The dorsal portion of the podosoma.

**podosoma:** The body region that bears the legs; between the gnathosoma and opisthosoma.

**posterior:** Toward the back end of the body.

**postscutum:** The posterior portion of the dorsal shield.

**preanal setae:** One or more pairs of setae that are anterior to the anus, and usually located on the ventrianal shield.

**predator:** An animal that preys on another.

**prodorsum:** The anterior portion of the body.

**proscutum:** The anterior portion of the dorsal shield.

**Prostigmata:** The suborder of mites characterized by stigmatal openings at the front of the body. Prostigmatans exhibit the full range of feeding habits. Most plant-feeding mites are prostimatans, including spider mites (Tetranychidae), false spider mites (Tenuipalpidae), or rust and bud mites (Eriophyidae).

**protonymph:** First nymphal stage of mites.

**reticulate:** Usually refers to shields with irregular, angular cells that give a netlike appearance.

**rugose:** Wrinkled or corrugated.

**saccular:** Resembling a sac.

**Sarcoptiformes:** The order that includes the suborders Astigmata and Oribatida.

**sclerotized:** Hardened cuticle.

**scutum:** Shield or plate.

**seta (pl. setae):** A hair or bristle.

**shield:** A hardened plate, usually on the dorsal or ventral surface, surrounded by softer integument.

**spermatheca:** A structure in the female for storing sperm; composed of a vesicle (various shapes), a narrow calyx, and a valve-like atrium that connects a major and minor duct.

**spermatodactyl:** A structure on the chelicerae of some male mites, used to transfer a sperm packet from his venter into the female spermatheca.

**spermatophore:** A structure that carries a packet of sperm; in phytoseiids, it is carried on the chelicerae of the male.

**spermatozoa:** The male sex cells by which the ovum is fertilized.

**sternal:** Forward area of the ventrum.

**sternal shield:** A ventral shield between the coxae, anterior to the genital shield.

**stigmata:** Spiracular pores, a surface opening to the tracheal (respiratory) system.

**styletiform:** Spear- or stylet-like.

**symbiont:** An organism closely associated with another organism.

**systematics:** The classification of organisms.

**tarsonemid:** In the family Tarsonemidae, some of which are crop pests, including broad mite and cyclamen mite.

**tarsus:** The sixth (subdistal) leg segment, between the tibia and the apotele.

**tenuipalpid: Mites in the family Tenuipalpidae, some of which are pests of crops—for example, flat mites.**

**tetranychid:** Mites in the family Tetranychidae, many of which are pests of crops—for example, twospotted spider mite, Pacific spider mite, Willamette spider mite, brown apple mite, citrus red mite, and European red mite.

**tibia:** The fifth leg segment, between the genu and the tarsus.

**tritosternum:** The ventral segment (sternum) between legs I; in phytoseiids, a thin, forward-projecting, forked structure that originates between the coxae of legs I and extends forward under the gnathosoma.

**trochanter:** The second leg segment between the coxa and the femur.

**Trombidiformes:** The order that includes the suborder Prostigmata.

**truncate:** Shortened or cut off.

**tubular:** Shaped like a tube.

**tydeidae:** Mites in the family Tydeiidae, often found on plants, but generally fungal feeders; they act as food sources for the phytoseiids.

**Typhlodrominae:** A subfamily of Phytoseiidae that has five to six pairs of anterolateral setae; the r3 setae is located next to the dorsal shield and 1-3 S setae are present.

**ventral (or venter):** The lower surface of the mite.

**ventrianal shield:** A ventral shield containing the anal opening and setae, posterior to the genital shield.

**ventrolateral:** On the lower shield, on the outer edge.

**vesicle:** A saclike structure, in phytoseiids for storing sperm in the spermatheca.

**volatiles:** Chemical "smells" produced by an organism.

## Appendix

A separate document, the appendix to *Key to the Phytoseiid Predatory Mites Found on California Crops*, provides photos of key characteristics of slide-mounted mites taken through a compound microscope. The appendix, which includes photos of forty-five of the forty-six mite species found in the key, will greatly aid in identification of these species. For the majority of mite species, photos of the dorsum, venter, ventrianal shield, spermatheca, and chelicera are provided. For some species, additional photos are included for structures that are especially important for confirming identification, such as the peritreme, macrosetae, pores, and dorsal shield indentations.

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