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The superfamily Raphignathoidea (Acari: Acariformes) of the Hawaiian Islands: Taxonomy, ecology and distribution

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THE SUPERFAMILY RAPHIGNATHOIDEA (ACARI: ACARIFORMES) OF THE HAWAIIAN ISLANDS: TAXONOMY, ECOLOGY AND DISTRIBUTION

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ABSTRACT

The superfamily Raphignathoidea in the Hawaiian Islands is represented by the families Caligonellidae, Camerobiidae, Cryptognathidae, Eupalopsellidae, Raphignathidae and Stigmaeidae. Five of these families had been previously recorded from the islands; Eupalopsellidae is a new record for the Hawaiian Archipelago. Caligonellidae is represented by 3 genera: Coptocheles with 3; Molothrognathus with 2; and Neognathus with 1 species. Camerobiidae is represented by 2 genera: Tycherobius with 1 and Neophyllobius with 4 species. Cryptognathidae is represented by the genus Favognathus with 4 species. Eupalopsellidae is represented by 2 genera: Exothorhis and Saniosulus with 1 species each. Raphignathidae is represented by the genus Raphignathus with 9 species and the family Stigmaeidae is represented by 6 genera: Agistemus with 2; Eustigmaeus with 7; Eryngiopus with 2; Ledermuelleriopsis with 2; Stigmaeus with 5 and Storchia with 2 species. Of the 46 recorded species, in 16 genera, 30 are new to science. Keys to the world genera of the 6 families are provided. All new species are described and illustrated.

Genus and species limits are based primarily on female characters, with the exception of some Raphignathus species

where larval phyletic characters are considered. Details of dorsal ornamentation; size and shape of idiosomal plates; condition and length of various dorsal setae; absence or presence of eyes, endopodal plates, callosities; and chaetotaxy of legs and anogenital region are some of the characters used in establishing generic and species limits.

Soil, litter, moss and bark habitats have the most number of raphignathoid species. Eustigmaeus kauaiensis Swift et al., is reported for the first time as a moss-feeding species.

The islands of Hawai'i and O'ahu have the most number of species. Distribution maps based on available data are included.

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ad - adoral seta

aed - aedeagus

ag - aggenital seta

c - hysterosomal seta on segment C

ch - chelicera

cpc - podocephalic canal

d - hysterosomal seta on segment D

dsj - disjugal suture

e - hysterosomal seta on segment E

ep - supracoxal seta on dorsal base of palpus

eI - supracoxal seta dorsolateral of leg I

f - hysterosomal seta on segment F

ft - fastigial seta of legs

g - genital seta

h - hysterosomal seta on segment H

ia - cupule on segment C or D

ih - cupule on segment H

im - cupule on segment E

ip - cupule on segment F

m - anterior infracapitular seta

n - posterior infracapitular seta

pdx - propodosomal seta, added in protonymph

per - peritreme

pob - postocular body

ps - pseudanal seta

sce - external scapular seta

sci - internal scapular seta

sol - solenidion

st - stylet

tc - tectal leg seta of tarsus

tr - trachea

ve - external vertical seta

vi - internal vertical seta

k - solenidion kappa, famulus-like, on leg genu

ϕ - solenidion phi on leg tibia, anterodorsal

ϕp - solenidion phi rho on leg tibia, posterodorsal

w - solenidion w on leg tarsus

1a - seta a of coxa I

3a - seta a of coxa III

4a - seta a of coxa IV

4c - seta c of coxa IV

INTRODUCTION

The superfamily Raphignathoidea is comprised of small mites, between 300-500 micrometers, of diverse form and color, and occurs in terrestrial and semiaquatic habitats worldwide. Over 500 nominal species are known (Sepasgosarian 1985, 1990) but many undescribed taxa await description, especially from major continents of the world. The raphignathoids of South Africa, New Zealand, North America (California and Florida), some parts of the former Soviet Union, and certain parts of Europe have been studied but areas such as Australia, South America, the oceanic islands of the Pacific, and the Asian continents are poorly known.

Included in the Raphignathoidea are predators (members of the genera Mediolata, Zetzellia, Agistemus, Saniosulus, Neophyllobius, among others) of other mites (Eriophyes, Tetranychus, Tenuipalpus) and scale insects, feeders on mosses (Eustigmaeus, Gerson 1972) and parasites of phlebotomine and crane flies (Stigmaeus, Eustigmaeus)(Hirst 1925, Chaudhri 1965, Swift 1987). They are inhabitants of litter, tree barks, stored grains, birds' nests, moss, lichens, soil, plants (Cryptognathidae, some Stigmaeidae, Barbutiidae, Raphignathidae and Xenocaligonellidae)(Summers 1960, Gerson 1968, Luxton 1973, Atyeo 1963, Robaux 1975,

Ueckermann and Meyer 1987) and are found in semiaquatic and aquatic habitats (Homocaligidae) (Habeeb 1962, Wood 1969).

A particularly large group within the superfamily, the Stigmaeidae, comprising 60% of the named raphignathoid species, is of both agricultural and medical importance (Summers 1966). They are associated with plants, live in soil and organic material and some species are fly parasites (Swift 1987). Studies of their ecology indicate that most species are predaceous and may be a factor in the biological control of phytophagous mites of the families Tetranychidae, Tenuipalpidae, Eriophyidae and Tarsonemidae (Parent and Le roux 1956, Muma 1961, Gonzalez-Rodriguez 1961, 1965, Ehara 1962, Ehara and Oomen-Kalsbeek, 1983, Van de Vrie 1963, Collyer 1964, Santos 1976, Gerson and Smiley 1990). The medical importance of stigmaeids stems from the discovery of 3 species of Stigmaeus and 4 species of Eustigmaeus associated with phlebotomine species (Abonnenc 1970, Chaudhri 1965, Mitra and Mitra 1953, Hirst 1925, Swift 1987). Flies in the subfamily phlebotominae (Diptera: Psychodidae) are vectors of human dermal leishmaniasis and papatasi fever in tropical areas of the world. The potential significance of the mites lies in the harmful effects of mite feeding to individual flies and in data they may provide on the biology of the flies, which are difficult to study due to their small size and nocturnal habits (Lewis and MacFarlane 1981).

This study concerns the taxonomy, ecology and distribution of mites in the superfamily Raphignathoidea in the Hawaiian Islands. The first raphignathoid species reported from the Hawaiian Islands was a Raphignathus species (Raphignathidae) from a pheasant (Schwartz and Schwartz 1949). Agistemus terminalis (Quayle, 1912) (Stigmaeidae) and Cryptognathus favus Summers and Chaudhri, 1965 (Cryptognathidae) were reported by Garrett and Haramoto (1967) in their catalogue of Hawaiian Acari. Goff (1983, 1987) reported several species from Kaua'i I. and Swift et al. (1985) described a Hawaiian species, Eustigmaeus kauaiensis, bringing the total number of raphignathoids to 13 species in 5 families.

Life Histories. Studies on biologies of raphignathoids are scarce. The few observations and life histories known at present are mostly of species of agricultural importance. Zetzellia mali (Ewing, 1917), and Agistemus spp. (Stigmaeidae) are predators of phytophagous mites and soft-bodied insects in orchards in the United States (Santos 1976; Rice et al., 1976), Canada (Nesbitt 1946; Parent and Le Roux 1956; Forest et al. 1982) as well as in Europe (Berker 1958; Dellattre 1971). Eustigmaeus frigida (Habeeb) (Stigmaeidae) occurs in Canada and in the northeastern United States and feeds on mosses. Brief summaries of these life histories are presented here.

The life cycle of this group is typical of the other Acariformes: egg, hexapod larva, protonymph (n1), deutonymph (n2), and adult. However, the tritonymph (n3) is suppressed in this group unlike the rest of the Prostigmata, a derived developmental character. The prelarvae should exist, according to Kethley (1990), but have not been described for any species of Raphignathoidea. Each active immature stage ends in a period of quiescence after which the old integument is shed. All the active stages are predaceous (for predators) or feed on mosses (for moss feeders) except for Neognathus (Caligonellidae) where only the larva is a regressive, inactive, non-feeding stage (Kethley 1990).

Zetzellia mali overwinters in the adult stage beneath apple bark in clusters of as many as 150 females. They can feed at very low temperatures ($5^{0}C$) however, adult winter mortality can be up to 90% (White and Laing 1978). During the growing season, an individual Z. mali develops from egg to adult in about 16 days at $20^{0}C$. At this temperature, a mature female's pre-ovipositional period is 1.5 days, ovipositional period is 9 days with approximately 20 eggs laid. The sex ratio is about 2.5 females to 1 male. Eggs from unfertilized females produce only males (arrhenotoky) (White and Laing 1977).

Larval Z. mali consume 2.2 motile apple rust mites (Aculus schlechtendali) per day, protonymphs consume 7.6 per day, deutonymphs 8 per day, and adults an average of 12.5

per day. The apple rust mite is the only species of phytophagous mite that could be used in the laboratory to rear Z. mali consistently to adult stage (White and Laing 1977).

Agistemus species are predators of soft-bodied insects and phytophagous mites in orchards. Collyer (1964) found that adult females of Agistemus longisetus Gonzalez in New Zealand live up to 10 weeks and can lay an average of 5 eggs per day. Development from egg to egg-laying adult takes approximately 23 days during the summer. This species prefers Panonychus ulmi, P. citri, Bryobia sp., Brevipalpus sp. to Tetranychus urticae or T. lambi (Collyer, 1964). Agistemus fleschneri Summers, 1960, the most common North American species found in orchards is difficult to rear in the laboratory due to low rate of reproduction (Nelson et al. 1973). Muma and Selhime (1971) report that A. floridanus Gonzalez-Rodriguez, 1965, consistently occurs on Florida citrus. It feeds on purple scale Lepidosaphes beckii (Newman); Florida scale (Chrysomphalus ficus (Ashmead); woolly whitefly eggs (Aleurothrixus flocossus (Maskell)) and 3 polyphagous mite species.

Gerson (1972) studied a phytophagous raphignathoid, Eustigmaeus frigida (Habeeb, 1962), in laboratory culture. E. frigida feeds on moss leaves, sucking out cell contents leaving the cell walls intact. The life cycle lasts about 30 days at approximately 23^{0}C. Isolated females produce

only male descendants, thus reproduction is arrhenotokous. The females lay 21 eggs whether confined with males or isolated and they reproduce freely under both long-day (16 hours) and short-day (9 hours) photoperiodic regimes. The eggs are orange-red in color and deposited on moss leaves, usually in axils. The egg-stage lasts from 7-15 days. Newly hatched larvae are orange-red as the eggs but after 1-2 days, when they begin to feed, gut contents turn dark green. Larval feeding is usually confined to leaves. Larval stage lasts for 2-5 days and pre-moult last 2-3 days. The protonymphal stage lasts 2-8 days. The deutonymph is more mobile than the preceding stages and lasts for 3-10 days. E. frigida feeds and survives on many moss species but reproduction only occurs while feeding on a few specific moss species such as Didymodon tophaceus and Amblystegium serpens.

Geographic distribution. Raphignathoid mites are known from all major regions and major biotopes of the world except Antarctica, the Arctic regions and major deserts. The family Homocaligidae inhabits aquatic and semiaquatic habitats (Wood 1969). Stigmaeus campbellensis Wood, 1970, occurs in the Subantarctic island of Campbell and Stigmaeus parmatus Summers, 1962, is known from Point Barrow, Alaska. Raphignathoids inhabit both warm tropical areas and cool, temperate and mountainous regions. Bolland and Magowski (1990) described Neophyllobius succineus, a fossil

camerobiid from Baltic amber, which dates back to the Upper Eocene (58-36,000 years ago). Even with this important information, no attempt is made here to determine the evolutionary history of the group being a regional study dealing with incomplete monophyletic units. When distribution records are more complete, many species will probably be found cosmopolitan in distribution.

Eustigmaeus segnis (Koch, 1836), Eustigmaeus microsegnis (Chaudhri, 1965) and Saniosulus nudus (Summers, 1960) are the 3 most widely distributed raphignathoid species. For example, E. segnis is reported from Somalia and South Africa, North America (California and Canada), USSR (Central Chernozem), Europe (Italy) and the Hawaiian Islands. For some raphignathoids associated with plant mites of agriculture importance, their wide distribution may be attributed to man's movements of his crops, his livestock and farming tools. For raphignathoids associated with moss and lichen, inhabiting undersides of bark and litter dwellers, their presence on the oceanic Hawaiian Islands is more complex and open for speculation. Theories on how land animals and plants reach the islands are numerous (Zimmermann 1948, Carlquist 1982) but no definitive case for mite arrival or origin has been documented. Jacot (1934) formed theories on the presence of the oribatid mites in the islands and Peck (personal communication, 1993) has been

studying the possible arrival of the oribatids in the Galapagos Islands.

Morphology. Each family in the Raphignathoidea has been given thorough morphological treatment by individual workers doing taxonomic work: Stigmaeidae: Summers 1957, 1960, 1962a, 1962b, 1964; Wood 1966, 1967, 1970, 1971a, 1971b, 1981; Homocaligidae: Wood 1969; Xenocaligonellidae: Deleon 1959, Gonzalez-Rodriguez 1978; Barbutiidae: Robaux 1975; Camerobiidae: van Eyndhoven 1941, McGregor 1950, Southcott 1957, DeLeon 1958, Gerson 1972, Robaux 1975, Zaher and Gomaa 1979, Bolland 1986, 1991; Cryptognathidae: Krantz 1958, Summers and Chaudhri 1965, Smiley and Moser 1968, Luxton 1972, 1973; Kuznetzov and Livshitz 1974, Robaux 1975, McDaniel and Bolen 1979; Eupalopsellidae: Summers 1960, Meyer and Ueckermann 1989; Caligonellidae: Summers and Schlinger 1955, Robaux 1975, Wainstein 1978, Chaudhri et al. 1979, Kuznetzov and Petrov 1984; Raphignathidae: Oudemans 1923, Meyer and Ryke 1960, Atyeo, Baker and Crossley 1961, Rack 1962, Atyeo 1963, Chaudhri et al. 1978, Zaher and Gomaa 1979. What follows in this section is a brief composite picture of the major body parts of the raphignathoids, morphological comparisons with possible homologies of some parts in some families, and dorsal setal notations if applicable, following Grandjean's system (1944) with Kethley's modification (1990).

The body of a raphignathoid mite is divided into three distinct regions: gnathosoma, propodosoma and hysterosoma, all of which have important taxonomic characters.

Gnathosoma. The gnathosoma consists of the chelicerae, infracapitulum and palpi. The palpus has six segments: coxa, trochanter, femur, genu, tibia and tarsus, the last segment bearing apically 1-4 eupathidia, a single trifid eupathidium or eupathidium absent as in Barbutiidae. The palpal thumb-claw complex is constant throughout the superfamily, except in Cryptognathidae (Figure 2C). In Cryptognathidae, the modified claw-like or sword-like seta is absent while the family Raphignathidae has small or reduced claw and the rest have well-developed claws of varying size and shape. Barbutiidae has a small notch on the internal lateral aspect of the claw, resembling a tooth. The palpal coxal bases bear a pair of supracoxal setae, ep, either with rounded or pointed tips and recessed in some species of Caligonellidae and Cryptognathidae.

The chelicerae are either separate or fused basally (Figure 1) forming a stylophore integrated with the infracapitulum on the venter of the gnathosoma. In Cryptognathidae, the chelicerae are partly retractable. In Raphignathidae, Caligonellidae, Camerobiidae and Xenocaligonellidae, the basal segments of the chelicerae are substantially thickened or inflated, positioned in a deep trough between the coxal areas of the capitulum, their

proximal ends covered by a thin fold of integument. The movable digits are stylate, slender and needle-like, thick and short, curved and partially retractile. Gerson (1972) suggested the chelicera-stylet ratio is of some value in raphignathoid studies as it will give an indication of the anchorage site of the stylets in the chelicerae. This ratio is useful to predict food preference of species if not of entire genus group.

Peritremes are either absent as in Stigmaeidae, Eupalopsellidae, Homocaligidae; very short as in Barbutiidae; or in chambered dorsal part of chelicerae with simple pattern as in Raphignathidae (Figure 1A), Neognathus in Caligonellidae (Figure 1D), Favognathus in Cryptognathidae (Figure 1D), Xenocaligonellidae (Figure 1E) and with various complex loops and patterns as in Coptocheles (Caligonellidae)(Figure 1C) and Tycherobius (Camerobiidae)(Figure 1F). Presence of peritremes at the base of the gnathosoma, on the mesal surface of cheliceral bases, or on the dorsal surface of partially or completely fused cheliceral bases in the Raphignathoidea is a derived feature (Kethley 1990).

Propodosoma. The anterior portion of the mite behind the gnathosoma is referred to as the propodosoma. This area is separated from the posterior hysterosoma by a suture or a band of transverse striae. Cryptognathidae (Figure 25) is unique in having an elongated anterior portion of the

prodorsum called "hood", supposedly, a protective cover. Adult Mullederia (Stigmaeidae) and Cryptognathidae (Figure 29) do not possess a dividing suture. The propodosoma usually has a thickened plate except the 2 known species in Barbutiidae. In species with plates, the size varies from a small bean shaped plate with 1-2 pairs of setae as in Stigmaeus seminudus Wood (Stigmaeidae) to extensive plating in Eustigmaeus (Stigmaeidae) (Figure 77). The plate usually has 4 pairs of setae, vi, ve, sci, and sce. Some setal elements may be absent (e.g, vi in Cryptognathidae; sci in some Stigmaeidae). In some instances, an additional pair of setae are added as pdx in the protonymphal stage of some species in Camerobiidae. One pair of eyes and postocular bodies (pob), located posterior of the eyes, may be present or absent. Propodosomal plating in males of the Raphignathidae covers the entire area and extends onto the entire hysterosoma with only lateral slits with a narrow band of striations to indicate the separation of propodosoma from the hysterosoma. The venter of this region consists of coxae I and II and endopodal plates may be fused (Raphignathus n.sp. E, Eustigmaeus spp.), entirely separated by striations (Eryngiopus sp., Stigmaeidae) or absent (Camerobiidae). Coxae I and II may be contiguous, coalesced with coxae III and IV (Figure 4A, Raphignathidae), or separated from coxae III and IV by varying distances (Figures 4B-F, Caligonellidae, Camerobiidae, Stigmaeidae).

The pair of ventral setae 1a are present in the entire superfamily. They vary in length and in setal condition. The plates may be plain or ornamented with reticulations, punctations or striations. Cupules ia in the form of a round, lens-like structure for Raphignathidae or slit or lyrifissure for Cryptognathidae are present lateral of the the propodosoma. Cupules ia are associated with the dorsal setae of segments C and D, im with setae E, ip with F, and ih (called iop in earlier works of Grandjean, e.g., 1934, 1935) with H (Lindquist 1977).

Hysterosoma. The platings on the dorsum of the hysterosoma vary in number, in shapes of plates and arrangement of the plates on the dorsal integument. Stigmaeus siculus (Berlese, 1883) (Summers 1961) has 10 plates, 2 unpaired; excluding the lateral plates with lateral setae c2. Barbutia anguineus (Berlese, 1910) has only the suranal plates on the posterior of the opisthosoma without any plating on the dorsum. These plates are similar to the propodosomal plates, either plain or with ornamentations. The setae may be simple, serrate or plumose. Lateral setae f2 are located laterad of h2 in the same suranal plate (Prostigmaeus, Stigmaeus, Macrostigmaeus, Stigmaeidae). Sets of cupules (im, ip, ih) are found in the Raphignathidae and Caligonellidae (Figures 5A, 35A). The hysterosomal venter includes the endocoxal plates, coxae, genital and pseudanal plates or the anogenital

plates. In some of the stigmaeid genera (Eustigmaeus, Mullederia, Ledermuelleriopsis) the endocoxal plates surrounding coxae III and IV are fused or divided medially with fine longitudinal striations. Ventral setae 3a and 4a are not consistently located relative to the locations of coxae III and IV (Figure 4). Usually, the ventral setae are short but most species of Eryngiopus have long, flagelliform ventral setae, including coxal setae 2b (Figure 4E). There usually are 3 pairs of pseudanal setae (ps) on the anal valves and a varying number (maximum of 4 pairs) or absence of genital setae. Aggenital setae (ag) number from 0 to 4 pairs. In males, ps1-3 are present, in reduced lengths. The aggenital setae vary from 1 to 4 pairs as in females, but the genital setae are absent. Cupules ih are located usually laterad of the genitoanal plate (Cryptognathidae, Raphignathidae). A uniform scheme of chaetotaxic notation of the hysterosoma and the propodosoma for the Raphignathoidea and other prostigmatic groups is well shown by comparing the various notations of other workers and Grandjean's (1944) as modified by Kethley (1990).

Legs. Leg segments of raphignathoids are composed of coxa, trochanter, femur, genu, tibia and tarsus. Grandjean (1944) determined the minimal and maximal numbers of setae to be found in each leg segment for stigmaeid mites. He also determined which setae are constant and which had a tendency to be lost. Atyeo (1963) found that the leg

segments in Raphignathus species are similar to those of the Stigmaeidae, with the exception of the tarsi. Atyeo also established the leg chaetotaxy of the Raphignathidae in comparison with leg setation of other groups in the Raphignathoidea. The numbers and positions of setae on the tarsi of the Caligonellidae are similar to those of the Raphignathidae. Ventral eupathids are present in the Caligonellidae. Homologies of these setae were not attempted in this study.

Tibiae I-IV are equipped with a thin, curved solenidion (op) in the Raphignathoidea. Tibia I may have a short, straight solenidion (o) which does not appear on tibiae II, III and IV. There are variations, for instance in the Raphignathidae and Caligonellidae where a thin, curved solenidion (op) appears proximally on tarsus I.

Sexual dimorphism is exhibited in the tarsal solenidia. The tarsi of all raphignathoid females have 1 claviform solenidion which becomes progressively smaller from tarsus I to tarsus IV and in Raphignathus species may be absent from tarsus III (rarely) and tarsus IV. Also in the families Raphignathidae, Caligonellidae and Camerobiidae, as in the females, the males have 1 claviform solenidion on each tarsus except that the structure is greatly enlarged (except in Coptocheles triscutatus Summers and Schlinger, 1955). In these families, there is no structure homologous to the solenidion (male omega) of other raphignathoid male mites.

Camerobiidae is unique among the raphignathoids by having long legs with elongate femora and tibiae and short genua (Figure 17A).

Genital Region. In most raphignathoids, the genital plates are weakly separated from the anal plates by fine longitudinal striations. In Favognathus (Cryptognathidae) and Raphignathus (Raphignathidae), the genital area is distinctly separate from the terminal anal plates. In Stigmaeidae, different genera or even species in the same genus show varying genital and anal configurations. For example, Stigmaeus n.sp. C (Figure 76B) has distinctive separations of the genital, aggenital and pseudanal plates each with their corresponding setae while Stigmaeus n.sp. D (Figure 78B) has coalesced genital and anal plates (anogenital region).

The female genitalia are simple, composed of a longitudinal opening with a sclerotized structure on the genital vestibule (Raphignathus, Figure 55B; Molothrognathus, Figure 14D). No ovipositor or genital papillae are evident. The males have either simple elongated aedeagus, e.g., Tycherobius (Figure 18), Favognathus (Figure 28I), or complex, e.g., Ledermuelleriopsis (Figure 66A), Raphignathus (Figures 38G, 48B). Males have the genital and anal regions coalesced as in other eleutherengones and only the pseudanal setae (psl-

3) and one or two pairs of aggenital setae are present (Figures 28, 47, 63).

Intraspecific Variation. Summers (1962) stated the lack of great anatomical detail to separate species in the genus Stigmaeus. Variations in ornamentation and arrangements of body plates, kinds, numbers and size of setae are characters he used in his numerous stigmaeid studies. Patterns of dorsal plates on the hysterosoma was used to separate fourteen genera of Stigmaeidae (Summers, 1966). In the well-studied Eustigmaeus, Gerson (1972) used the following characters in separating females of this genus: nature, length and position of various dorsal setae; details of dorsal ornamentation; presence or absence of eyes; occurrence of pleural callosities; number of ventral, intercoxal (endopodal) and paragenital setae; number of setae on femur II and tarsus IV and length of cheliceral stylets. The chaetotaxy of dorsal idiosoma, palpi, legs and anogenital region were the characters used by Gonzalez-Rodriguez (1965) in his key to the genera of the family Stigmaeidae.

For species in the family Raphignathidae, Atyeo (1963) demonstrated size and shape of the idiosomal plates of both male and female, number and position of integumental pores or cupules, pattern formed by small subcutaneous apodemes of dorsal idiosoma, presence or absence of solenidion o on tibia I, relative size and position of the dorsal idiosomal

setae and chaetotaxy of legs and palpi as the key characters in species separation.

Among members of the family Caligonellidae, the genera are separated mainly by the relative origin of the peritremes on the stylophore and its arrangement (Summers 1955). Absence or presence of propodosomal plates, condition of plates if present, leg chaetotaxy, number and position of integumental cupules are characters used in species separation. In Cryptognathidae, species are distinguished according to patterns of ornamentation on the single idiosomal plate (Summers and Chaudhri 1965). Absence or presence of plates are not at all considered in the Camerobiidae. Leg chaetotaxy on tarsi I-IV is used in distinguishing genera (Bolland 1986). Species distinctions are based on the number, relative lengths and nature of various dorsal setae, coxal setal differences and chaetotaxy of the legs and palpae.

The species concept in the Raphignathoidea went beyond simple descriptions when Grandjean (1944) described Storchia robusta (Berlese, 1885) (= Apostigmaeus navicella) in great detail. Later workers such as Summers (1962, 1964) and Wood (1967, 1971) and many others followed and modified Grandjean's initial exhaustive work. In this study, the species concept follows that of Grandjean (1944) combined with recent findings of present raphignathoid workers.

Taxonomic History. The superfamily Raphignathoidea was proposed by Grandjean (1944) for the families Caligonellidae Grandjean, 1944, Stigmaeidae Oudemans, 1931, and Raphignathidae Kramer, 1877. It was Cunliffe (1955), however, who first defined the superfamily when he proposed a new classification for the trombidiform mites. In his classification, in addition to aside from the 3 families proposed by Grandjean (1944), the families Cryptognathidae Oudemans, 1902 and Pomerantziidae Baker, 1949 were included. Southcott (1957) was unaware of Cunliffe's (1955) definition of the superfamily when he proposed another definition that included only the Raphignathidae and his two newly described families, Camerobiidae and Neophyllobiidae, both from Australia. Meyer and Ryke (1960) studied the superfamily that included the families Caligonellidae, Stigmaeidae, Raphignathidae and Cryptognathidae associated with South African plants. Atyeo (1961) rejected the elevation of the genus Neophyllobius to family status, Neophyllobiidae, as proposed by Southcott (1957) by synonymizing Neophyllobiidae with Caligonellidae. He also suggested that Pomerantziidae Baker, 1949, may belong to a separate group as it possesses 3 pairs of genital discs and lacks pretarsal empodia. Summers (1966), recognizing that recognition of raphignathoid families and genera was difficult, constructed the first key to 7 families of the superfamily. In this

key, Pomerantziidae was excluded from the superfamily and Atyeo's (1961) synonymy of Neophyllobiidae with Caligonellidae was rejected. Wood (1969) proposed the family Homocaligidae, which contains the only known aquatic or semi-aquatic raphignathoid mites. Gerson (1972), in his description of Camerobia southcotti, synonymized Neophyllobiidae Southcott, 1957 with Camerobiidae Southcott, 1957, because the camerostome used by Southcott to separate the two families is non-existent. Robaux (1975) elevated the genus Barbutia to family status, Barbutiidae, with the discovery of a second species in the genus. Krantz (1978) included 9 raphignathoid families in his key and suggested that the Pomerantziidae be accommodated elsewhere in the suborder Prostigmata (Actinedida) although he retained it in the Raphignathoidea. Krantz accepted Gerson's (1972) synonymy of Neophyllobiidae with Camerobiidae by excluding the former in the key. The genus Pomerantzia (Pomerantziidae Baker, 1949), alluded to by Atyeo (1961) as belonging to another group, was found by Lindquist (1976) to be closely related to Stigmocheylus Berlese. Lindquist (1976) suggested that these genera belong to the Anystoidea rather than to any of the superfamilies of Heterostigmata. Gonzalez-Rodriguez (1978) elevated Xenocaligonellidae from DeLeon's (1959) subfamily Xenocaligonellidinae status based on the contiguous coxae, palptibia lacking claw, anal pore

terminal, body broadly oval to nearly circular, and the numerous long dorsal body setae.

Kethley (1982) defined the superfamily as now accepted by raphignathoid workers. It consists of 9 families: Barbutiidae, Caligonellidae, Camerobiidae, Cryptognathidae, Eupalopsellidae, Homocaligidae, Raphignathidae, Stigmaeidae and Xenocaligonellidae. Bolland and Ueckermann (1984) treated the raphignathoids from Cameroon, including chromosome numbers of some members of stigmaeid and eupalopsellid mites. The South African Raphignathoidea was reviewed by Meyer and Ueckermann (1989) listing 71 known species in 9 families. Sepasgosarian (1990), in his addendum to the world species of Raphignathoidea recorded 509 species in 49 genera and 9 families. As of this writing, a new genus of Stigmaeidae, Neilstigmaeus, Meyer and Gerson, from Australia is in press (Gerson, personal communication) raising the number of genera to 50.

MATERIALS AND METHODS

A number of mite collections was available for this study: the extensive collection F. Haramoto and L.H. Nakahara from Hawai'i on Metrosideros, part of the U.S. International Biological Program (IBP), collection of M. Lee Goff from remote areas in the islands of Hawai'i and Kaua'i and Shiela Conant's collection from Nihoa and Pearl Hermes Atoll. Other specimens studied were collections of staff and graduate students of the Department of Entomology, housed at the Acarology Laboratory, University of Hawaii at Manoa and by some staff of the Bishop Museum's Department of Entomology. In addition to collections from Kaua'i, Hawai'i, Nihoa and Pearl and Hermes Atoll, specimens from the islands of Maui, Moloka'i, O'ahu, Lana'i and Midway were all represented in the study material.

On Kaua'i, collections were conducted during wet and dry seasons. At the upper fringe of Hono O Na Pali Natural Area Reserve (1300 m), the collection sites have cool temperature with constant moisture on the forest floor. At Kuia Natural Area Reserve, mite habitats were collected at a transect with collecting sites at 890, 1000, and 1110 meter elevation along Nualolo Trail. Collections of S.F. Swift, F. Haramoto and L.H. Nakahara were concentrated on the native forest tree `Ohi`a (Metrosideros polymorpha, Myrtaceae) on the islands of Kaua'i and Hawai'i. Collecting

techniques from `Ohi`a by Haramoto and Nakahara were followed in this study.

Leaf litter, top soil, tree bark, leaves, flowers, moss on bark of trees, stones and forest floor, lichen, and bird's nests were obtained. Sample size of 2-4 cups of leaf litter and soil was the standard measure. Mites were extracted using Berlese-Tullgren funnels, then mounted on microscope slides using two mounting media: Hoyer's medium, prepared following Baker and Wharton's formula (1952) and Polyviol-17 (Polyvinyl alcohol without the extremely volatile chloral hydrate and phenol), widely used by aphid workers in Sweden (Danielson 1980). Specimens mounted in Polyviol-17 need thorough clearing in lactic acid of internal contents otherwise twisting of appendages occur 2-4 days after mounting and pilosity of dorsal setae become indistinguishable. Dirt adhering on the appendages do not detach from mites during mounting procedures, unlike in Hoyer's medium. Polyviol-17 seems to possess a most desirable optical property but further clearing and testing on different mite groups are warranted. Remounting was necessary for specimens mounted between 1960 and 1980, as Hoyer's medium had deteriorated.

Slide mounts were dried in 40-50^{o}C oven temperature for two weeks and were sealed with Glyptal®. A phase contrast microscope was used to study the specimens. Illustrations were made using a camera lucida attachment.

Microphotographs were taken of Favognathus species using photoautomat attachment on a Wild M20 phase contrast microscope. All measurements are in micrometers. Measurements of species are either of holotype and ranges of paratypes in parentheses, or holotype only, or ranges of specimens for previously described species as noted in each section. Only adult females and males were critically studied with the exception of a few species where the larval immatures showed distinctive morphological differences and these differences used to separate the otherwise closely related adults. Numbers appearing after major categories in text, i.e., Males. 10. or Specimens examined. 54. refer to the total number of specimens examined, the breakdown as to number and sex of specimens shown at the end of each locality and habitat, in parentheses.

Terminology follows that of Summers (1962), Wood (1981) and Swift (1987). Idiosomal and leg notations follow Grandjean (1944) and Kethley (1990). Illustrations are given of representative species of each family with applicable idiosomal and leg notations.

Type and non-type specimens examined during the study are listed below, with the name of the institutions where obtained: Bernice P. Bishop Museum, Honolulu: Eustigmaeus kauaiensis Swift, Gerson and Goff, 1987, female holotype, paratypes; Bohart Museum, University of California-Davis: Cryptognathus favus Summers and Chaudhri, 1965, female

paratype; Cryptognathus ochraceus Summers and Chaudhri, 1965, 2 female paratypes; Exothorhis caudata Summers, 1960, female holotype, paratype, nymphs; Saniosulus nudus Summers, 1960, 4 females; British Museum (Natural History), London: Stigmaeus perplexus Wood, 1971, female holotype; Stigmaeus seminudus Wood, 1971, female holotype; Department of Scientific and Industrial Research, Auckland: Summersiella coprosmae (Wood, 1867), female paratypes; Zoologisches Museum, Hamburg: Raphignathus gracilis (Rack, 1962), female holotype, male and female paratypes; Plant Protection Research Institute, Pretoria: Eustigmeus ornatus Ueckermann and Meyer, 1989, female holotype, male and female paratypes; U.S. National Museum, Washington: Agistemus congolensis Gonzalez-Rodriguez, 1965, female holotype, 2 female paratypes; Agistemus floridanus Gonzalez-Rodriguez, 1965, female holotype, male paratype; Agistemus terminalis (Quayle, 1912), female non-type; Storchia pacifica (Summers, 1964), female holotype; Coptocheles boharti Summers and Schlinger, 1955, female holotype; Coptocheles triscutatus Summers and Schlinger, 1955, female holotype; Favognathus ochraceus (Summers and Chaudhri, 1965), female holotype; Favognathus pictus Summers and Chaudhri, 1965, female holotype; Exothorhis armata Summers, 1960, female holotype; Eustigmaeus microsegnis (Chaudhri, 1965), female non-type; Eustigmaeus anauniensis (Canestrini, 1889), female non-type; Eustigmaeus segnis (Koch, 1836), female non-type;

Ledermuelleriopsis plumosus Willmann, 1951, female non-type; Molothrognathus leptostylus Summers and Schlinger, female holotype and paratype; Raphignathus gracilis (Rack, 1962), female non-type; Saniosulus nudus Summers, 1960, female holotype; Stigmaeus gracilimus Summers, 1962, female holotype; Neognathus spectabilis (Summers and Schlinger, 1955), female holotype and paratype.

Holotypes of new species will be deposited at the Bishop Museum, Honolulu; paratypes at the Bishop Museum, Acarology Laboratory at the University of Hawaii-Manoa, Honolulu, and the U.S. National Museum of Natural History, Washington, D.C.

ACCOUNTS OF THE TAXA

Superfamily Raphignathoidea Grandjean, 1944

Raphignathoidea Grandjean, 1944: 103; Cunliffe 1955: 213; Meyer and Ryke, 1960; 209; Summers, 1966: 226; Krantz, 1978: 254: Wainstein, 1978: 147; Kethley, 1982: 137; Meyer and Ueckermann, 1989: 1.

Diagnosis. Soft-bodied or well-sclerotized mites; variable number of dorsal shields either weakly sclerotized, reticulated or dimpled; well developed gnathosoma, sometimes retractile; chelicerae with styletiform, partially retractile movable digits arising from fused or separate cheliceral bases, not fused to rostrum; palpi 5-segmented, palpal-thumb-claw process present, sometimes poorly developed, obsolete or absent; tarsi with empodia commonly bearing tenent hairs; claws generally present on all legs (genus Pilonychiopus Meyer, Stigmaeidae, an exception).

Key to the Families of Raphignathoidea

(Based on Meyer and Ueckermann, 1989)

1. Gnathosoma enclosed by a dorsal sheath or hood formed from prodorsum; cheliceral bases free.....Cryptognathidae Oudemans, 1902
- Gnathosoma not enclosed within a dorsal sheath or hood; cheliceral bases fused into a stylophore..... 2

2. Palpi greatly elongate, longer than stylophore; stylophore narrow and elongate.....
.....Eupalopsellidae Willmann, 1952

- Palpi not elongate, or, if elongate, stylophore (if present) short or of medium length..... 3

3. Palpal-thumb claw process composed of claw on palptibia and ventrally placed palptarsus..... 4

- Palpi simple, tibial claw absent..... 8

4. Prodorsum with a narrow transverse groove leading leading internally to a pair of sacs (females) or tubes (males); body heavily sclerotized.....Homocaligidae Wood, 1969

- Body without prodorsal groove, internal sacs or tubes; body light to moderately sclerotized..... 5

5. Body elongate, virtually unsclerotized; cheliceral bases fused, free distally.....Barbutiidae Robaux, 1975

- Body mostly ovoid; a variety of shield arrangements dorsally, if shields absent peritremes extend into cheliceral bases; fixed cheliceral digits either free or coalesce into a stylophore..... 6

6. Cheliceral bases fused to form a stylophore; sinuous, chambered peritremes embedded in dorsal surface of stylcphore; dorsal shields absent or weakly developed.....Caligonellidae Grandjean, 1944

- Cheliceral bases independent or forming a stylophore; peritremes not embedded in dorsal surface of

chelicerae; dorsum completely or partially covered by shields..... 7

7. Cheliceral bases form stylophore with cervical peritremes running laterally from its base; confluent coxae.....Raphignathidae Kramer, 1877

- Cheliceral bases usually contiguous but not completely fused; peritremes absent; coxae II-III narrowly or widely separated..... .....Stigmaeidae Oudemans, 1931

8. Femur and tibia short; legs generally shorter than idiosoma; some dorsal body setae flagelliform..... .....Xenocaligonellidae De Leon, 1959

- Femur and tibia long, legs stilt-like; some or all legs longer than idiosoma; none of dorsal body setae flagelliform..... .....Camerobiidae Southcott, 1957

Family Caligonellidae Grandjean, 1944

Caligonellidae Grandjean, 1944: 105; Summers, 1966: 226; Wainstein, 1978: 168; Chaudhri et al., 1979: 139; Kuznetzov and Petrov, 1984: 95; Meyer and Ueckermann, 1989: 15.

Type genus: Caligonella Berlese, 1910.

Diagnosis. Cheliceral bases inflated, fused to form stylophore with sinuous peritremes which may be looped around base; palpi 5-jointed, with single, well-defined tibial claw; palptarsus equipped apically with 4 eupathidial setae; idiosoma finely striated, dorsal plates absent or poorly developed; eyes present or absent; 2-4 pairs cupules present; tarsi with 2 claws and empodium with 2 or more tenent hairs; anus terminal or subdorsal.

Remarks. Grandjean (1944) proposed the family Caligonellidae for the genus Caligonella, based on the distinctive respiratory character on or around the cheliceral stylophore of the gnathosoma. Baker and Wharton (1952) synonymized both the Stigmaeidae and Caligonellidae with Raphignathidae. Summers and Schlinger (1955) however retained the family Caligonellidae and this classification is accepted by present workers.

Species in this family are primarily free-living predators found in soil, bird's nests, underneath rocks and associated with plants infested with scale insects.

The family contains 30 species in 4 genera worldwide. In the Hawaiian Islands, the genera Coptocheles, Neognathus and Molothrognathus are represented. Aside from the Hawaiian Islands, the family is reported from Africa, Australia, New Zealand, North America, Central and South America.

Key to the Genera of Caligonellidae

1. Peritremes on laterobasal margins of stylophore.....2
_ Peritremes not as above.....3
2. Basal half of stylophore inflated; peritremes form ornate loops .....Coptocheles Summers & Schlinger, 1955
_ Stylophore elongate and conical; peritremes as simple loop in the form of W .....Neognathus Willmann, 1952
3. Peritremes emerging anteriorly on stylophore..... .....Caligonella Berlese, 1910
_ Peritremes emerging medially, posterior of cheliceral condyle.....Molothrognathus Summers & Schlinger, 1955

Genus Coptocheles Summers and Schlinger

Coptocheles Summers and Schlinger, 1955: 548; Robaux, 1975: 240.

Type species: Coptocheles triscutatus Summers and Schlinger, 1955.

Diagnosis. Stylophore compact, well-chitinized, basal half inflated; peritremes arising midsection of stylophore, form

ornate loops, diverge posteriorly, loop laterobasal as pair of lobules directed anteriorly; median propodosomal plate present or absent; prodorsum with pair of small ellipsoidal plates bearing the eyes; w III and IV absent.

Remarks. Summers and Schlinger (1955) proposed this genus for two species, Coptocheles triscutatus and C. boharti, collected from California and Florida respectively. Robaux (1975) described C. grandjeani from California and C. peltatus was described by Meyer and Ueckermann (1989) from South Africa. The additional three new species described below from the Hawaiian Islands give the genus a total of 7 species worldwide.

Habitats of Coptocheles species are primarily soil, leaf molds from various plants, plant litter and lichen on lava.

Coptocheles n. sp. A Figures 5, 6, 7, 80A

Holotype. Female. O'AHU I: Diamond Head, 2.V.1972, ex Kiawe litter, L. Nakahara.

Diagnosis. This species is closely similar to Coptocheles triscutatus Summers and Schlinger, 1955, in the configuration of the median and the pair of ellipsoidal plates on the propodosoma and faintly pilose dorsal setae. However, it differs from C. triscutatus by the distinctive character on the venter between coxae I and II, the distinctive extended ends of the peritremes on the

laterobasal part of the stylophore and femur has 4-4-3-3 leg setation compared to 5-5-4-4.

Description. Female. Natural color reddish; length (excluding gnathosoma) 560; width 413.

Gnathosoma (Figures 6D, 7F, 7G). Length (from cheliceral base to tip of palpus) 226; stylophore compact, pyriform, bases inflated; peritremes form ornate loops wrapped around cheliceral bases ending in pair of ear-like lobes, lobes stick out 25 microns off edge of stylophore, distance between lobe tips 141; segments of peritremes of unequal lengths. Number of setae from palpfemur to palptarsus 2-2-3-9; palpfemur inflated; palptarsus about as long as tibial claw, with 6 setae, rod-like solenidion and 2 eupathidial terminal setae. Setae m, n subequal; adoral setae 1 and 2 faintly pilose.

Dorsum (Figure 5A). Ovoid, widest in humeral region; striated throughout with dual striae, striae mix of fine and strong lines except for median propodosomal plate and a pair of small ellipsoidal shields bearing adjacent eyes and setae ve; eyes faintly discernible; propodosomal plate bears setae vi and sci; 11 pairs of faintly pilose dorsal setae Figure 5C) 21 to 34, h2 the longest, e2 and f2 absent; four pairs of cupules, ia, im, ip on the dorsum, ih ventrally on opisthosoma. Pseudoanal setae ps1-3 of subequal length (27), terminal.

Venter (Figure 5B). Striated throughout like dorsum except 2 adjacent plates between the coxal groups and a larger plate posterior of the pair at same level as coxae IV; 1a and 3a long, aciculate setae compared to 4a and 4c; 2 pairs genital setae adjacent to genital covers.

Legs (Figure 6A, 6B). Length (excluding coxae) of legs I-IV: 489, 428, 404, 513; number of setae on leg segments I-IV (special sensillae in parentheses): tarsi 21(w)-20(w)-12-12; tibiae 7(o,op)-6(op)-5(op)-5(op); genua 6(k)-5-4-4; femora 4-4-3-3; trochanters 1-1-2-1; coxae 2-2-2-1; oI, opI transversely located next to each other (Figure 7A), oI short; legs terminate with pair of claws, empodium between claws with undetermined capitate tenent hairs projecting beyond claws, wI 10.

Male (Figures 7A, 7B, 7C, 7D, 7E). Length (excluding gnathosoma) 423; width 318. Differs from female in the following respects: median propodosomal plate feebly discernible, striation pronounced; dorsal setae short (17-26); ps1 reduced, very short, thorn-like; g1 and g2 absent; tarsal chaetotaxy 17(w)-16(w)-10-10; length of legs I-IV: 366, 323, 309, 375.

Aedeagus (Figure 7E) slightly S shape, probably long, distal end not discernible, simple structure.

Specimens examined. 2. O'AHU I: Diamond Head, 2.V.1972., ex Kiawe litter, L. Nakahara (1 female, 1 male).

Remarks. The variation in the number of tarsal setae between female and male is unusual. Four laterals each on tarsi I and II and two laterals each on tarsi III and IV are the missing setae in male. In the absence of another male for comparison, this abnormality is considered a teratology. It is also possible that this is male of a closely related sympatric species. The arrangement of solenidia o and op on tibia I is similar to C. boharti Summers and Price, 1955. The podocephalic canal (cpc) which arises from the base of the hypostome appears to end on the supracoxal solenidion eI.

Coptocheles n. sp. B Figures 8, 9, 80

Holotype. Female. HAWAI'I I: Kalapana, 19.VII.1972, ex lichen on lava, L. Nakahara.

Diagnosis. Coptocheles n.sp. B can be distinguished from the two other species of Coptocheles from the Hawaiian Islands by the form of the dorsal setae and the absence of the propodosomal plate. Like the two other Hawaiian species, the pattern of the peritremes superficially resembles that of C. boharti Summers and Schlinger, 1955; however, the terminal ends of the peritremes loop around hugging the base instead of protruding ear-like.

Description. Female. Natural color reddish-brown; length (excluding gnathosoma) 536; width 323.

Gnathosoma (Figure 9C). Length (from cheliceral base to tip of palpus) 207; stylophore compact, pyriform, bases inflated; peritremes originate from middle of stylophore, form ornate loops towards posterior and wrap around, end smoothly on laterobasal part of stylophore, no ear-like lobes, segments of unequal lengths. Number of setae from palpfemur to palptarsus 2-2-3-9; palptarsus about as long as tibial claw, with 6 aciculate setae, 1 rod-like solenidion and 2 eupathidial terminal setae; pair of setae n absent; 2 pairs of adoral setae; stylets short, curved at base.

Dorsum (Figure 8A). Oval shape; striated throughout with continuous unbroken lines; median propodosomal plate absent, area around 2 pairs of eyes without plates; ve adjacent to anterior eye; 11 pairs of minutely barbed attenuate dorsal setae (Figure 8C) 31 to 50, h2 longest; complete 3 sets of cupules present, ia, im and ip, presence of cupule-like cuticular structure anterolaterad of c1; pseudanal setae ps1-3 33, 31, 26 respectively.

Venter (Figure 8B). Striated throughout including ovoid area between the two coxal groups; 1a and 3a strong, long (62, 71) respectively, ceratiform setae; ag1 present; ih not discernible, probably covered by cuticular fold; genital setae as in Coptocheles n. sp. A; anus terminal.

Legs (Figure 9A, 9B). Length (excluding coxae) of legs I-IV: 508, 447, 437, 546; number of setae on leg segments I-IV (special sensillae in parentheses): tarsi 22(w)-19(w)-12-

12; tibiae 7(o,op)-6(op)-5(op)-6(op); genua 6(k)-4-4-4; femora 5-5-4-4; trochanters 1-1-2-1; coxae 2-2-2-1; wI 22, wII 19; oI anterior of opI; legs terminate as in Coptocheles n. sp. A.

Male. Not known.

Specimens examined. 1. HAWAI'I I: Kalapana, 19.VII.1972, ex lichen on lava, L. Nakahara.

Remarks. C. boharti Summers and Schlinger, 1955 is the only other species in the genus lacking a propodosomal plate; however, C. n. sp. B may be distinguished from C. boharti by the arrangement of solenidia on tibia I, absence of setae n, and presence of agl on the ventral opisthosoma. As the two other Hawaiian species of Coptocheles, the pattern of the peritremes superficially resembles that of C. boharti, except the terminal ends of the peritremes loop laterally slightly anterior of base appended to the lateral surface. End of the left peritreme showed an opening.

Coptocheles n. sp. C. Figures 10, 11, 12, 80

Holotype. Female. NIHOA I.: 17.V.1987, ex Solanum nelsoni litter, S. Conant.

Diagnosis. Coptocheles n. sp. C is similar to C. triscutatus Summers and Schlinger, 1955, and C. grandjeani Robaux, 1975, in the presence of the median propodosomal plate, the subcapitular setae m, n, the claviform solenidion on genu, tibia and tarsus I and tarsus II and in the distal-

proximal arrangement of o and op solenidia on tibia I. It differs from C. triscutatus and C. grandjeani by the absence of agl on the opisthosomal venter.

Description. Female. Natural color reddish; length (excluding gnathosoma) 589(484-578); width 356(268-329).

Gnathosoma (Figures 11A-C). Length (from cheliceral base to tip of tarsal claw) 207 (198-214); stylophore compact, pyriform; peritremes occupy 2/3 of inflated base, ornate loops, unequal lengths of segments, terminal ends appended to base, earlike (Figure 11A); internal tracheal connection with peritremes discernible. Number of setae from palpfemur to palptarsus 2-2-3-9; palptarsus cylindrical, with capitate solenidion, 6 tactile setae and 2 eupathidial terminal setae; m, n arranged transversely, subequal (36); adoral setae 1 and 2 strong.

Dorsum (Figure 10A). Ovoid; striated throughout with dual striae except for median propodosomal plate and pair of small ellipsoidal plates anterolaterad of median plate bearing seta ve and 2 eyes each plate, punctate; anterior eye distinct, with refractive spheres, posterior pair less discernible; median propodosomal plate finely punctate, with fine longitudinal striations bearing setae vi, sci; 11 pairs nude, strong, blunt-tipped dorsal setae, on small platelets with single row punctation around setal base (Figure 10C) 21 to 32 (19-32), h2 longest, c1, d1, e1, f1 shortest; 3 pairs of cupules present; ps1-3 subequal (22).

Venter (Figure 10B). Striated except feebly discernible plate between coxal groups; plate finely punctate; 1a and 3a long, 57 (53-55) and 66 (62-64) respectively, ceratiform; 4a short, 19 (17-19); 2 pairs genital setae adjacent to genital covers.

Legs (Figures 12A, 12B). Length (excluding coxae) of legs I-IV: 489, 432, 418, 532; number of setae on leg segments I-IV (special sensillae in parentheses): tarsi 21(w)-19(w)-12-12; tibiae 7(o,op)-6(op)-5(op)-5(op); genua 6(o)-5-4-4; femora 5-5-4-4; trochanters 1-1-2-1; coxae 2-2-2-1; wI short (11); oI, opI arranged proximal-distal; solenidion oI short, configuration as ep, eI.

Male. Not known.

Nymph. Arrangement of propodosomal plates as in female adults; length 432, width 290; dorsal setae vi to f1 relatively short 9-13, h1 18, h2 20; ventrally, as in adult except absence of g1 and g2; length (excluding coxae) of legs I-IV: 290, 266,280, 299; number of setae on leg segments I-IV (special sensillae in parentheses): tarsi 17(w)-15(w)-10-8; tibiae 7(o,op)-6(op)-5(op)-5(op); genua 6(o)-5-4-3; femora 4-4-3-2; trochanters 1-1-2-0; coxae 2-1-2-0.

Larva. Arrangement of propodosomal plates as in female adult and nymph; length 223, width 147; length of leg segments I-III: 265, 234, 237; leg segments robust; m, n and ps1-3 absent; posterior dorsal setae f1, h1-2 strong, long.

Specimens examined. 5. NIHOA I: 17.V.1987, ex Chenopodium oahuense litter, S. Conant (2 females, 1 nymph, 1 larva); NIHOA I: 17.V.1987, ex Solanum nelsoni litter, S. Conant (1 female).

Remarks. The presence of the median propodosomal plate and the ventral plate in between the coxal groups separates this species from Coptocheles n. sp. B. It is distinguished from Coptocheles n. sp. A by the proximal-distal arrangement of oI, opI on tibia I (C. n. sp. A has transverse arrangement of tibial solenidia on leg I).

Genus Molothrognathus Summers and Schlinger

Molothrognathus Summers and Schlinger, 1955: 543; McGregor 1959: 112; Smiley and Moser, 1968: 309; Soliman,1971: 95; Meyer and Ueckermann, 1989: 23.

Type species: Molothrognathus leptostylus Summers and Schlinger, 1955.

Diagnosis. Delicate mites, propodosomal plate feebly discernible; stylophore conical, peritremes arising dorsally immediately behind the stylet condyle descending on latero-basal margins of stylophore; palptarsus generally as long as palptibial claw (except M. tumipalpus Meyer and Ueckermann, 1989), equipped with a claviform solenidion, 4 eupathidial setae distally.

Remarks. Molothrognathus leptostylus, M. fulgidus and M. crucis are the three species on which Summers and

Schlinger (1955) based their formation of the genus, all recorded from California. McGregor (1959) described M. washingtonia, also collected from California. Nine years later, Smiley and Moser (1968) described M. rosei. During the same year, Gerson (1968) recorded for the first time the presence of M. fulgidus in Israel. Molothrognathus minutus Soliman (1971) was described from Egypt. Meyer and Ueckermann (1989) described 6 new species and recorded M. minutus Soliman for the first time in Africa. The two new species treated have raised the number of Molothrognathus species to 15 worldwide.

Habitats of Molothrognathus vary from bark of Citrus, bird's nests, manure, fallen citrus fruits and debris, litter of mostly perennial trees, grass and roots, leaf molds, oak mulch and soil. Several species were collected in unquestionable association with other arthropods especially mites, e.g., M. leptostylus and M. fulgidus were collected from under bark of almond trees infested with Bryobia praetiosa (Koch). These species feed on eggs of Bryobia (Summers and Schlinger 1955).

Molothrognathus n. sp. A Figures 13, 14, 80

Holotype. Female. MAUI I: Haleakala National Park, w. slope, 2743 m, VIII.1985, ex pitfall trap substrate mostly cinder with scattered Styphelia bushes, R. Cole.

Diagnosis. Molothrognathus n. sp. A resembles M. terrulentus Meyer and Ueckermann, 1989, in the presence of spindle-shaped propodosomal shield, long c2, sce, f1, h1 and h2, and 4 terminal eupathidia on palptarsus with similar configuration. It differs however, in relatively longer c2 (82-107, 63-72 in M. terrulentus), sce (102-106, 78-85 in M. terrulentus), f1 (67-70, 32-38 in M. terrulentus). Tarsus II has 11 setae including an w, whereas M. terrulentus has only 10.

Description. Female (ranges of holotype and 8 female specimens in parentheses). Natural color unknown; length (excluding gnathosoma) 366 (352-356); width 214 (201-219).

Gnathosoma (Figure 14C). Length (from cheliceral base to tip of palpus) 140(138-145); stylophore tapered, deeply cleft anteriorly at midline; peritreme strong with 8-9 irregularly divided segments; numbers of setae from palpfemur to palptarsus 1-1-3-7; 4 terminal eupathidia forked; palptibial claw 24; 1 pair of subcapitular seta present (m); solenidion ep on palpcoxal base recessed; 1 pair of adoral setae present, other pair not discernible or reduced.

Dorsum (Figure 13A). Oval shape, widest in region of propodosoma; striated throughout with fine dual striae, striation pattern as in figure; 2 pairs of eyes; propodosomal plate spindle shaped, no dorsal setae on plate; 11 pairs of nude, aciculate to flagelliform setae (Figure

13C), relatively deeply set in c2 and dt of palpfemur; 3 pairs of integumental cupules, ia behind eyes, ip anterolateral of f1; ps3 absent. Setal measurements: vi 29(32-38); ve 32(31-36); sci 29(29-36); sce 106(107-117); c1 25(21-26); c2 82(102-107); d1 24(21-25); e1 32(32-35); f1 70(69-71); h1 68(67-74); h2 82(67-74); h3 14(14-15).

Venter (Figure 13B). Straight longitudinal striations in between intercoxal groups, becoming transverse posterior of 4a; 1 pair of genital setae posterior of genital plates; ih laterad of ag1; internal genital organ as in Figure 14D.

Legs (Figure 14A, 14B). Length (excluding coxae) of legs I-IV: 328, 232, 263, 313. Number of setae on leg segments I-IV (special sensillae in parentheses): tarsi 16(w)-11(w)-9-9; tibiae 7(o,op)-5-4-4; genua 6(o)-5-2-2; femora 2-2-2-2; trochanters 1-1-1-1; coxae 2-1-1-1; oI, opI shared same alveolus on tibia I, oI short, opI 3 times longer than oI, both baculiform; tibiae I-IV bear long, flagelliform dorsal setae; empodium as figured.

Male. Unknown.

Specimens examined. 14. MAUI I: Haleakala National Park, west slope, 2743 m, VIII.1985, ex pitfall trap, substrate mostly cinder with scattered Styphelia bushes, R. Cole (8 females); HAWAI'I I: Mauna Loa Trail, 2745 m, II.1973, ex Styphelia litter, J. Jacobi (5 females); HAWAI'I I: Hawaii Volcanoes National Park, Kipuka Ki Weather

Station, 1220 m, 20.I.1973, ex pitfall associated with soil, J. Jacobi (1 female).

Remarks. This species inhabits the high elevations of the two main Hawaiian Islands, associated with Styphelia litter. It appears likely this species is also found in the cool, moist areas of the islands of Kaua'i and O'ahu.

Molothrognathus n. sp. B Figures 15, 16, 81

Holotype. Female. NIHOA I: 17.V. 1987, ex Chenopodium oahuense litter. S. Conant.

Diagnosis. The short setae on the idiosoma are similar to Molothrognathus leptostylus Summers and Schlinger, 1955 and M. citrivallis Meyer and Ueckermann, 1989. Molothrognathus n. sp. B can be distinguished by the presence of a single baculiform solenidion on tibia I which M. leptostylus has 2 solenidia originating from the same alveolus. The species is distinguished from M. citrivallis by the absence of weakly sclerotized propodosomal shield located on the area between setae ve and cl, dorsal integument with dual striae and the lateral position of scapular setae sce.

Description. Female. Natural color unknown; length (excluding gnathosoma) 404; width 233.

Gnathosoma (Figure 16D). Length (from cheliceral base to tip of palpus) 121; stylophore tapered roundly, median cleft anteriorly indistinct; peritreme strong; number of

setae of from palpfemur to palptarsus 1-1-3-8; palptibial claw 17, subequal to palptarsus; palptarsus equipped with short baculiform solenidion, 4 forked eupathidia and 3 relatively short tactile setae; 2 pairs subcapitular setae, m short and delicately located anteriorly; supracoxal solenidion ep recessed.

Dorsum (Figure 15A). Ovoid, widest in region of the hysterosoma; striation throughout with coarse dual striae except in certain area, striation pattern as figured; 2 pairs of eyes; propodosomal plate absent, a finely striated spindle-shaped area on propodosoma can be mistaken as plate; 11 pairs nude, short, aciculate dorsal setae on platelets; 3 pairs integumental cupules, ia behind posterior eyes; pseudanal setae ps1 to ps3 present, subterminal. Setal measurements: vi, sce, e1 14-17; v2, sci, c2, f1, h1 10-12.

Venter (Figure 15B). Striation as figured; 5 pairs of ventral setae, 1a and 3a borne along edge of coxal plate; 2 pairs aggenital setae, ag1 anterolaterad of genital plate, ag2 laterad of g1; ih laterad in between ag1 and ag2; internal female genital organ equipped with multi-petalled flower-like structure more or less anterior of genital opening.

Legs (Figures 16A, 16B). Length (excluding coxae) of legs I-IV: 276, 209, 257, 295. Number of setae on leg segments I-IV (special sensillae in parentheses): tarsi 15(w)-10(w)-8-8; tibiae 6(O)-5-4-4; genua 6(o)-4-2-2; femora

2-2-2-2; trochanters 1-1-1-1; 1 short baculiform solenidion (o) on tibia I; 1 short claviform solenidion (o) distal of genu I; empodium as figured.

Male (Figures 16E, 16F). Smaller than female; length (excluding gnathosoma) 285; width (widest portion of propodosoma) 176; dorsal setae slightly longer than female; idiosomal and leg chaetotaxy and leg solenidiotaxy of male similar to female except dorsal placement of pseudanal ps1-3, presence of genital setae g1 and g2.

Specimens examined. 2. NIHOA I: 7.V.1987, ex Chenopodium oahuense litter, S. Conant (1 female); NIHOA I: 7.V. 1987, ex Solanum nelsoni litter, S. Conant (1 male).

Remarks. This species is readily distinguished from Molothrognathus n. sp. A by the absence of propodosomal shield and the short dorsal setae on platelets throughout the idiosoma.

Genus Neognathus Willmann

Neognathus Willmann, 1952: 162; Summers, 1957: 55; Gerson, 1968: 429; Soliman, 1971: 97; Chaudhri et al., 1979: 141; Meyer and Ueckermann, 1989: 17.

Type species: Neognathus insolitus Willmann, 1952.

Stigmagnathus Summers and Schlinger, 1955: 546

Type species: Stigmagnathus spectabilis Summers and Schlinger, 1955: 546.

Diagnosis. Delicate, relatively small; dorsal plates and eyes absent; stylophore elongate, conical, tapered anteriorly to a bifid point; peritremes confined to stylophore, W-shaped, outer arms ascending, terminate on small lobules projecting from side walls of inflated base of stylophore; two pairs subcapitular setae present.

Remarks. When Summers and Schlinger (1955) proposed the genus Stigmagnathus to accommodate S. spectabilis and S. terrestris from California, they were unaware of the genus Neognathus described by Willmann (1952) from German mites. Summers corrected the mistake after Willmann called Summers' attention to the existence of the genus (Summers 1957). At the present time, there are 11 described species in the genus: 2 from California, 2 from Africa, 1 from Europe, 3 from Egypt, 2 from Pakistan and 1 from Israel. Neognathus afrasiaticus, N. oblongus and N. orientalis all described by Soliman (1972) from Egypt were also reported in South Africa by Meyer and Ueckermann (1989). N. summersi Gerson, 1968 and N. spectabilis (Summers and Schlinger, 1955) are the species found in Israel. In the Baltic Region of Russia (Kuznetzov and Petrov 1984) and in the Hawaiian Islands, N. spectabilis is the only species reported (this study).

Species in the genus are mostly found on soil in Africa, on plant litter in California and Israel, on bird's nests and manure in Egypt, on dried leaves and on trees in

Pakistan and on tree bark and tree holes in the Hawaiian Islands.

Neognathus spectabilis (Summers and Schlinger)

Stigmagnathus spectabilis Summers and Schlinger, 1955: 546. Holotype and 3 paratype females, and allotype male on 1 slide, CALIFORNIA: Quincy, April 1, 1951, ex manzanita leaf mold (USNM No. 2193).

Stigmathus sp. Goff, 1987: 25.

Neognathus spectabilis (Summers and Schlinger, 1955). Summers, 1957: 55; Gerson, 1968: 429; Kuznetzov and Petrov, 1984: 97.

Diagnosis. Length of body (excluding gnathosoma, ranges of 10 females) 320-414; width 179-249; length of gnathosoma (cheliceral base to tip of palpus) 127-138; number of setae from palpfemur to palptarsus 1-2-3-9; length (excluding coxae) of legs I-IV: 233-237, 192-195, 182-185, 238-242. Number of setae on leg segments I-IV (special sensillae in parentheses): tarsi 16(op,w)-11(op,w)-9(w)-9(w); tibiae 7(o,op)-6(op)-6(op)-5(op); genua 6(k)-6(k)-3-3; femora 4-3-2-2; trochanters 1-1-2-1; coxae 2-1-1-1.

Stylophore and peritremes as in genus; terminal ends of peritremes just about same level of supracoxal solenidion ep on palpal coxa; idiosoma ovoid, simple striae; dorsal setae relatively short, unequal (13-29), 11 pairs; 3-4

integumental cupules present; venter with 6 pairs of setae excluding 2 pairs on genital plates (g1 and g2); anal plates usually subdorsal with 3 pairs of pseudoanal setae (ps1-3).

Male smaller (body length excluding gnathosoma 211, width 114) than female. Baculiform solenidion (w) on each leg tarsus enlarged; w male solenidion found in other male raphignathoids absent. Internal genital organ complex in structure.

Specimens examined. 26. HAWAI'I I: Hawaii Volcanoes National Park (HAVO), Mauna Loa Strip Road, Kipuka Ki, 1220 m, 6.VI.1984, ex Metrosideros bark, S.F. Swift and J. Diaz (8 females, 4 nymphs); HAWAI'I I: HAVO, Mauna Loa Strip Road, Kipuka Ki, 1220 m, 6.VI.1984, ex Koa bark, S.F. Swift (1 nymph); HAWAI'I I:, HAVO, Mauna Loa Strip Road, Kipuka Ki, 1220 m, 6.VI.1984, ex Koa tree hole, M.L. Goff (2 females, 3 nymphs); HAWAI'I I: HAVO, Mauna Loa Transect, 2133 m, IX.1972, ex Metrosideros bark, F. Haramoto and L. Nakahara (1 nymph); HAWAI'I I: HAVO, Mauna Loa Transect, 2012 m, 16-17.VII.1972, ex 'Ohi'a bark, F. Haramoto and L. Nakahara (1 female); HAWAI'I I: HAVO, Mauna Loa Transect, 1219 m, 23-24.III.1973, ex Metrosideros bark, F. Haramoto and L. Nakahara (1 female, 1 nymph); KAUA'I I: Kawaikoi Stream Trail, 1061 m, 27.V.1989, ex 'Ohi'a bark, S.F. Swift (1 female); KAUA'I I: Kuia Natural Area Reserve, Nualolo Trail, 27.XI.1990, ex Metrosideros bark, S.F. Swift (1 male).

Remarks. The Hawaiian specimens resembled Summers and Schlinger's (1955) description of Neognathus spectabilis in having 7-8 segments in the peritremes terminating into paired lateral lobules and in the idiosomal chaetotaxy. However, there are two differences between the two populations: the presence of famulus-like solenidion (k) on genu II and the presence of integumental cupule ia in one specimen from Hawaii. One of the paratypes examined showed a possible presence of solenidion k on genu II but because of the poor condition of the specimen, the presence of this character could not be ascertained. Integumental cupule ia is not discernible in the Hawaiian specimens, as in N. spectabilis, except in one specimen from Hawai'i I that has a complete set of 4 cupules. In spite of these differences, and because of unverifiable characters or unstable characters, the Hawaiian specimens are identified as Neognathus spectabilis, until more specimens from the islands are examined, the type materials remounted, or the genus Neognathus revised.

Family Camerobiidae Southcott, 1957

Camerobiidae Southcott, 1957: 311; Gerson, 1972: 502; Bolland, 1986: 192; Bolland, 1991: 59.

Type genus: Camerobia Southcott, 1957.

Neophyllobiidae Southcott, 1957: 311; Gerson, 1968: 432.

Type genus: Neophyllobius Berlese, 1886.

Diagnosis. Idiosoma oval or nearly round, dorsoventrally flattened; legs mostly longer than idiosoma, elongate femora and tibiae, genua short, stilt-like; gnathosoma small, sometimes covered by prodorsum; palpus small with 5 segments; palpal tibial claw sword-like; palptarsus with 1 or 2 setae, 1 or 2 eupathidia and a solenidion; peritremes with 1 to 4 loops or segments linked to form cells (as in Tycherobius); chelicerae fused; some cupules present or all absent.

Remarks. Southcott (1957) proposed the family Camerobiidae for his monotypic genus Camerobia. In the same paper he created the family Neophyllobiidae for the related genus Neophyllobius Berlese, 1886. He separated the two based on the presence of a camerostome-like structure in Camerobia.

Neophyllobius was formerly classified under Tetranychidae by Berlese (1886), Canestrini (1890), Geijskes (1939) and Womersley (1940). McGregor (1950) placed it in

Stigmaeidae; Baker and Wharton (1952) in Raphignathidae; Summers and Schlinger (1955), Meyer and Ryke (1959), Atyeo (1961), Meyer (1962), Wood (1964) and Chaudhri (1974) in the Caligonellidae. In 1961, Atyeo synonymized Neophyllobiidae with Caligonellidae Grandjean, 1944, based on the occurrence of sinuous gnathosomal peritremes in the stylosphore of both families, establishing close relationship. Gerson (1972) however, in his study of Camerobia southcotti Gerson, 1972, re-evaluated the characters of the families Camerobiidae and Neophyllobiidae as Southcott had presented them and concluded that there was insufficient ground to retain both families. Gerson (1972) rejected Atyeo's (1961) synonymy of Neophyllobiidae with Caligonellidae and instead synonymized Neophyllobiidae with Camerobiidae placing Neophyllobius in the latter family. This classification had been followed by Robaux (1975), Kuznetzov and Livshits (1979), Kethley (1982), Krantz (1978), Meyer and Ueckermann (1989) and Bolland (1983, 1986, 1991).

Camerobiidae has a worldwide distribution. They have been reported from Europe, Asia, Africa, North and South America, Australia, New Zealand, and the Hawaiian Islands (Goff 1987).

Bolland (1986) reported 98 species in 5 genera. The genus Neophyllobius is the largest genus with 86 species, Camerobia with 4, Decaphyllobius with 1, Tillandsobius with 1 and Tycherobius with 6.

Members of this family are presumably predaceous on other mites and crawlers of scale insects (McGregor 1950; Meyer 1962; Richards 1962; Gerson 1971, 1973; Zaher and Gomaa 1979).

Key to the Genera of Camerobiidae

(Based on females)

1. Solenidion w on tarsi I and II situated distally.....2
- Solenidion w on tarsi I and II situated proximally.....3
2. Dorsum with 9 pairs lateral setae, tibial setal formula 7(6)-6-6-6; trochanter I without setae.....Camerobia Southcott, 1957
- Dorsum with 10 pairs lateral setae; tibial setal formula 8-7-7-7; trochanter I with one seta.....Decaphyllobius Bolland, 1986
3. Two medio-ventral setae on tarsi I and II not placed in a longitudinal line; tibial setal formulae varies.....4
- Two medio-ventral setae, if present on tarsi I and II placed in a longitudinal line; tibial setal formula 9-8-8-7.....Neophyllobius Berlese, 1886
4. Tibial setal formula 8-7-6-6.....Tillandsobius Bolland, 1986
- Tibial setal formula 9-8-7-7.....Tycherobius Bolland, 1986

Genus Tycherobius Bolland

Tycherobius Bolland, 1986: 205

Type species: Neophyllobius lombardinii Summers and Schlinger, 1955.

Diagnosis. Dorsum with 9 pairs of lateral setae, 5 pairs middorsal setae: cl, dl, el, fl, hl [except Tycherobius rhytis (Chaudhri, 1974) with pdxl]; peritremes chambered with almost 2 complete loops; trochanters I-IV each with a seta; tibial setal formula 9-8-7-7, each with a solenidion (ϕ); w on tarsi I and II proximal, absent on tarsi III and IV. Palptibiae with 3 setae and a sword-like claw; palptarsi with 1 or 2 setae, 1 terminal eupathidium and a solenidion.

Remarks. Bolland (1986) created this genus based on the number of setae on the tibial segments, 9-8-7-7 or 10(ϕ)-9(ϕ)-8(ϕ)-8(ϕ) including the solenidion o located distally on the segment. Six species were placed in this genus from North America (California, Florida) (2), Europe (Poland, Italy) (2), Israel (1) and Pakistan (1). Tycherobius n. sp. A is the first record of the genus in the Hawaiian Islands and from Oceania.

Tycherobius n. sp. A Figures 17, 18, 19, 81

Holotype. Female. NIHOA I. 17.V.1987, ex Chenopodium oahuense litter, S. Conant.

Diagnosis. Tycherobius n. sp. A is similar to T. polonicus Bolland, 1986, in having 2 setae on the palptarsus; however it differs from T. polonicus in having sci (l3) shorter than ve (l1) and in configurations of peritreme and genital region.

Description. Female. Length (excluding gnathosoma) 310(280-390); width 280(241-315).

Gnathosoma. Gnathosoma small, length (from base of subcapitulum to tip of palpus) 64; width 52. Peritremes arise posterior of subcapitulum, with unequal segments, producing cells as segments meet in the chambered structure (Figure 17B). Two pairs adoral setae present, short; stylets short, almost indiscernible. Number of setae from palpfemur to palptarsus 2-1-4-4, palptibia with a sword-like claw, strong; palptarsus with a single eupathidium and one solenidion (Figure 17C). Venter of gnathosoma with one pair of setae (m).

Dorsum (Figure 17A). Almost round, lateral striations and vintage of plate separations with heavier lines; finer mostly transverse striations all over; 14 pairs of dorsal setae (Figure 17D), pdx (mcl) absent, cl, dl longest, subequal (130); two pairs eyes present. Dorsal setal measurements: vi 61(57-69), ve 40(36-45), sci 28(28-36), sce 26(25-33), cl 130(130-155), c2 64(50-64), dl 130(121-148, d2 31(26-43), el 64(55-79), e2 33(33-40), fl 64(57-76), f2 28(28-36), hl 26(26-38), h2 24(23-28).

Venter. Striated mostly longitudinally except towards posterior area; 1a, 3a, 4a present, on small platelets, strong, aciculate. Setae on coxa I and II as in Figure 17F. Aggenital pair of setae anterior of plate, genital pair of setae (g1) on anogenital plate; ps1-3 short (Figure 17E). A pair of cupules (ih) present, laterad of anogenital plate.

Legs. Length (excluding coxae) of legs I-IV: 508(440-518), 418(377-418), 447(404-447), 499(454-508); number of setae on leg segments I-IV (special sensillae in parentheses): tarsi 9(w)-9(w)-7-7; tibiae 10(ϕ)-9(ϕ)-8(ϕ)-8(ϕ) or 9-8-7-7 excluding sensillae of Bolland; genua 2(k)-2(k)-1-1; femur 4-3-3-2; trochanters 1-1-1-1; coxae 2-1-2-2. Solenidion k on genu I and genu II minute, distal of dorsal seta.

Male (Figure 18) Body length 310, width 202. Aside from smaller size, differs from female in relatively shorter dorsal setae: c1 100, d1 40; vi, c2 36-45; ve, sci, sce, d2, e1, e2, f1, h2 17-25; h1 12. Length of legs I-IV: 479, 385, 409, 470. Tibia I has two solenidia on distal end (ϕ, ϕp), long (ϕp) and short (ϕ), tibiae II-IV with one solenidion (ϕ) only. Tarsi I-IV with robust, curved male solenidion w, wI 43; anogenital plate with 4 pairs of short, simple setae; aedeagus long 112, width 8, simple elongate structure.

Protonymph (Figure 19). Fourteen pairs of dorsal setae pdx (mc1) absent; number of setae on leg segments I-IV: tarsi 8-7-7-5; tibia 5-5-5-3; genua 1-1-1-1; femur 3-2-1-1;

trochanters 1-1-1-1; coxae 2-1-2-0. Genual setae on II-IV whip-like; genua I and II with solenidion k; all tibiae with solenidion op on distal end; tarsi I and II with proximal solenidion w.

Larva (Figure 19). Fourteen pairs of dorsal setae; number of setae on leg segments I-III: tarsi 6-5-5; tibiae 3-3-3; genua 1-1-1; femur 2-2-1; trochanters 0-0-0; coxae 1-0-0. Tibiae I-III with distal solenidion op; tarsi I and II with proximal solenidion w; genua I and II with solenidion k. Palpfemur with one long posterior seta present, solenidion on palptarsus not observed.

Specimens examined. 31. NIHOA I.: 17.V.1987, ex Chenopodium oahuense litter, S. Conant (7 females, 1 male, 2 nymphs); NIHOA I.: 17.V.1987, ex Solanum nelsoni litter, S. Conant (1 female, 1 male, 1 larva); NIHOA I.: Miller Peak, 28.VI.1990, ex Eragrostis sp., J. Strazanac (1 male); O'AHU I.: North Halawa Valley, 19.IX.1990, ex ground litter, S.F. Swift (1 female, 1 nymph, 5 larvae); O'AHU I.: Honolulu, 13.IV.1972, ex Duff on ground, E. Okada (1 female); O'AHU I.: Manoa, 25 m, 11.XI.1983, ex Koa litter, A. Ogasawara (1 male, 1 nymph); O'AHU I.: Diamond Head, 18.X.1983, ex soil, S.F. Swift (1 male); HAWAI'I I.: Kalapana, 19.IV.1972, ex lichen on lava flow, L. Nakahara (1 male); MAUI I.: Haleakala Volcanoes National Park, Kalahaku Treatment and Control, Area #1, north of Kalahaku Overlook, 2806 m, pitfall trap, R. Cole.

Remarks. Bolland (1986) stated that stilt-legged mites are usually found singly, or in very small numbers. This observation is no longer valid as one habitat sample from Nihoa I., an uninhabited island in the Northwestern Hawaiian Islands group, yielded 73 specimens including approximately 50 of which were larvae and nymphs. This species was found on most of the islands with the exception of Kaua'i, and may be an island endemic.

This is first record of this genus in the Hawaiian Islands.

Genus Neophyllobius Berlese

Neophyllobius Berlese, 1886: 19; McGregor 1950: 55; Summers and Schlinger, 1955: 549; De Leon, 1958, 1958: 173; Meyer and Ryke, 1960: 210; Zaher and Gomaa, 1979: 123; Bolland, 1986: 59; Meyer and Ueckermann, 1989: 53.

Type species: Neophyllobius elegans Berlese, 1886.

Diagnosis. Idiosoma nearly round, small 210-400. Dorsum with 9 pairs of dorsolateral setae, 5-6 pairs of dorsocentral setae; two pairs of eyes present. Gnathosoma small, almost covered by anterior flap of prodorsum; peritremes arise on dorsum of gnathosoma, segmented, with one almost complete loop; bases of chelicerae fused; stylets short. Trochanters I-IV with one seta each; genual seta often whiplike, genu I and II with minute solenidion; tibial setal formula 9-8-8-7, each with a solenidion (ϕ) distal of

segment; w on tarsi I and II proximal, absent on tarsi III and IV. Two pairs of cupules present, one pair between d2 and e2, the other pair on venter laterad of anogenital opening.

Remarks. One or two median-ventral setae are found on tibiae I and II in Neophyllobius. When two setae are present, these setae are always placed in a longitudinal line. This character plus the 9-8-8-7 tibial setal formula separate Neophyllobius from the other genera in the family.

Bolland (1991) reviewed the genus Neophyllobius and found 86 species distributed world-wide, in Europe, Asia, North and South America, Africa, Australia and New Zealand. Three new species from the Hawaiian Islands and a new record for Neophyllobius consobrinus De Leon, 1958 are included in this study.

Neophyllobius n. sp. A Figures 20, 81

Holotype. Male. HAWAI'I I.: Hawaii Volcanoes National Park, Mauna Loa Transect, 2438 m., 17-18.XI.1972. ex Metrosideros leaves, F. Haramoto and L. Nakahara.

Diagnosis. This species is unique in that nearly the entire dorsal integument is covered with small (4) dark gray to black plump structures like mushroom caps never observed in other species in the genus.

Description. Male. Length (excluding gnathosoma) 343; width 244.

Gnathosoma. Length (from base of infracapitulum to tip of tibial seta) 100; width 96. Stylophore compact, round anteriorly, length 79, width 30; peritremes arise posterior of stylophore, single segmented strand loops laterad of cheliceral base, ends anterior of gnathosoma; two pairs adoral setae, short; stylets short (32). Number of setae from palpfemur to palptarsus 2-1-4-5; palptibia with a sword-like, strong seta (homologous to claw of others); palptarus with 1 solenidion, 2 eupathidia (Figure 20C). Venter of gnathosoma with one pair of aciculate setae (m), slightly setose.

Dorsum (Figure 20A). Round; striations on integument combination of transverse and longitudinal lines, dark gray to black plump structures like mushroom caps (Figure 20B) dispersed on nearly entire dorsum; 15 pairs of dorsal setae, pdx (mc1) present, all on strong tubercles (Figure 20E); two pairs eyes present. Dorsal setal measurements: vi, ve, sci 62-66; sce 59; pdx1 (mc1) 71; c1 84; c2 80; d1 74; d2 46; e1 54; e2 49; f1, f2 36-38; h1 11; h2 29. Podocephalic canal absent or not discernible.

Venter. Striated; 1a, 3a, 4a present, aciculate. Setae in coxae I and II as in Figure 20D. Anogenital plate with terminal 4 short, subequal setae (g1 and ps1-3); aedeagus simple, elongate, about 85 long, 11 wide. Cupule ih absent.

Legs. Length (excluding coxae) of legs I-IV: 535, 474, 493, 566; number of setae on leg sements I-IV (special sensillae in parentheses): tarsi 11(w)-11(w)-9(w)-9(w); tibiae 11(10)(ϕ,ϕp), 9(ϕ)-9(ϕ)-8(ϕ); genua 2(k)-2(k)-1-1; femora 4-3-3-2; trochanters 1-1-1-1; coxae 2(1)-1-2-2. Solenidion k on genu I and II minute, distal of dorsal seta; length of wI 26.

Female. Unknown.

Specimens examined. 1. HAWAI'I I.: Hawaii Volcanoes National Park, Mauna Loa Transect, 2438 m. 17-18.XI.1972, ex Metrosideros leaves, F. Haramoto and L. Nakahara (1 male).

Remarks. This description is based on only one male specimen since no females are available. This male has an atypical integumental structure that resembles a mushroom bed with young capped mushrooms sprouting up, not seen previously in any of the 86 described Neophyllobius species. Solenidion w in this male is less robust, less curved, baculiform, unlike the enlarged solenidia of other camerobiid males.

Neophyllobius n. sp. B Figures 21, 22, 82

Holotype. Female. HAWAI'I I.: South Kona, 10.V.1967, ex lichen on lava, F.H. Haramoto.

Diagnosis. The presence of two setae on coxae II separates Neophyllobius n. sp. B from the other Neophyllobius species. This character seems to be reliable

for this species as it is also present in the nymphal stage. This is the only species in the entire Camerobiidae that exhibits this character.

Description. Female. Length (excluding gnathosoma) 318; width 257.

Gnathosoma. Length (from cheliceral base to tip of palpus) 76, width 77; stylophore retracted under anterior of propodosoma, length approximately 76, width 60, peritremes not discernible. Number of setae from palpfemur to palptarsus: 2-1-4-5, palptibia with a sword-like seta, strong; palptarsus with 2 terminal eupathidia and a solenidion (Figure 21C). Infracapitulum with one pair of setae (m).

Dorsum (Figure 21A). Almost round, fine striations on integument except laterally with heavier lines; 15 pairs of dorsal setae, pdx (mc1) present, set on small tubercles; with 2 pairs eyes. Dorsal setal measurements: vi 59; ve, sci, sce 43; pdx1 45; c1, d1 47; c2 61; d2 45; e1 50, e2 45; f1 54; f2, h1 36; h2 33. Condition of dorsal setae as in Figure 21D.

Venter. Striated, mostly longitudinal. 1a, 3a, 4a present, aciculate; 2 setae on coxae II (Figure 21C); aggenital setae (ag1) anterior of anogenital plates; one pair genital setae (g1) on anogenital plates; ps1-3 short, terminal.

Legs. Length (excluding coxae) of legs I-IV: 488, 406, 432, 465; number of setae on leg segments I-IV (special sensillae in parentheses): tarsi 11(w)-11(w)-8-8; tibiae 10(ϕp)-9(ϕp)-9(ϕp)-8(ϕp); genua 2(k)-2(k)-1-1; femora 4-3-2-2; trochanters 1-1-1-1; coxae 3-2-2-2; length of dorsal setae on genua I-IV: 145, 154, 194, 206, setae whip-like.

Male. Unknown.

Protonymph (Figure 22). Fifteen dorsal setae, pdx1 (mc1) present; number of setae on leg segments I-IV: tarsi 9-9-7-5; tibiae 5-5-5-3; genua 1-1-1-1; femur 3-2-1-1; trochanters 1-1-1-0; coxae 3-2-2-0; genual setae I-IV whip-like.

Specimens examined. 2. HAWAI'I I.: South Kona, 10.V.1967, ex lichen on lava, F.H. Haramoto (1 female); O'AHU I.: Wahiawa, 10.IV.1968, on Norfolk Pine litter, R. Mau and F. Haramoto (1 protonymph).

Neophyllobius n. sp. C Figure 23, 82

Holotype. Female. HAWAI'I I.: Mauna Kea, 2438-2590 m, 10.XII.1974, ex Mamane forest litter, J. Jacobi (BBM-Berlese 01612).

Diagnosis. This species is closely related to Neophyllobius panici Bolland, 1986, from South Africa in the presence of 1 seta midventral on tarsus IV and e1 being the longest seta in the dorsocentral setal series; however, it differs from N. panici in its much longer dorsal setae,

for example pdx (mc1) in N. panici is 10 microns, N. n. sp. C has 57.

Description. Female. Length (excluding gnathosoma) 342; width 290.

Gnathosoma. Length 95, width 100; stylophore length 64, width 67, striated; peritremes arise from posterior of stylophore, loop laterad and end anterior of gnathosoma, segmented; two pairs adoral setae present, short; number of setae from palpfemur to palptarsus: 2-1-4-5; palptibia with a sword-like seta (homologous to claw of others), strong; palptarsus with 2 terminal eupathidia, 1 solenidion (Figure 23B); infracapitulum with one pair of setae (m).

Dorsum (Figure 23A). Almost round, fine striations on integument of varying directions and patterns, lateral striations coarse; 15 pairs of dorsal setae, pdx (mc1) present, set on tubercles; 2 pairs eyes. Dorsal setal measurements: vi 71; ve 61; sci 52; sc2, d2 59; pdx1 57, c1 54, c2 73, d1 81; e1 83; e2 62; f1 66; f2 36; h1, h2 31. Condition of dorsal setae as in Figure 23C .

Venter. Longitudinal striations; 1a, 3a, 4a, present, aciculate; setae on coxae I and II as in Figure 23D; one pair aggenital setae anterior of anogenital plate; genital setae (g1) on anogenital plates; ps1-3 short.

Legs. Length (excluding coxae) of legs I-IV: 516, 471, 514, 556; number of setae on leg segments I-IV (special sensillae in parentheses): tarsi 11(w)-9(w)-8-7; tibiae

10(ϕp)-9(ϕp)-9(ϕp)-8(ϕp); genua 2(k)-2(k)-1-1; femora 4-3-2-2; trochanters 1-1-1-1; coxae 3-1-2-2; length of d (dorsals) on genua I-IV: 48, 55, 88, 133, setae elongated version of idiosomal setae.

Male. Unknown.

Specimens examined. 1. HAWAI'I I.: Mauna Kea, 2438-2590 m, 10.XII.1974, ex Mamane forest litter, J. Jacobi (BBM-Berlese 01612).

Remarks. This species seems to be a montane, high elevation inhabitant of Mauna Kea. Compared to Neophyllobius consobrinus and Neophyllobius n.sp. B which inhabit warm, dry habitats, this species and Neophyllobius n.sp. A are two montane species from the islands.

Neophyllobius consobrinus De Leon Figures 24, 82

Neophyllobius consobrinus De Leon, 1958: 177.

Holotype female, MEXICO: Tuxtla Gutierrez, Chiapas, January 18, 1957, D. De Leon, from Jaquinia pungens; Bolland, 1991: 207.

Diagnosis. Female. Ovate, almost round; integument striated; length (excluding gnathosoma) 278, width 233; length of gnathosoma (cheliceral base to tip of palpus) 81; stylophore retracted under anterior propodosoma, length 57, width 57; number of setae from palpfemur to palptarsus: 2-1-4-5; palptibia with sword-like claw; palptarus with 2 terminal eupathidia, 1 solenidion; 15 pairs of dorsal setae, pdx (mcl) present; dorsal setal measurements: vi 59; ve,

sci, sce, e2, pdx 47; c1, d1 50; c2 66; d2 44; e1 56; f1 57; f2 41; h1, h2 30; condition of dorsal setae as in Figure 24C. Length (excluding coxae) of legs I-IV: 518,428, 456, 523. Number of setae on leg segments I-IV (special sensillae in parentheses): 11(w)-11(w)-8-8; tibiae 10-11(o,op)-9(op)-9(op)-8(op); genua 2(k)-2(k)-1-1; femora 4-3-2-2; trochanters 1-1-1-1; coxae 3-1-2-2; length of dorsal setae on genua I-IV: 163, 167, 194, 212.

Adoral setae (ad1-2) short; one pair setae on infracapitulum (m) present, aciculate; 1a, 3a, 4a present, long, aciculate; aggenital setae (ag1) anterior of anogenital plates, one pair genital setae (g1) on anogenital plates; cupules ih laterad of anogenital plates; ps1-3 short, terminal.

Specimen examined. 1. O'AHU I.: Wahiawa, Schofield Barracks, 10.IV.1968, ex Norfolk pine litter, R. Mau and F. Haramoto (1 female).

Remarks. This species is closely related to N. inequalis De leon, 1958, in the dorsal chaetotaxy with negligible differences in lengths of setae, but can be distinguished from the latter by the distinct longer dorsals on genua I-IV, longer, fine, aciculate 1a on coxa I and the position of first three proximal setae on tibia III. This close similarity of the two species is being questioned by Bolland (1986) surmising that possibly N. inequalis is a deutonymph of N. consobrinus. Unfortunately, the holotypes

of N. consobrinus and N. inequalis were not examined in this study, although Bolland had examined both types and also this Hawaiian specimen.

Males of camerobiids have 2 solenidia (ϕ, ϕp) on tibia I; females have only one solenidion (ϕ). This particular female has 2 solenidia on tibia I of one leg and one solenidion on the other, which is unusual.

Family Cryptognathidae Oudemans, 1902

Cryptognathidae Oudemans, 1902: 59; Thor, 1931: 78; Womersley, 1935: 151; Meyer and Ryke, 1959: 209; Schweizer and Bader, 1963: 246; Kuznetzov and Livshitz, 1974: 1721; Wainstein, 1978: 150; Chaudhri et al., 1979: 1167; Kethley, 1982: 137; Kuznetzov and Petrov, 1984: 91; Luxton, 1987: 113; Meyer and Ueckermann, 1989: 2.

Type genus: Cryptognathus Kramer, 1879.

Diagnosis: Idiosoma covered with ornamented exoskeleton separated from the ventral plate by distinct ornamented narrow pleural integument; anterior dorsal plate with dimpled hood (buccal shield of Robaux, 1975); prosternal apron situated ventrally between coxae I and at base of hood either wedge-shaped and dimpled or crescentric and smooth; gnathosoma protrusible into extremely long delicate, tubular stalk; when gnathosoma retracted, the chelicerae and rostrum enclosed and protected by hood; peritremes located on lateral margins of chelicerae originating from inverted y-shaped joined base; palptarsus with 3-4 eupathidia distally, 4 acicular setae and a solenidion; palptibial claw absent; 2 pairs of supracoxal setae, one on palpal coxa and the other between hood base and dorsal base of coxa I; venter with 6 pairs of setae; 2 or 3 pairs of aggenital setae; genital setae present; anal opening terminal in female, posterodosal in male; coxal

fields incorporated into ventral plate; legs terminate with 2 claws and a rayed empodium.

Remarks: The genus Cryptognathus was erected in 1879 by Kramer, with C. lagena Kramer as the type species. In 1893, Oudemans placed the genus in the family Raphignathidae. The distinctive gnathosomal and integument structures of Cryptognathus prompted Oudemans (1902) to remove the genus from Raphignathidae and made Cryptognathus the type genus of the new family Cryptognathidae. Fourteen years later, Berlese (1916) described the second species, Cryptognathus cucurbitae, and the subspecies C. cucurbitae var. subnitida.

Summers and Chaudhri (1965) recognized 2 morphologically distinct species-groups, imbricatus and favus, among the 11 species of Cryptognathus. Luxton (1973) established 2 new subgenera based on what appeared to be constant characters, Favognathus for the favus group and Cryptognathus for the imbricatus group. Luxton (1987) elevated the 2 subgenera, Cryptognathus and Favognathus, to generic status.

Sixteen species are currently recognized in the genus Cryptognathus including C. summersi and C. incertus, both species Robaux (1975) described, and 18 in the genus Favognathus including F. texasensis and F. dakotaensis of McDaniel and Bolen (1979) and the 3 new species from the Hawaiian Islands.

Members of this family have been reported from North America (California and Texas), Europe, Australia, New Zealand, Crimea, Galapagos Islands, Africa and the Hawaiian Islands. Cryptognathus lagena Kramer, 1879, is a widespread species not only in Great Britain but worldwide (Luxton 1987). This family appears to be cosmopolitan in distribution.

The cryptognathids have been suggested to be predatory (Baker and Wharton 1952, Meyer and Ryke 1959) but their small size and very delicate extrudable mouthparts with edentate chelicerae are not typical of adaptations or modifications for predation. Luxton (1973) suggested that they may be selective feeders on fungal spores or with their needle-like chelicerae pierce plant cells and drain its contents.

Key to the Genera of Cryptognathidae

1. Prosternal apron a cresentic, transparent flange on front margin of ventral plate; 3 pairs aggenital setae.....Cryptognathus Kramer, 1879
- Prosternal apron wedge-shaped, dimpled; 2 pairs aggenital setae.....Favognathus Luxton, 1973

Genus Favognathus Luxton

Cryptognathus (Favognathus) Luxton, 1973: 57.

Favognathus Luxton, 1987: 113; Meyer and Ueckermann, 1989:2.

Type species: Cryptognathus cucurbita Berlese, 1916

Diagnosis: Wedge-shape prosternal apron (on ventral base of gnathosoma) with dimples and presence of 2 aggenital setae.

Remarks: Thirteen species were recognized by Luxton (1987) in the genus. McDaniel and Bolen (1977) described two new species from North America, Cryptognathus texasensis and Cryptognathus dakotaensis, which Luxton missed in his 1987 paper. These two species belong to the genus Favognathus. Meyer and Ueckermann (1989) described two new species from Africa, F. pongolensis and F. latibarrus raising the number of species to 15. Three new species from the Hawaiian Islands are described here, raising the number to 18 species worldwide. Favognathus pictus (Summers and Chaudhri, 1965), a species originally described from Galapagos Is., is reported for the first time in the Hawaiian Islands.

Favognathus n. sp. A Figures 25, 26, 31, 82

Holotype. Female. O'AHU I: Mt. Kaala, 500 m., 10.x.1989, ex Casuarina litter, S.F. Swift.

Diagnosis. This species closely resembles Favognathus cucurbita (Berlese, 1916); however, it can be separated from the latter by the following characters: punctations both on dorsal and ventral areas are evenly distributed, punctations also found on the pleural integument separating structure of

the dorsal and ventral plates and the anal plates; dorsal setae 19-36 long; ventral plate less reticulated laterally; and leg segments porose.

Description. Female. Color in life, red; length (tip of hood to caudal end) 287(273-296); width 201(187-222).

Gnathosoma (Figures 26E). Palpi and chelicerae extrudable from underneath hood, 1/3 of chelicerae underneath hood in most specimens; palpi 83 long (from palpal trochanter to tip of tarsus); chelicerae 83 long; peritremes originate from midbase section of chelicerae, loops around the basal rim, lying on lateral walls of each chelicera, ending on one or two small rounded knobs. One pair of supracoxal setae (eI) on lateral walls of elongated palpcoxal base; number of setae from palpfemur to palptarsus: 3-2-3-9; palptarsus with 4 terminal eupathidia, 4 tactile setae and a solenidion.

Dorsum (Figures 25A, 31A). With 11 pairs of medium length, aciculate, simple dorsal setae; 1 pair of eyes, 1 pair postocular bodies; 3 pairs of cupules (slit-like), ia, im, ip; anterior margin of hood smooth; 6-8 dimples in each longitudinal row; dorsolateral extensively reticulated with evenly distributed punctations and fine, broken striae both medially and on reticular cells; dorsocentral punctations relatively larger; dorsal setae 19-36 long, sometimes curved.

Venter (Figures 25B, 31B). Prosternal apron with 15(14-16) dimples; venter with lateral reticulations (Figure 31B); fine striae and evenly distributed punctations except the sternocoxal area; venter with 6 pairs of short setae; 2 pairs genital setae (g1, g2) set adjacent to genital plates; 1 pair aggenital setae (ag1) anterior of genital plates; anal opening terminal, with 3 pseudanal setae (ps1-3).

Legs (Figures 26A, 26B, 26c, 26D). Length (excluding coxae) of legs I-IV: 188(169-203), 149(140-163), 154(143-166), 186(162-187). Number of setae on leg segments I-IV (special sensillae in parentheses): tarsi 16(op,w)-12(op,w)-9(w)-10(w); tibiae 7(o,op)-6(o,op)-5(op)-3(op); genua 6(k)-5(k)-2-3; femora 4-3-2-2; trochanters 1-1-2-0; coxae 2-1-2-1; genua I and II with solenidion o; tarsi I and II with solenidia op and w; addorsals tc on tarsus II dissimilar: tc' eupathidial, tc'' aciculate; coxae III have long, strong seta on tubercle (3b) in between coxae II and III; dorsal surface of trochanters I and II and femur I with large punctations.

Male. Unknown.

Specimens examined. 20. O'AHU I: Mt. Kaala, 500 m, 10.X.1989, ex Casuarina litter, S.F. Swift (1 female); O'AHU I: Mt. Kaala, 500 m, 10.X.1989, ex Eucalyptus bark, S.F. Swift (2 female); O'AHU I: Mt. Kaala, 500 m, 10.X.1989, ex Koa and grass litter, S.F. Swift (2 females); O'AHU I: Mt. Kaala, 10.X.1989, ex Koa litter, 10.x.1989,

S.F. Swift (5 females); O'AHU I: Honolulu, Univ. of Hawaii Campus, 24.X.1961, ex Panicum litter, F.H. Haramoto (8 females); MOLOKA'I I: Kamakou Preserve, Pu'u Kolekole, 1204 m, 15.VII.1985, ex grass roots and litter along stream, S.F. Swift (2 females).

Remarks. Clusters of one to three cells with numerous punctations usually associated with dorsal setae in the integument are found in 11 of the 20 examined specimens, adjacent to setae dl. Some specimens have one dl seta with adjacent clusters, the other has none. One specimen from O'ahu has one cluster associated with cl. Since this character is unstable for this species, it is not considered of taxonomic significance.

The basis capituli, which is unusually long, is not always extruded among the specimens examined. From the base of hood to the base of chelicerae, the delicate tubular stalk with circumferential striae can be very long (152 microns in 1 specimen). The entire protrusible gnathosoma in 3 specimens ranges in length from 246 to 291 microns, almost as long as the entire dorsum.

Variation occurs on the presence of large punctations on trochanters I and II and femur I. The mite population on Panicum on O'ahu lacks these large punctations while the population from Mt. Kaala, collected from different substrates of plants, has large punctations. Then these

variations were also seen on 2 specimens from Moloka'i, one with punctated legs, the other not.

The illustrated holotype is the only specimen in the series with ag2 not visible, probably covered by the folded pleural integument.

Favognathus n. sp. B Figures 27, 28, 32, 83

Holotype. Female. O'AHU I: Mt. Kaala, 500 m, 10.X.1989, ex soil and grass roots along road, S.F. Swift.

Diagnosis. Favognathus n. sp. B closely resembles F. ochraceus in the presence of denticles on the anterior edge of hood, but differs from it by the reticulated dorsal and ventral idiosoma and the uninterrupted non-porous sternocoxal area on the venter.

Description. Female. Color in life, red; length (tip of hood to caudal end) 313; width 223.

Gnathosoma. Length of palpi 96, chelicerae 110. Number of setae from palpfemur to palptarsus: 3-2-3-9; palptarsus small with 4 terminal eupathidia, 4 tactile setae and a solenidion; solenidion long, almost reaching base of terminal eupathidia (Figure 28H).

Dorsum (Figures 27A, 32A). Hood denticled on the frontal edge, 6-7 dimples in each longitudinal row (Figure 27E); laterals of dorsum extensively reticulated, with punctations and very fine striations (Figure 27C); 11 pairs of dorsal setae, 17-35 long, curved.

Venter (Figures 27B, 32B). Prosternal apron with 15(13-17) dimples; reticulated laterally, cells with punctations and fine striations; sternocoxal area with uninterrupted punctations and fine striations; 1a, 3a, 4a, 4c, ag1 and ag2 present, short and delicate; g1 and g2 set adjacent to genital plates; anal opening terminal with 3 pseudanal setae (ps1-3).

Legs (Figures 28A, 28B). Length (excluding coxae) of legs I-IV: 246(225-246), 192(180-192), 178(155-178), 213(183-213). Number of setae on leg segments I-IV (special sensillae in parentheses): tarsi 16(op,w)-13(op,w)-10(w)-10(w); tibiae 7(o,op)-6(op)-5(op)-3(op); genua 6(k)-6(k)-2-3; femora 4-3-2-2; trochanters 1-1-2-1; coxae 2-1-2-1; trochanters without large punctations dorsally; genua I and II with small clavate solenidion (k); wI 18 long; empodium as in Figure 28C.

Male (Figures 28D, 28E, 28F, 28G). Body length (including hood) 261, width 163; aside from smaller than female, has relatively shorter dorsal setae; length of legs (excluding coxae) I-IV: 197, 159, 155, 183. Tarsi I and II have 2 solenidia (op,w); solenidion w on tarsi I-IV 23-26 long, all reaching beyond tc setae; anal opening posterodorsal with ps1-3 on anal plates; setae f1, h1, h2 lie close together in a cluster slightly anterior of anal plates; genital opening on ventral plate absent; aedeagus simple, elongated structure (Figure 28I).

Specimens examined. 15. O'AHU I: Mt. Kaala, 500 m, 10.X.1989, ex soil and grass roots along road, S.F. Swift (2 females, 2 males); HAWAI'I I: Hawaii Volcanoes National Park, Mauna Loa Transect, 1676 m, 21.VII.1972, ex soil under Metrosideros, F. Haramoto and L. Nakahara (1 female, 1 male); MIDWAY I: 19.V.1965, ex nest of Diomedea nigripes (6 females, 3 males).

Other specimens examined. Holotype female, Cryptognathus ochraceus Summers and Chaudhri, 1965, GALAPAGOS ISLANDS: Santa Cruz I, Old Bella Vista Trail, 20 m alt., 2.XII.1964, ex rotting leaves Tourneyia, R.O. Schuster (USNM) and 2 paratype females of the same collection data (Bohart Museum, University of California, Davis).

Remarks. Examination of the type and paratypes of Cryptognathus ochraceus Summers and Chaudhri, 1965 showed the apparent lack of reticulations or as Summers and Chaudhri described "dorsal and ventral plates essentially non-reticulate" (Figure 27D) as the main difference between this new species and C. ochraceus. One paratype housed at Bohart Museum showed faint reticulations on the lateral edge, and if these lines are indeed reticulations, they seem to be around each punctation.

Males and females are essentially alike in form and can only be distinguished by differences in the organization of the genitalia as described for this species. Unlike other males of families in the raphignathoids, which possess a

large additional w male solenidion on one, two, or all of the tarsi, males of cryptognathids do not possess additional tarsal solenidion. However, the solenidion w differs between sexes; the males have larger and longer w than that of females.

The Midway specimens misidentified as Cryptognathus favus Summers and Chaudhri, 1965, (Garrett and Haramoto 1967, Goff 1987) are Favognathus n. sp. B. C. favus is separated from F. n. sp. B by the identical addorsals tc on tarsus II, striation on the dorsal plate, and porous ventral podosoma. It is interesting the Midway specimens were collected from nest of Black-footed Albatross, Diomedea nigripes.

Favognathus n. sp. C Figures 29, 30, 33, 83

Holotype. Female. KAUA'I I: Kuia Natural Area Reserve, Nualolo Trail, 1000 m, 27.XI.1990, ex Metrosideros bark, S.F. Swift and P. Cairy.

Diagnosis. The presence of 3 pairs of non-porous, non-reticulated circular areas on dorsum with 2-5 dark apodemal marks separates this species from the rest in the genus.

Description. Female. Color in life, red; Length (from tip of hood to caudal end) 304(300-314); width 193(185-195).

Gnathosoma (Figures 30C-E). Length of palpi 87, chelicerae 108(105-108). Number of setae from palpfemur to

palptarsus: 3-2-3-9; palptarsus with 4 terminal eupathidia, 4 tactile setae and a solenidion; solenidion short.

Dorsum (Figures 29A, 33A). Anterior edge of hood smooth (Figure 30F), 5-6 dimples on each longitudinal row; dorsum extensively reticulated, each cell with 4-8 large punctations, at the dorsocentral area, reticulum less distinct with large punctations more or less evenly distributed; with three pairs of anomalous non-porous, non-striated circular patch on dorsum (Figure 30G, 33A, arrows) with apodemal dark markings at center; cluster of cells with numerous small punctations associated with setae c1; 11 pairs of dorsal setae; setae fairly long 15-36, ve shortest, the rest longer, mostly curved.

Venter (Figures 29B, 33B). Prosternal apron with 19(18-20) dimples; reticulated, but reticulation not as distinct as dorsum; punctations large, evenly distributed; 5 pairs of ventral setae; setae 3b strong, longest of all ventral setae; ag2 absent; g1 and g2 adjacent to genital plates; anal opening terminal with pseudanal ps1-3; cupules ih anterolaterad of ps3.

Legs (Figuress 30A, 30B). Length (excluding coxae) of legs I-IV: 236(214-236), 177(169-190), 168(167-185), 195(182-195). Number of setae on leg segments I-IV (special sensillae in parentheses): tarsi 17(op,w)-14(op,w)-10(w)-10(w); tibiae 7(o,op)-6(op)-5(op)-3(op); genua 6(k)-5(k)-2-3; trochanters 1-1-1-1; coxae 2-1-2-1; trochanters with

large punctations; leg segments with sculpturing that resemble reticulations; genua I and II with small clavate sensillum (k); wI 15 long.

Specimens examined: 7. KAUA'I I: Kuia Natural Area Reserve, Nualolo Trail, 1000 m, 27.XI.1990, ex Metrosideros bark, S.F. Swift and P. Cairy (7 females).

Remarks. The idiosoma compared to the idiosoma of the 3 other species from the Hawaiian Islands is strongly sclerotized. Fungal hyphae are found associated with some specimens which raise the possibility that this species feeds on fungal spores as Luxton suspected (1973).

Favognathus pictus Summers and Chaudhri Figures 34, 83

Favognathus pictus Summers and Chaudhri, 1965: 319

Holotype female, Horneman Farm, Santa Cruz Island, GALAPAGOS ISLANDS, February 15, 1964, R.O. Schuster, from moss and lichen on coffee (USNM).

Diagnosis. Female (ranges of 10 specimens). Length (including hood) 246-280, width 142-188. Length of palpi 71-82; chelicerae 79-86. Number of setae from palpfemur to palptarsus: 3-2-3-9; palptarsus with 4 terminal eupathidia, 4 tactile setae and a solenidion; hood with 7-8 dimples in each longitudinal row, smooth edge; dorsum reticulated, each cell of reticulated area with 3-5 relatively large punctations (Figure 34A); 11 pairs of dorsal setae, vi absent, 17-35 long; one cell or clusters of 2-3

multipunctate cells adjacent to c1 and d1 or just d1 absent or present; prosternal apron with 10-13 dimples; venter not similarly ornamented as dorsum, reticulations only on lateral opisthosoma (Figure 34B), with punctations, fine striations; sternocoxal area non-porous, finely striated longitudinally; with 6 pairs of ventral setae; genital setae g1 and g2 set alongside genital plates; anal opening terminal with 3 pseudanal setae (ps1-3); length (excluding coxae) of legs I-IV: 180-188, 142-152, 142-152; 170-175; number of setae on leg segments I-IV (special sensillae in parentheses): tarsi 16(op,w)-14(op,w)-12(w)-8(w); tibiae 7(o,op)-6(op)-5(op)-3(op); genua 6(7)(k)-6(k)-2-3; femora 4-3-2-2; trochanters 1(0)-1-2-1; coxae 2-1-2-1.

Specimens examined. 24. O'AHU I: Mt. Kaala, 500 m, 10.X.1989, ex Eucalyptus bark, S.F. Swift (1 female); O'AHU I: Mt. Kaala, 500 m, 10.X.1989, ex Casuarina litter, S.F. Swift (6 females, 1 nymph); O'AHU I: North Halawa Valley, 19.IX.1990, ex Christmas Berry tree bark, S.F. Swift (1 female); O'AHU I: North Halawa Valley, ex litter and soil among introduced plants, 19.IX.1990, S.F. Swift (1 female); O'AHU I: Waimanalo Beach, sea level, ex Casuarina bark, 27.IX.1992, S.F. Swift (2 females); O'AHU I: Waimanalo, 29.I.1970, ex Araucaria leaf litter, E.S. Raros (1 female); MOLOKA'I I:, Kaunakakai, 200 m, 16.VII.1989, ex dry Kiawe bark, 16.VII. 1989, S.F. Swift (1 female); KAUA'I I: Kalalau Trail, 0-150 m, 20.XI.1990, ex dry Pandanus leaves

(8 females), S.F. Swift (8 females); KAUA'I I: Kuia Natural Area Reserve, Nualolo Trail, 1000 m, 27.XI.1990, ex moss on Metrosideros bark, S.F. Swift (1 female); KAUA'I I: Hono O Na Pali Natural Area Reserve, Coastal Area, between Hoolulu Stream and Waiahuakua Valley, 60-100 m, 4.IX.1991, ex Metrosideros litter, S.F. Swift (1 female).

Remarks: The Hawaiian Favognathus pictus varies from the description by Summers and Chaudhri (1965) in the presence of one cell or clusters of two to three multipunctate cells near setae c1 and d1 on the dorsum. This character is unstable that, in the same series, specimens occur with these clusters found only adjacent to d1, absent on c1; absent in some specimens; only 1 multipunctate cell in entire dorsum; 3 multipunctate cells in each of d1 and c1.

The other variation in the Hawaiian F. pictus is the shape of sensillum k in genu I and II. Hawaiian specimens have an oar-shaped solenidion, imbedded, while the Galapagos specimens have round paddle-shaped solenidion, and is difficult to discern if imbedded in the well-cleared type specimen. There is a possibility that the Hawaiian specimens are a new species very closely related to F. pictus, but pending examination of the paratype and more specimens from the Galapagos Islands, these specimens are classified as Favognathus pictus.

Family EUPALOPSELLIDAE Willmann, 1952

Eupalopsellidae Willmann, 1952: 163; Evans, 1954: 805; Summers, 1960: 124-125; Summers, 1966: 228; Meyer & Rodrigues, 1966: 17; Meyer et al., 1973: 9; Standtmann & Prasse, 1976: 15; Livshitz & Kuznetzov, 1976: 69; Charlet & McMurty, 1977: 199; Wainstein, 1978: 153; Krantz, 1978: 255, 300; Kethley, 1982: 137; Kuznetzov & Petrov, 1984: 94.

Type genus: Eupalopsellus Sellnick, 1949.

Diagnosis. Cheliceral bases fused; peritemes and stigmata absent; palpi long, slender and attenuate with palptarsus elongate or short; palptarsus with a single unbranched distal eupathidium; tibial claw uncinate, reduced, or obsolete; idiosoma oval or elongate; dorsum of idiosoma usually covered with 4 distal shields but prodorsal shield reduced or divided, opisthosoma with 1 to 3 shields or dorsal shield may cover entire dorsum; 13 pairs of dorsal body setae, sci (pm) on dorsocentral propodosoma, setae h2 absent or present in male; venter of female without plate; ventral setae usually very long and flagelliform; empodium usually consists of 2 pairs of raylets on median knob, longer than claws, tipped with concave pads.

Remarks. Willmann (1952) proposed the family Eupalopsellidae based on the monotypic genus Eupalopsellus Sellnick, 1949. As currently understood, this family consists of four genera, namely: Eupalopsis Canestrini,

1886; Eupalopsellus Sellnick, 1949; Exothorhis Summers, 1960 and Saniosulus Summers, 1960. The genus Paraeupalopsellus was proposed by Smiley and Moser, 1968 to accommodate Paraeupalopsellus hodgesi based on the fused gnathosoma, characteristic elongate, slender palps and the shape of the anogenital area. However, the absence of the internal median scapulars (sci), placement and size of eyes, the tridentate eupathidium on the palptarsus (P. aquatilis Meyer and Ueckermann, 1984) and empodia of legs bearing 3 pairs of tenent hairs put this genus closer to Stigmaeidae than Eupalopsellidae. The genus Paraeupalopsellus does not occur in the Hawaiian Islands.

Until recently, the genus Eupalopsis was included in the closely-related raphignathoid family, the Stigmaeidae. Gonzalez-Rodriguez (1965) transferred E. maseriensis to the Eupalopsellidae, accommodating other former members of Eupalopsis in the stigmaeid genus Mediolata Canestrini, 1889. The genus Eupalopsis is thus left with E. maseriensis as its only species. Gerson (1966) redescribed E. maseriensis and confirmed that it belongs in the family Eupalopsellidae as defined by Summers (1960). Species such as Eupalopsis aegyptiaca Zaher and Soliman, 1966, seem to belong to the family Stigmaeidae, probably in the genus Mediolata (Gerson 1966). Recently described species, e.g., E. pentascuta Zaher and Gomaa, 1978 and E. vandergeesti Gomaa and Bolland, 1982, appear to belong in the family

Stigmaeidae and probably accommodated in the genus Mediolata.

Eupalopsellus currently has 10, Exothorhis 9, Eupalopsis 8, Peltasellus 1 and Saniosulus 1 species. Of the 29 species, 18 are Afrotropical, 3 Nearctic, 2 Palearctic, 1 Palearctic and Neotropical, 1 Nearctic and Neotropical, 1 Afrotropical and Nearctic, 1 Australian, 1 Oceania and 1 Oriental.

Key to the Genera of Eupalopsellidae

1. Propodosomal plate divided, sometimes indistinct..... 2
- Propodosomal plate undivided and distinct..... 4
2. Opisthosoma with 1 or 2 plates; prodorsal plate without or with 2 pairs setae; eyes and postocular bodies on integument..... 3
- Opisthosoma with 3 plates; prodorsal plates with 3 pairs of setae, 1 pair of eyes and 1 pair of postocular bodies.....Eupalopsis Canestrini, 1885
3. Propodosomal plates small, vi slightly set on propodosomal plate, ve not borne on plates; setal pair el not borne on communal plate.....
.....Saniosulus Summers, 1960
- Propodosomal plates distinct, vi and ve on paired plates; setal pair el borne on communal plate
.....Peltasellus Meyer and Ueckermann, 1984
4. Dorsum with thin skeletal sheath, some plates

distinct; dorsal setae robust, coarsely denticulate, all set on tubercles.....Exothorhis Summers, 1960

- Dorsum partly covered with 4 plates; dorsal setae slender, nude or slightly serrated, not borne on tubercles.....Eupalopsellus Sellnick, 1949

Genus Exothorhis Summers

Exothorhis Summers, 1960: 131; Summers, 1966: 15; Wainstein, 1978: 153; Meyer and Ueckermann 1989: 8.

Type species: Exothorhis caudata Summers, 1960.

Diagnosis. Idiosoma covered with either a thin skeletal sheath or one or more usually poorly-demarcated plates; dorsal body setae and some leg setae of proximal leg segments coarsely denticulate and originate on tubercles; palptibial claw present or absent; palpfemur with 3 setae; rostrum long, 2 pairs adoral setae present; setae m, n, long, flagelliform set distal-proximal on subcapitulum; sci (pm) set medially adjacent to each other.

Remarks. This genus is easily distinguished from the rest of the eupalopsellid genera by its robust, coarse, and denticulate dorsal body setae set on tubercles.

Of the 9 described species, 6 are Afrotropical (Ethiopian), 1 Australian, 1 from Okinawa, 1 Nearctic. This is the first record of this genus in the Hawaiian Islands.

Members of the genus are associated with plants where they feed on scale insects (Zaher and Yousef 1973) and

probably some other small phytophagous arthropods and their immatures.

Exothorhis caudata Summers Figure 83

Exothorhis caudata Summers, 1960: 131.

Holotype female, FLORIDA: Lake Alfred, Block 20, University of Florida Citrus Experiment Station, May 25, 1959, D.W.C., ex Citrus; Muma et al., 1961: 11; Zaher and Yousef, 1973:447; Meyer and Ueckermann, 1984: 125.

Diagnosis. Quite small, body length (excluding gnathosoma) 256; width 178; length of gnathosoma (cheliceral base to tip of palpus) 132; number of setae from palfemur to palptarsus 3-1-2-7; length (excluding coxae) of legs I-IV: 194, 175, 166, 147. Number of setae on leg segments I-IV: tarsi 10(w)-9(w)-7(w)-6; tibiae 6 (o, op)-5(op)-5(op)-5(op); genua 2(k)-1-1-1; femora 4-4-3-1; trochanters 1-1-1-1; coxae 2-1-1-1.

Idiosoma covered by thin skeletal sheath, no discernible dorsal plating; dorsal body setae robust, coarsely denticulate; setal measurements: vi, h2, 33-38; ve, d1, f1, 57-59; sci, sce, c2, 50-55; c1, h1, 47; d2, e1, 64-69; cheliceral length (t of Gerson, 1972)/stylet length (s) ratio .97; tibial claw present, reduced; ventral setae long and flagelliform; ps1, ps2, strong, subequal (20); ps3,

flagelliform, short (10); gl, flagelliform, long, 36; wI slightly shorter than wII (17), wIII shortest (8).

Specimen examined. 1. O'AHU I: Kane'ohe, Ho'omaluhia Botanical Park, 5.vi.1989, ex moss, R. Brown (1 female).

Other specimens examined. Holotype female, Exothorhis caudata Summers, 1960, FLORIDA: Lake Alfred, Block 20, University of Florida Citrus Experiment Station, May 25, 1959, ex Citrus, D.W.C. (UCD-98); FLORIDA: Ft. Pierce, February 17, 1959, ex orange leaf, H.L.G. (paratype female); FLORIDA: Ft. Pierce, August 19, 1955, ex dirty Citrus leaf, H.L.G. (paratype female + 2 nymphs); FLORIDA: Tice, December 12, 1958, ex Citrus sinensis, L.C. Knorr (nymph).

Remarks. The single specimen from O'ahu I. resembled Summers' Florida specimens including the downwardly curved tailpiece. The type of E. caudata has a single seta on genu IV which Summers missed in his description. The tubercle of spine-like seta k of genu I is on its own tubercle and set close to the tubercle base of coarsely denticulate dorsal seta, contrary to Summers description and drawing showing the two setae originating from a single alveolus.

According to Muma (1975) this species is fairly common on citrus leaves and fruits and is called spiny red mite. This is the first time E. caudata has been recorded outside of Florida and collected from non-Citrus host.

Genus Saniosulus Summers

Saniosulus Summers, 1960: 135; Summers, 1966: 227; Gerson, 1966: 153; Wainstein, 1978: 153; Meyer and Ueckermann, 1984: 124.

Type species: Saniosulus nudus Summers, 1960, by monotypy.

Diagnosis. Fusiform, striated throughout except for pair of small, ill-defined plates on propodosoma and suranal area; 13 pairs simple, short dorsal body setae; 1 pair eyes, 1 pair large postocular bodies adjacent to eyes; palptibia with 2 setae and 1 curved claw; sci widely spaced, each seta displaced laterally to postocular position.

Remarks. Summers (1960) erected this genus from two female specimens, one from Mexico and one from Texas. Zaher and Gomaa (1978) described for the first time the male of this genus.

The elongate, fusiform idiosoma, small propodosomal plates and short dorsal body setae of Saniosulus resemble Storchia Oudemans, 1923 and some Stigmaeus species of the family Stigmaeidae. However, the elongate, slender palptarsus and characteristic pair of unequal tenent hairs on a short arolium of the tarsal empodium conform with the characters of the family Eupalopsellidae.

Saniosulus nudus Summers

Saniosulus nudus Summers 1960: 135.

Holotype female, MEXICO, intercepted at Brownsville, Texas, September 22, 1952, ex orchid plants, Anonymous, Lot 52-10595. Gerson, 1968: 431; Zaher and Gomaa, 1978: 547; Meyer and Ueckermann, 1989: 7.

Diagnosis. Female. Length of body (excluding gnathosoma, ranges of 8 females) 410-442; width 200-254; length of gnathosoma (cheliceral base to tip of palpus) 121-131; number of setae from palpfemur to palptarsus 2-1-2-7; length (excluding coxae) of legs I-IV: 150-185, 127-142, 131-145, 143-173. Number of setae on leg segments I-IV (special sensillae in parentheses): tarsi 11(w)-9(w)-7(w)-6(w); tibiae 6(op)-5(op)-5(op)-5(op); genua 2(k)-1-1-1; femora 4-4-2-2; trochanters 1-1-1-1; coxae 2-1-2-2.

Rostrum elongate, 2 pairs of adoral setae present; m, n long, flagelliform, set proximal-distal on ventral hypostome. Dorsal body setae finely barbed, posterior f1, h1, h2 longer and heavier than anterior pairs; venter striated with fine straight lines; ventral setae 1a, 3a very long, flagelliform; ano-genital plates with 4 pairs of setae, 1 pair genital setae (g1) and three pairs pseudanal setae (ps1-3), posteroventral; ps1, ps2 heavier, finely barbed, ps3, g1 thinner, aciculate; 3 pairs aggenital setae, thin, aciculate, subequal (27-29).

Male. As in female except smaller (body length 280, width 128); palpfemur with small, stubby seta distal on

segment; tarsi I-IV each with w male solenidion; aedeagus slender with posterior accessory structures, small cup-like structure anteriorly.

Specimens examined. 13. O'AHU I: Honolulu, Univ. Hawaii Campus, Manoa, 9.X.1965, ex soil with litter, F.H. Haramoto (1 female); O'AHU I: Honolulu, 19.XI.1959, ex feeding on Cactus scales, F.H. Haramoto (4 females); O'AHU I: Univ. Hawaii Campus, Manoa, Henke Hall, 12.XI.1967, ex grass litter, P. Vaivanijkul (1 female); O'AHU I.: Honolulu, Hawaii Kai, Mariner's Ridge, 213 m, 3.VI.1990, ex Eragrostis variabilis with scales; J. Strazanac (5 females, 1 male); O'AHU I: Waianae Beach, 30.III.1972, ex Kiawe litter, D.M. Tsuda (1 female).

Other specimens examined. Holotype female, Saniosulus nudus Summers, 1960, MEXICO: at Brownsville, Texas, September 22, 1952, ex orchid plants, Anonymous, Lot 52-10595; EGYPT: Meamora, Alexandria, August 24, 1964, ex P. oleae, olive plant (1 female); ISRAEL: Nahalal, November, 1963, ex trunk and bark of Citrus limon, U. Gerson (1 female); CALIFORNIA: Riverside, on insectary culture of purple scale, June 2, 1965, J.A. McMurty (1 female); INDIA: Coimbatore, Tamil Nadu, ex scale insects on sugar cane (1 female).

Remarks. Summers (1960) indicated the palptibia has "one minute spine-like seta close beside its longer dorsal seta" but this character could not be verified in the type

specimen and the other specimens examined. He might have referred to the dorsal base of the claw that has a dark, spine-like, sclerotized area, actually part of the curved claw; thus there are only 2 setae in the palptibia of Saniosulus nudus. Slightly posterior of the eupathidial terminal seta of the palptarsus is another seta slightly thicker, seemingly eupathidial, with slightly blunt tip, compared to aciculate configuration of the other four.

Of the eupalopsellids, this is the only species with the pair of setae sci (pm of other authors) of the propodosoma set marginally posterior of the postocular bodies; the other genera have sci located midorsally.

This species was reported in Israel to feed on chaff scale, Parlatoria pergandii Comstock, a pest of citrus trees (Gerson and Blumberg 1969). If this species has biocontrol potential against scales, it can also reach pest status in laboratory rearings of Diaspididae necessitating eradication measures (Gerson 1968).

In the Hawaiian Islands, this species appears to be confined to O'ahu I.

Family Raphignathidae Kramer, 1877

Raphignathidae Kramer, 1877: 215; Oudemans, 1922: 114; Meyer and Ryke, 1960: 228; Atyeo, 1963: 172; Chaudhri et al., 1979: 191; Wainstein, 1978: 149; Kuznetzov and Petrov, 1984: 98; Meyer and Ueckermann, 1989: 28.

Type genus: Raphignathus Duges, 1834.

Diagnosis. Coxae contiguous; fused cheliceral bases form a stylophore, peritremes on the basal notch of the stylophore directed posterolaterally; presence or absence of 4 small to large dorsal plates in females, a single large plate of fused hysterosomal and propodosomal plates in males; idiosoma with 12 pairs of setae; venter with 4-5 pairs of setae. Endopodal plates on coxae I and II either divided or fused; on coxae III and IV divided or absent. Genital and anal openings separate in females; fused in males; genital and anal plates each with 3 pairs of setae; 2 pairs aggenital setae present.

Remarks. When Oudemans (1931) proposed the family Stigmaeidae, the family Raphignathidae was restricted to the genera Acheles Oudemans and Raphignathus Duges, which possess the characteristic tetranychid-like peritremes. Baker and Wharton (1952) however, placed the families Stigmaeidae and Caligonellidae in the family Raphignathidae. Summers and Schlinger (1955) and Cunliffe (1955) however, regarded them as separate families. Atyeo et al. (1961)

recognized the family by the presence of cervical peritremes and the confluent coxae.

Raphignathus Duges, 1833, and Neoraphignathus Smiley and Moser, 1968, are the two genera in the family. Raphignathus is widely recognized while Neoraphignathus is a monotypic genus. Acheleopsis was proposed by Willmann (1951) in the Raphignathidae to accomodate Acheleopsis quadrioculata. Subsequently, Summers & Schlinger (1955) transferred Acheleopsis to the Caligonellidae based on the similarities of Willmann's illustrations of the idiosoma and palpus of A. quadrioculata to Caligonella humilis.

Members of the family are predaceous, usually found in soil, organic manure, plant debris, stored grain, and bird nests (Rakha and Mohamed 1980, Zaher and Gomaa 1979, Atyeo et al. 1961). Price (1973) found two Raphignathus species in deep soil layers of pine forests in California.

Its distribution seems to be cosmopolitan. Members of the family have been reported from Europe, Egypt, Pakistan, Africa, North America, Russia and Australia.

Key to the Genera of Raphignathidae

1. Dorsal plates present .....Raphignathus Duges, 1834
- Dorsal plates absent.....Neoraphignathus Smiley and Moser, 1968

Genus Raphignathus Duges

Raphignathus Duges, 1834: 53; Oudemans, 1923: 138; Oudemans, 1927: 260; Meyer and Ryke, 1960: 228; Atyeo et al., 1961: 14; Atyeo, 1963: 172; Chaudhri et al., 1979: 193; Zaher & Gomaa, 1979: 198; Meyer and Ueckermann, 1989: 28.

Type species: Raphignathus ruberrimus Duges, 1834.

Acheles Oudemans,1903: 101; Oudemans, 1927: 260; Meyer & Ryke, 1960: 231; Rack, 1962: 281.

Type species: Acheles mirabilis Oudemans, 1903.

Acheleopsis Willmann, 1951: 141. Transferred to family Caligonellidae by Summers and Schlinger, 1955: 540.

Type species: Acheleopsis quadrioculata Willmann, 1951.

Diagnosis. Small mites, with 3 or 4 large propodosomal plates and one large hysterosomal plate on dorsum of females, 2 small plates may be present posterior of the median propodosomal plate; one large single plate in male; dorsum with 12 pairs of dorsal setae and a complete set of cupules (4) including ih on venter; one pair of eyes on lateral podosomal plates; cheliceral bases fused forming a conical stylophore; simple peritreme arising from posterior cleft of stylophore, terminating in cervical membrane of anterolateral margins of idiosoma.

Remarks. There are 25 species in the genus worldwide. Eight species are found in the Hawaiian Islands. The Hawaiian species can be separated into two morphological groups based on the number of dorsal setae on the

interscutal membrane (striated portion of the idiosoma). The first group has 2-3 pairs (dl, el, f2); the second has 1 pair (dl) borne on the interscutal membrane.

Raphignathus n. sp. A Figures 35, 36, 84

Holotype. Female. HAWAI'I I: Hawaii Volcanoes National Park, Mauna Loa Road, 1340 m, 16.VI.1970, ex grass and litter, M.L. Goff and F.J. Radovsky.

Diagnosis. The uniquely reduced lateral plates, presence of c2 on individual platelets, and relatively small hysterosomal plate separate this species from others in the genus.

Description. Female. Length (excluding gnathosoma) 323; width 214.

Gnathosoma. Stylophore finely striated longitudinally; chelicera/stylet ratio (t/s) 2.0; palplength (from trochanter base to tip of tarsus) 115 (Figure 36D); number of setae from palpfemur to palptarsus: 2-2-3-9; claw-like seta 7 long; palptarsus with 4 terminal eupathidia, 4 tactile setae, 1 solenidion as long as eupathidia; peritremes and tracheal ducts as in Figure 36E.

Dorsum (Figure 35A). Anterior shoulder of median propodosomal plate where sci located not expanded; lateral propodosomal plates reduced carrying dorsal setae ve and sce; c2 borne on individual small platelets; dorsal plates finely striated with sparse punctations; dorsal setae dl, el

and f2 on interscutal membrane; 3 pairs of hysterosomal setae on the opisthosomal plate; 4 pairs of integumental cupules (ia, im, ip, ih) present on the striated cuticle, ih located postero-lateral of genital plate; dorsal setae simple (Fig. 35B), length varies from 32 to 40; c1 shortest (32), sc2 longest (40).

Venter. Endopodal shield on bases of coxae III and IV (Figure 35C) finely striated; genital plates have 3 pairs of missing genital setae, 4c and ag1 on finely striated cuticle (Figure 35D).

Legs (Fig. 36A, 36C). Length (excluding coxae) of legs I-IV: 342, 299, 333, 409. Number of setae on leg segments I-IV (special sensillae in parentheses): tarsi 21(w,op)-16(w)-14(w)-13; tibiae 6(op)-6(op)-6(op)-5(op); genua 6(k)-6(k)-4-4; femora 6-5-3-2; trochanters 1-1-2-1; coxae 2-2-2-1; length of wI 9; femora IV with 2 setae (Figure 36C); empodium as depicted in Fig. 36B.

Male. Unknown.

Specimen examined. 1. HAWAI'I I: Hawaii Volcanoes National Park, Mauna Loa Road, 1340 m, 16.VI.1970, ex grass and litter, M.L. Goff & F.J. Radovsky.

Remarks. Raphignathus n.sp. A is the first reported species of Raphignathus with reduced lateral propodosomal and opisthosomal plates. Unfortunately, there is only one known specimen of this species.

Raphignathus n. sp. B Figures 37, 38, 39, 84

Holotype. Female. PEARL AND HERMES REEF: Southeast I, 21.VII.1983, ex litter under Eragrostis, S. Conant.

Diagnosis. Although related to Raphignathus gracilis (Rack) and Raphignathus n. sp. C, this species is distinctive in the absence of punctation on the dorsal plates and tarsus II having 16 setae including solenidion w.

Description. Female (holotype plus ranges of 3 females). Length (excluding gnathosoma) 376(282-376); width 259(174-259).

Gnathosoma. Stylophore finely striated longitudinally; chelicera/stylet ratio 2.0; palplength (from trochanter base to tip of tarsus) 101(95-101); number of setae from palpfemur to palptarsus: 2-2-3-9; claw-like seta 7-8 long; palptarsus with 4 terminal eupathidia, 4 tactile setae, 1 solenidion.

Dorsum (Figure 37A). Anterior shoulder of median propodosomal plate slightly expanded; median propodosomal plate much wider than narrow lateral plates; plates with fine longitudinal striations, punctations absent; 12 pairs simple, aciculate setae on dorsum, 25-33 long (Figure 37C); interscutal membrane with 2 pairs setae, dl and el on platelets; opisthosomal plate sort of rectangular with anterior side wider than posterior; 4 pairs of setae on plate; plate does not cover entire opisthosoma; anal opening terminal with 3 pairs pseudanal setae, ps1-3.

Venter (Figure 37B). Small, narrow endopodal shield on coxae III and IV, finely striated; with 5 pairs of setae; aggenital pair posterior of genital plate; 3 pairs of genital setae; ih laterad of genital plate.

Legs (Figures 37D, 37E, 37F). Length (excluding coxae) of legs I-IV: 249(235-254); 212(206-212); 240(207-240); 291(287-296). Number of setae on leg segments I-IV (special sensillae in parentheses): tarsi 21(op,w)-16(w)-14(w)-13; tibiae 6(op)-6(op)-6(op)-5(op); genua 6(k)-6(k)-4-4; femora 6-5-3-3; trochanters 1-1-2-1; coxae 2-2-2-1; length of wI 8.

Male (Figure 38). 2. Length of body (excluding gnathosoma) 282-306; width 188-193; length (excluding coxae) of legs I-IV: 238-254, 190-207, 230-245, 274-296.

Dorsum covered by weakly sclerotized shield, bordered by lateral striated areas; shield with fine striation, punctation absent (Figure 38A); dorsal setae simple, aciculate 13-24 long; genital setae absent (Figure 38B); palp and leg chaetotaxy the same as female except presence of solenidion w on tarsi IV; w I-IV enlarged, length of wI 17 (Figures 38C-F); aedeagus complex, as in Figure 38G.

Larva (Figure 39). 4. Length of body (including gnathosoma) 277-301; length (excluding gnathosoma) 179-193; width 140-167; length (excluding coxae) of legs I-III: 180-190; 155-164; 170-190.

Dorsum striated with feebly sclerotized median propodosomal plate, small, posteriorly tapered lateral

propodosomal plates and suranal plate; 11 pairs of dorsal setae, on platelets (Figure 39A); setal length varies, 23-40; 4 pairs of cupules; number of setae on leg segments I-III (special sensillae in parentheses): tarsi 16(w)-12(w)-10(w); tibiae 6(op)-6(op)-6(op); genua 5(k)-5(k)-2; femora 3-3-2; trochanters 0-0-0; coxae 1-0-0; addorsal tc' minute, coupled with eupathidial p' on tarsi I and II; addorsal tc'' absent; p'' simple tactile setae; wI and wII round-tipped, stubby, wIII peg-like (Figures 39B-D); 1a and 3a present on venter; number of setae from palpfemur to palptarsus: 2-1-3-9; palptarsus with a solenidion, 6 tactile setae and 2 terminal eupathidia.

Specimen examined. 10. PEARL and HERMES REEF: Southeast I, 21.VII.1983, ex litter under Eragrostis, S. Conant (4 females, 2 males, 4 larvae).

Remarks: Males of Raphignathus n. sp. B have long-oval (oval but twice as long as wide) tarsal solenidia compared to enlarged baculiform or ceratiform types of Raphignathus karrooi and R. kamiensis both described by Meyer and Ueckermann, 1989. Notation of addorsal leg setae tc and p of larvae follows Grandjean (1944).

Raphignathus n. sp. C Figures 40, 41, 42, 84

Holotype. Female. KAUA'I I: Kuia Natural Area Reserves, Nualolo Trail, 890 m, 27.XI.1990, ex Metrosideros bark, S.F. Swift and P. Cairy.

Diagnosis. The minutely pilose, thick dorsal setae longer than their distances to the next posterior setae of d1, e1 and f2 separate this species from R. gracilis, which has also minutely pilose but aciculate dorsal setae and d1, e1 and f2 are shorter than intervals between consecutive setae.

Description. Female (holotype and ranges of 7 female specimens in parentheses). Length (excluding gnathosoma) 261(244-258); width 180(159-188).

Gnathosoma (Figure 41C). Stylophore striated, chelicera/stylet ratio 2.0; palplength (from trochanter base to tip of tarsus) 86(79-88); number of setae from palpfemur to palptarsus: 2-2-3-9; palptibial claw 5-6 long; palptarsus with 4 terminal eupathidia, 4 tactile setae and 1 solenidion; palpgenu and palptibia globular, lengths 15 and 17 respectively (Figure 41D); m, n present, transverse arrangement on swollen ventral gnathosomal base; 2 pairs of adoral setae, branched.

Dorsum (Figure 40A). Anterior shoulder of median propodosomal plate expanded; disjugal furrow (dsj) on plate prominent; posterior of dsj triangular; plates porous with longitudinal striations; 12 pairs strong, indistinctly pilose dorsal setae, 22-37 long (Figure 40C); h2 usually shortest, sce usually longest; 2 pairs of setae on interscutal membrane, d1 and e1 on platelets; hysterosomal setae longer than alveoli of next posterior setae; f2 arise

on border of anterior opisthosomal plate; 3 pairs of cupules present; anal opening terminal.

Venter (Figure 40B). With 5 pairs of setae; narrow, finely striated endopodal shield on coxae III and IV; 3 pairs genital setae on finely striated genital plates.

Legs (Figures 41A, 41B). Length (excluding coxae) of legs I-IV: 232(211-240; 189(174-193); 209(201-211); 246(226-259). Number of setae on leg segments I-IV (special sensillae in parentheses): tarsi 21(w,op)-16(w)-14(w)-13; tibiae 6(op)-6(op)-6(op)-5(op); genua 6(k)-6(k)-4-4; femora 6-5-3-3; trochanters 1-1-2-1; coxae 2-2-2-1; femur IV with 3 setae; length of wI 10-11.

Larva (Figure 42). 2. Length of body (including stylophore) 195-223; width 124-138. Length (excluding coxae) of legs I-III: 171-178; 152; 167-174. Legs as in Figures 42B, 42C, 42D.

Dorsum striated with median propodosomal, lateral propodosomal and suranal plates; plates reduced in size, finely striated, with sparse punctations; 11 pairs of dorsal setae, h2 absent; setal length varies from 19-36; 4 pairs of integumental cupules, ih laterad of anterior anal opening; number of setae on leg segments I-III (special sensillae in parentheses): tarsi 16(w)-11(w)-10(w); tibiae 6(op)-6(op)-6(op); genua 5(k)-5(k)-3; femora 3-3-2; trochanters 0-0-0; coxae 1-0-0; addorsal tc' minute, coupled with eupathidial p' on tarsi I and II; addorsal tc'' absent; p'' simple

tactile setae; ventral setae 1a and 3a present on venter; number of setae on palpfemur to palptarsus: 2-1-3-9; palptarsus with a solenidion, 6 tactile setae and 2 terminal eupathidia; m, n absent; 2 pairs adoral setae, branched.

Male. Unknown.

Specimens examined. 9. KAUA'I I: Kuia Natural Area Reserve, Nualolo Trail, 890 m, 27.XI.1990, ex Metrosideros bark, S.F. Swift and P. Cairy (5 females, 2 larvae); KAUA'I I, Kuia Natural Area Reserve, Nualolo Trail, 890 m, 27.XI.1990, ex Metrosideros litter, S.F. Swift (1 female); KAUA'I I, Kuia Natural Area Reserve, Nualolo Trail, 890 m, 27.XI.1990, ex soil under Metrosideros, S.F. Swift (1 female); O'AHU I: Waimanalo Beach Park, sea level, 27.IX.1992, ex Casuarina bark, S.F. Swift (1 female, 1 larva).

Remarks. Placement of f2 in Raphignathus n.sp. C is generally at the border of the anterior margin of the opisthosomal plate with exception of 1 specimen where f2 is more on the interscutal membrane.

This species belongs to the morpho group characterized by the presence of 2 pairs of dorsal setae on the interscutal membrane and thus morphologically similar to Raphignathus gracilis (Rack, 1962). Specimens collected from 5 main islands and from 3 of the Northwestern Hawaiian Islands are all very closely related except for variations in size and condition of dorsal setae, size and condition of

dorsal plates, differences in size and lengths of special sensillae like omega (w) on tarsi of larvae and males, numerical differences in larval leg setation and configuration of the male genitalia.

Raphignathus n. sp. D Figures 43, 44, 85

Holotype. Female. NIHOA I: 17.VII.1987, ex Chenopodium oahuense litter, S. Conant.

Diagnosis. Closely related to Raphignathus giselae and Raphignathus n. sp. C but differs from both in the presence of a pair of small platelets on the interscutal membrane posterolaterad of the anteromedian plate.

Description. Female (holotype and ranges of 9 females in parentheses). Length (excluding gnathosoma) 278(250-287); width 188(182-197).

Gnathosoma (Figure). Stylophore finely striated; chelicera/stylet ratio 2.15; palplength (from trochanter base to tip of tarsus) 98(85-95); number of setae from palpfemur to palptarsus: 2-2-3-9; claw like seta small, 6 long; palptarsus with 4 terminal eupathidia, 4 tactile seta, 1 solenidion.

Dorsum (Figure 43A). Anterior shoulder of median propodosomal plate slightly expanded; plates with fine striations; sparse punctations faint to distinct; 12 pairs of dorsal setae, simple, aciculate, 21-31 long; interscutal membrane with 2 pairs setae, dl and el on small platelets; 4

pairs of setae on opisthosomal plate; f2 near anterior margin of opisthosomal plate, as long as distance of f2-f1; anal opening terminal with pseudanal setae ps1-ps3.

Venter (Figure 43B). With 5 pairs of flagelliform setae; endopodal shield on coxae III and IV finely striated; ag1 anterior of genital opening; 3 pairs of genital setae (g1-3) and ih posterolaterad of genital plates.

Legs (Figures 44A-C). Length (excluding coxae) of legs I-IV: 250(228-240); 205(190-202); 226(214-226); 281(252-276). Number of setae on leg segments I-IV (special sensillae in parentheses): tarsi 22(21)(w,op)-16(w)-14(w)-13; tibiae 6(op)-6(op)-6(op)-5(op); genua 6(k)-6(k)-4-4; femora 6-5-3-3; trochanters 1-1-2-1; coxae 2(3)-2-2-1; wI 9 long.

Male. Unknown.

Specimens examined. 16. NIHOA I: 17.V.1987, ex Chenopodium oahuense litter, S. Conant (16 females).

Remarks. This species keys to Raphignathus giselae Meyer and Ueckermann, 1989. The median propodosomal plate is widely separated from the peritremes anteriorly and in most cases the dorsal setae e1 do not reach the anterior margin of the opisthosomal shield. However, this latter character is not reliable as the integument folds or stretches during mounting that some specimens have dorsal setae reaching beyond the alveoli of the next posterior setae. The presence of a pair of small platelets

posterolaterad of the median propodosomal shield separates it from R. giselae Meyer and Ueckermann, 1989. In some specimens these platelets are elongated with the apodemal marks on them and in some they are insconspicuous and only the dark markings could be seen. Generally, tarsus IV does not have solenidion w, but 1 specimen examined for this species had wIV on both tarsi, 2 specimens with 1 tarsus with the solenidion, the other without. Also, 2 specimens have 4 genital setae on 1 side and 3 on other side of the genital plates. This species is similar to Raphignathus n. sp. C, however, the relatively larger body size, the aciculate, less strong linear-lanceolate dorsal setae, presence of platelets posterolaterad of the median propodosomal plate and setae f2 shorter or equidistant to the distance between f1-f2 distinguish it from the latter.

Raphignathus n. sp. E Figures 45, 46, 47, 48, 85

Holotype. Female. NIHOA I: Miller Peak, 28.VI.1990, on Eragrostis sp., J. Strazanac.

Diagnosis. The distinct contiguous coxal plates of coxae I and II with dense punctations and absence of striation and the presence of small platelets posterolaterad of the median propodosomal plate separate this species from others belonging to this morphological group (d1 on the interscutal membrane).

Description. Female (holotype and ranges of 9 females in parentheses). Body length (excluding gnathosoma) 423(395-461); width 235(277-323).

Gnathosoma. Stylophore conical, striated posteriorly, dashed anteriorly (Figure 46D); stylets long, needle-like; chelicera/stylet ratio 1.8; palplength (from trochanter base to tip of palptarsus) 140(136-142); number of setae from palpfemur to palptarsus: 3-2-3-9; claw-like seta, 8 long; palptarsus with 4 terminal eupathidia, 4 tactile setae, 1 solenidion; palpsegments porose (with punctations) (Figure 46C). Infracapitulum as in Figure 48C.

Dorsum (Figure 45A). Propodosomal and hysterosomal plates large separated by narrow bands of fine striae; densely punctate plates; a pair of platelets posterolaterad of median propodosomal plate; dl on interscutal membrane posterior of median plate; 12 pairs of strong, linear-lanceolate dorsal setae, 28-43 long; 4 pairs of integumental cupules present, ih located posterolaterad of genital opening; one pair of eyes on lateral propodosomal plates.

Venter (Figure 45B). Endopodal plates on coxae I and II contiguous, porose, striations absent except at the posterior margin of plate, same level as base of coxae II; coxae III and IV with large endopodal shields; ventral setae 1a, 3a, on endopodal plates, 4a on small platelets located medially of endopodal plates; hysterosomal plate extends subventrally; aggenital setae (ag1) present anterior of

genital opening; 3 pairs of genital setae (gl-3); anal opening separate from genital opening; anal plates with 3 pairs of pseudanal setae (psl-3).

Legs (Figures 46A, 46B). Length (excluding coxae) of legs I-IV: 287(282-291); 240(230-244); 263(249-273); 329(254-338). Number of setae on leg segments I-IV (special sensillae in parentheses): tarsi 21(op,w)-16(w)-14(w)-14(w); tibiae 7(o,op)-6(op)-6(op)-5(op); genua 6(k)-6(k)-4-4; femora 6-6-4-4; trochanters 1-1-2-1; coxae 2-2-2-1; length of wI 19.

Male (Figures 47, 48A-B). 7. Length of body (excluding gnathosoma) 315-348; width 211-244. Length (excluding coxae) of legs I-IV: 254-268; 207-216; 221-235; 277-282.

Dorsum covered by a large shield except for narrow striated band on lateral margin of idiosoma, on interspace between setae c2 and d1 (Figure 47A); 12 pairs of setae including h2 on the venter; dorsal setae c1, d1, e1, f1 short, aciculate, 14-17 long; dorsal setae vi, ve, sci, sce, f2, h1, h2 long, strong and thick to the tip, 24-31 long; genital and anal openings combined, terminal; ventral setae on striated membranes on platelets; only 1 cupule (ih) present, located laterad of genito-anal opening; structure of genital organ complex (Figure 48B); leg chaetotaxy as in female except solenidia on tarsi I-IV long (24-33), baculiform (Figure 48A).

Specimens examined. 11. NIHOA I: Miller Peak, 28.VI.1990, on Eragrostis sp., J. Strazanac (4 females, 7 males).

Remarks. Both males and females exhibited the contiguous endopodal plates on coxae I and II, a character unique to this species. Like Raphignathus bathursti Meyer and Ryke, 1960, and Raphignathus n. sp. G (from Maui), this species has solenidion o on tibia I.

The Eragrostis grass sampled for mites was infested with scale insects. It is presumed that this species fed on the scales.

Raphignathus n. sp. F. Figures 49, 50, 51, 85

Holotype. Female. KAUA'I I: Kuia Natural Area Reserve, Nualolo Trail, 1000 m, 27.XI.1990, ex Metrosideros bark, S.F. Swift and P. Cairy.

Diagnosis. Very similar to Raphignathus n. sp. E but can easily be distinguished by the striated endocoxal plates on coxae I and II.

Description. Female (holotype and ranges of 9 females in parentheses). Body length (excluding gnathosoma) 385(348-484); width 235(221-357).

Gnathosoma. Stylophore conical, striated posteriorly, dashed anteriorly; chelicera/stylet ratio 1.86; palplength (from trochanter base to tip of palptarsus) 133(100-159); number of setae from palpfemur to palptarsus: 3-2-3-9; claw-

like seta 6-8 long; palptarsus with 4 terminal eupathidia, 4 tactile setae, 1 solenidion (Figure 50D). Infracapitulum as figured (Figure 51A).

Dorsum (Figure 49A). Median and 2 lateral propodosomal and opisthosomal plates large separated by narrow bands of striae; posterolateral platelets absent; el on border of anterior opisthosomal plate; dorsal setae 40-62 long, strong, linear-lanceolate (Figure 49C); complete set of integumental cupules including ih on venter.

Venter (Figure 49B). Endocoxal plates on coxae I and II, coxae III and IV separated by striations, porose, large; 5 pairs of setae on venter; hysterosomal plate extends subventrally; agl located anterior of genital opening, on platelets; genital plates porose, with 3 pairs of setae (gl-3); anal plates also porose, with psl-3.

Legs (Figures 50A-B). Length (excluding coxae) of legs I-IV: 296(277-329); 249(235-277); 282(249-310); 348(310-380). Number of setae on leg segments I-IV (special sensillae in parentheses): tarsi 21(op,w)-16(w)-14(w)-14(w); tibiae 7(o,op)-6(op)-6(op)-5(op); genua 6(k)-6(k)-4-4; femora 6-6-4-4; trochanters 1-1-2-1; coxae 2-2-2-1; wI 17-19 long; femora IV with 4 setae (Figure 50C).

Male. 5. Length of body (excluding gnathosoma) 320-353; width 216-244.

Dorsum covered by a large shield bordered by striate areas on lateral margin of idiosoma, in between c2 and dl;

dorsal setae c1, d1, e1 and f1 short (17-29), aciculate, while vi, ve, sci, sce, c2, f1, h1 and h2 long (33-45), strong; cupules ia, im, ip absent on dorsum; ih present on venter, anterolaterad of combined anogenital opening; structure of genital organ complex (see Figure 48B); w on tarsi I-IV enlarged, 31-39 long.

Materials examined. 23. KAUA'I I: Kuia Natural Area Reserve, Nualolo Trail, 1000 m, 27.XI.1990, ex Metrosideros bark, S.F. Swift and P. Cairy (13 females, 4 males); KAUA'I I: Kuia Natural Area Reserve, Nualolo Trail, 1000 m, 27.XI.1990. ex Metrosideros bark, S.F. Swift (2 males); KAUA'I I: Kuia Natural Area Reserve, Nualolo Trail, 1145 m, 29.IV.1991, ex Metrosideros bark, S.F. Swift (2 males); HAWAI'I I: Kipuka Ki, 6.VI.1984, ex Koa tree hole, M.L. Goff (2 females).

Remarks. Two females from Hawai'i are longer (461-484 body length) than the Kaua'i females (367-423). The striated area on the ventral opisthosoma not covered by the extended hysterosomal plate is also larger as the extended plate on the lateral sides is narrower compared to the specimens from the Kaua'i population. Aside from these variations, the two populations are basically similar.

Metrosideros bark and Koa tree holes seem to be the favored habitats of this species.

Raphignathus n. sp. G Figures 52, 53, 85

Holotype. Female. MAUI I: Haleakala National Park, Headquarters Treatment and Control, Area #3, 2150 m, just below Park Hdqtr., pitfall trap, VI.1987, R. Cole and L. Loope.

Diagnosis. Very similar to Raphignathus n. sp. E and Raphignathus n. sp. F in the condition of dorsal plates and leg chaetotaxy but the anterior-posterior arrangement of subcapitular setae m, n and the finely setose, aciculate adoral setae distinguish the species from the other two species.

Description. Female. Body length (excluding gnathosoma) 418; width 282.

Gnathosoma. Stylophore conical, with broken striation; stylets long, needle-like, chelicera/stylet ratio 1.58; palplength (from trochanter base to tip of palptarsus) 158; number of setae from palpfemur to palptarsus: 3-2-3-9; palptibial claw 8 long; palptarsus with 4 terminal eupathidia, 4 tactile setae, 1 solenidion; 3 tactile setae and solenidion lumped on distal half of palptarsus leaving 1 long tactile seta at dorsal base (Figure 53C).

Dorsum (Figure 52A). Propodosomal and hysterosomal plates large with fine bands of striation separating them as in Raphignathus n. sp. E and F.; plates punctate; no distinct platelets posterolaterad of median propodosomal plate; 12 pairs of short setae, 19-28 long (Figure 52C); dorsal setae c2 on lateral propodosomal plates located on

inside midlateral area of plates, anterolateral of c1; 1 pair of integumental cupule (im) distinctly present.

Venter (Figure 52B). Coxal seta 1a of coxa I on narrow endopodal shield; coxal group III and IV flanked by endopodal shield with faint striations; 4a, 4c, ag1 on small platelets; genital and anal opening as figured.

Legs (Figures 53A-B). Length (excluding coxae) of legs I-IV: 306; 240; 259; 324. Number of setae on leg segments I-IV (special sensillae in parentheses): tarsi 21(op,w)-16(w)-14(w)-14(w); tibiae 7(o,op)-6(op)-6(op)-5(op); genua 6(k)-6(k)-4-4; femora 6-6-4-4; trochanters 1-1-2-1; coxae 2-2-2-1; length of wI 10, wII 6; empodium a rod-like stalk in between claws, with 8 raylets.

Specimens examined. 2. MAUI I: Haleakala National Park, Headquarters Treatment and Control, Area #3, 2140 m, just below Park Hdqtr., pitfall trap, VI.1987, R. Cole and L. Loope (2 females).

Remarks. Aside from the diagnostic characters mentioned above, this species has the shortest dorsal setae (19-28) compared to Raphignathus n. sp. E, (28-44) and Raphignathus n. sp. G (38-62). It also has a single cupule (im) present on the interscutal membrane; the other 3 pairs of cupules not discernible or absent. This is the only representative of the genus from the island of Maui, collected in pitfall trap on high elevation at Haleakala National Park.

Raphignathus n. sp. H Figures 54, 55, 56, 57, 86

Holotype. Female. O'AHU I: Manoa, 11.XI.1982, ex soil, S.F. Swift.

Diagnosis. Similar to Raphignathus ensipilosus Meyer and Ueckermann in the condition of the dorsal plates and the sword-like dorsal setae, however this Hawaiian species is easily distinguished by the presence of 2 setae on femur IV and complete separation of the genital and anal openings.

Description. Female (holotype and ranges of 3 females in parentheses). Body length (excluding gnathosoma) 400(333-423); width 273(221-329).

Gnathosoma. Stylophore striated posteriorly, tubercled centrally, dashed anteriorly; stylet long, needle-like; chelicera/stylet ratio 1.47; palplength (trochanter base to tip of tarsus) 119(108-118); palptibial claw 5-7 long; palptarsus with 4 terminal eupathidia, 4 tactile setae, 1 solenidion; palpfemur with 3 setae (Figure 55C).

Dorsum (Figure 54A). Propodosomal and hysterosomal plates large separated by narrow bands of fine striae; plates punctate; a pair of relatively large platelets posterolaterad of median propodosomal plate porose; cupule ia on round posterior margin of lateral propodosomal plates; cupules im, ip not discernible or absent; 12 pairs of strong, sword-like dorsal setae, 33-50 long (Figure 54B); d1 on small platelet with punctations.

Venter (Figures 55A-B, 55D). Endopodal shields around bases of coxae I and II and coxae III and IV, faintly punctate (Figure 55D; genital plates separated from anal plates with distinct fine striations; both plates each with 3 pairs of setae, gl-3 and psl-3 respectively; plates punctate (Figure 55A); internal structure of female genitalia as in Figure 55B. cupule ih laterad of genital plates.

Legs (Figures 57A-B). Length (excluding coxae) of legs I-IV: 351(240-334); 285(197-282); 295(221-302); 394(273-367). Number of setae on leg segments I-IV (special sensillae in parentheses): tarsi 21(op,w)-16(w)-14(w)-14(w); tibiae 6(op)-6(op)-6(op)-5(op); genua 6(k)-6(k)-4-4; femora 6-5-3-2; trochanters 1-1-2-1; coxae 2-2-2-1; femora III and IV with 3, 2 tactile setae respectively; length of wI 11-15 long.

Male (Figures 56A-B). Length of body (excluding gnathosoma) 286; width 183. Length (excluding coxae) of legs I-IV: 235, 188, 202, 243.

Dorsum as in Raphignathus n. sp. E except dl set farther apart, aligned with el and f2; combined genital and anal openings, terminal; 12 pairs of setae including ventrally located h2; setae not as strong and as long as female; structure of genital organ complex (Figure 56A); leg chaetotaxy as in female except solenidia (w) on tarsi I-IV long (28, 25, 28, 30) and well developed (Figures 57C-F).

Specimens examined. 5. O'AHU I: Manoa, 11.XI.1982, ex soil, S.F. Swift (1 female); O'AHU I: Diamond Head Crater, 18.X.1983, ex soil under Haole Koa, M. Early (1 female); O'AHU I: Honolulu, Maile, 19.X.1965, ex cow dung, B. Park; LANA'I I: Maunalei, 9.IV.1970, ex Kiawe litter, E.S. Raros (1 female); O'AHU I: Honolulu, U.H. Campus, Manoa, IV.1972, ex leaf litter, S. Higa (1 male).

Remarks. Raphignathus ensipilosus Meyer and Ueckermann, 1989, has 3 setae on femur IV and other species belonging to the same morpho group (d1 on interscutal membrane) have 4 setae while this species has 2 setae on femur IV. Compared also to the other species, d1-d1 is farther apart, almost equidistant with f2-f2.

The specimen from Lana'i I varies in that porosity is not as discernible, which could be due to over clearing during mounting. Also, wI and wII are slightly longer than the other females.

Raphignathus aethiopicus (Meyer and Ryke) Figure 86

Acheles aethiopica Meyer and Ryke, 1960: 231.

Holotype and one paratype female from grass and soil, Bathurst, Cape Province, SOUTH AFRICA, January, P. Graham.

Raphignathus aethiopicus (Meyer and Ryke, 1960). Meyer and Ueckermann, 1989: 38.

Diagnosis. Female. Length of body (excluding gnathosoma, ranges of 4 females) 296-315; width 197-204. Palplength (from trochanter base to tip of tarsus) 119-122; number of setae from palpfemur to palptarsus: 3-2-3-9. Length (excluding coxae) of legs I-IV: 240-259; 216-221; 235-244; 287-306; number of setae on leg segments I-IV (special sensillae in parentheses) tarsi 21(op,w)-16(w)-14(w)-13; tibiae 6(op)-6(op)-6(op)-5(op); genua 6(k)-6(k)-4-4; femora 6-5-3-3; trochanters 1-1-2-1; coxae 2-2-2-1; length of wI 12.

Dorsum with weak sclerotized propodosomal and opisthosomal shields, finely striated, with sparse punctations; 12 pairs dorsal setae, 28-40 long, indistinctly pilose to nude, linear-lanceolate; d1, e1, f2 on interscutal membrane; platelets posterolaterad of median propodosomal shield absent; stylophore striate; palpfemur with 3 tactile setae; chelicera/stylet ratio 2.45; venter with 5 pairs of fine flagelliform setae; ag1 anterior of genital opening; integumental cupules present, cupule ip not on opisthosomal shield; genital opening with 3 pairs genital setae (g1-3); anal opening with 3 pairs pseudanal setae (ps1-3), terminal.

Specimens examined. 4. MOLOKA'I I: Along road to Kamakou Preserve, about 200 m, 16.VII.1989, ex dry Kiawe bark, S.F. Swift (3 females); HAWAI'I I: Hawaii Volcanoes National Park, east slope of Mauna Loa, Power Line Area,

1490 m, 12.X.1973, ex pitfall associated with soil, J. Jacobi (1 female, 1 nymph).

Remarks. Raphignathus aethiopicus specimens from the Hawaiian Islands agree generally with the redescription of R. aethiopicus by Meyer and Ueckermann (1989). The peritremes in the Hawaiian specimens are directed caudad whereas the South African specimens, as illustrated, loop laterally and then bend anteriorly hugging the cheliceral bases. Meyer and Ueckermann had not mentioned the presence of cupules, which the Hawaiian specimens possess. The cupule ip usually is located on the anterior lateral corner of the opisthosomal plate, but in this species, the pair is located on the striated area, anterolaterad of the opisthosomal plate.

One specimen has 5 infracapitular setae, 3 on one side, 2 on the other side, arranged transversely, a deviation from the usual 2 pairs. Until the type specimen and materials from South Africa are examined the Hawaiian specimens are assigned to this species.

Family Stigmaeidae Oudemans, 1931

Stigmaeidae Oudemans, 1931: 252; Summers, 1966: 231; Wainstein, 1978: 153; Kethley, 1982: 138; Kuznetzov and Petrov, 1984: 101; Ueckermann and Meyer, 1987: 371; Meyer and Ueckermann, 1989: 42.

Type genus: Stigmaeus Koch, 1836.

Diagnosis. Adnate or fused cheliceral bases; stigmata and peritremes absent; idiosoma ovoid, fusiform or in-between; platings on dorsum variable; fusiform idiosoma usually weakly sclerotized; dorsal body setae vary from 12 to 14 pairs; palpal thumb-claw present, well-developed usually with an accessory claw or seta at its base; palptarsus bears either a tridentate, bidentate, a simple spine or 4 eupathidial setae on its apex; coxal fields II and III usually separate; genital and anal openings either separate or coalesced.

Remarks. Although Koch (1836) proposed the genus Stigmaeus which was followed by Berlese (1882-1893), this family had its beginning when Oudemans (1927) provided the first comprehensive key to the raphignathoid group of mites which then comprised but one family, the Raphignathidae Kramer, 1877. His key proved unworkable because of complex quantitative judgement of anatomical details and inclusion of genera like Storchia Oudemans, Caligonus Koch, Podaia

Oudemans and Homocaligus Berlese which were classified dubious at the time (Summers 1966). Three years later, Oudemans (1931) proposed the family Stigmaeidae with Stigmaeus Koch as type genus. Baker and Wharton (1952) synonymized Stigmaeidae with the family Raphignathidae. Gonzalez (1965) formulated the first key to the genera of the family and Summers (1966) illustrated the characteristic idiosomal plates and setae of representative species of the different genera in the family. Aside from Gonzalez (1965) and Summers (1966), Wood (1967), Wainstein (1978) and Tseng (1982) have provided keys to genera in the family that stabilize the current generic concepts.

Members of the family Stigmaeidae comprise 60% of the named raphignathoid species. There are approximately 250 species in 21 genera currently known worldwide. According to Kethley (1982), the family is a heterogeneous assembly of three lineages, with close affinity to the families Barbutiidae, Eupalopsellidae and Homocaligidae.

Stigmaeids occur in a wide variety of habitats. The genera Zetzellia, Agistemus and Mediolata contain species that are predators of phytophagous mites in orchard crops. Zetzellia mali (Ewing) feeds on spider mite species in North America, Europe and Israel (Jeppson et al. 1975). Aside from what had been observed of Agistemus in other places, here in the Hawaiian Islands, Agistemus congolensis Gonzalez-Rodriguez was observed feeding on tenuipalpid mites

on Anthurium. Agistemus and Mediolata species have been reported preying on spider mites and other arthropods on orchard crops in various parts of the world (Gonzalez-Rodriguez 1965, Summers 1966, Jeppson et al., 1975). Studies of their ecologies indicate that most species are predaceous on phytophagous mites of the families Tetranychidae, Tenuipalpidae, Eriophyidae and Tarsonemidae (Ehara 1983, Collyer 1964, Santos 1976, Laing and Knop 1983, Gerson and Smiley 1991) and are seriously being considered for future use in biological control programs (Gerson, personal communication, 1991).

Three species of Stigmaeus and 3 species of Eustigmaeus are associated with phlebotomine and crane fly species (Abonnenc 1970, Chaudhri 1965, Mitra and Mitra 1953, Hirst 1926). Eustigmaeus sinai Swift, 1987, is a parasite of Phlebotomus spp. in Egypt, Saudi Arabia and India. Most known species live in moss, litter, soil, bark of trees and are assumed also to be predators. Habeeb (1958, 1961) recorded a few species from aquatic or semi-aquatic habitats. Eustigmaeus frigida (Habeeb) feed on mosses (Gerson 1972).

This family is cosmopolitan.

Key to Genera of Stigmaeidae

(Based on Females)

1. Hysterosoma partially or completely covered by 1 or more dorsal plates; prodorsal and hysterosomal plates separate or fused.....2

- Hysterosoma without dorsal plates; platelets (small plates) may be present at bases of setae but none bears more than 1 seta.....17

2(1) Prodorsal and hysterosomal plates fused; dorsal setae borne on tubercles; setae c2 borne on independent plates or elaborated with dorsal plate.....3

- Prodorsal and hysterosomal plates not fused; dorsal setae not borne on tubercles; setae c2 invariably borne on independent plates or on prodorsal plate.....4

3(2) Setae c2 borne on independent plates; one pair dorsocentral setae present (c1); coxal field II with 2 setae.....Mendanaia Wood, 1971

- Setae c2 borne on elaborated dorsal plate, pleural region; two pairs dorsocentral setae present (c1, d1); coxal field II with 1 seta.....Mullederia, Wood, 1964

4(2) Chelicerae partly or fully fused.....5

Chelicerae free.....6

5(4) Chelicerae fully fused; sci absent.....Postumius Kuznetzov, 1976

- Chelicerae partly fused;

sci present.....Cheylostigmaeus Willmann, 1951

6(4) Dorsum with 9-16 plates.....7

- Dorsum with less than 9 plates.....9

7(6) Hysterosomal dorsal plates not transverse; 3 to 4 pairs of setae on prodorsal plate; setae e2 may or may not be on median hysterosomal plate.....8

- Hysterosomal dorsal plates transverse; 4 pairs of setae on prodorsal plate; setae e2 only on a single transverse plate.....
.....Villersiella Willmann, 1953

8(7) Maximum number of setae on median hysterosomal plate 4 pairs; median plates somewhat represented by 1-3 pairs of smaller plates; dorsal setae e1-2 never on separate plates.....Zetzellia Oudemans, 1927

- Maximum number of setae on median hysterosomal plate 3 pairs; median plate comprise of either 1 large median plate only or 1 large median plate 2 smaller zonal plates; setae e1-2 invariably occur on different plates.....Stigmaeus Koch, 1836

9(6) Median hysterosomal plate bears 5 pairs of setae; prodorsal plate with 3 pairs setae.....10

- Plates on hysterosoma variable; prodorsal plate with 3-4 pairs of setae.....11

10(9) Setae f1 on independent plates; setae d2 on large median median plate, not isolated

on independent plates.....Agistemus Summers, 1960

- Setae f1 present on large median plate; setae d2 on independent plates....Villersia Oudemans, 1927

11(9) Prodorsal plate with 4 pairs setae; c2 on independent plates; dorsal setae may or may not be on tubercles; palptibia of normal length; c1, d1 on communal plate.....12

- Prodorsal plate with 4 pairs of setae including c2; dorsal setae may or may not be on tubercles; palptibia long or of normal length; c1, d1 on communal plate.....13

12(11) Hysterosomal plate large, without transverse suture; dorsal plates usually strongly ornamented.....Eustigmaeus Berlese, 1910

- Hysterosomal plate with transverse suture; setal pairs e1, e2, f1 all borne on a common plate.....Ledermuelleriopsis Willmann, 1951

13(11) Dorsal setae on tubercles; palps elongate, palptibia at least 4 times the length of palpal tarsus.....Mecognatha Wood, 1967

- Dorsal setae not borne on tubercles; palps not elongate, length of palpal tibia less than or equal to length of palpal tarsus.....14

14(13) Setae c1, d1 on communal plate; d2 not on communal plate; setae h1, h2, f2 on communal plate.....15

- Setae d2 on communal plate with c1, d1; setae f2 absent.....16

15(14) Globular or pyriform; palptarsus terminates with 4 eupathidia.....Prostigmaeus Kuznetzov, 1984

- Fusiform; palptarsus terminates with eupathidia fused into a three-pronged trident.....Macrostigmaeus Berlese 1910

16(14) Setae c2 inserted on prodorsal plate with vi, ve, sce; postocular body present.....Mediolata Canestrini, 1890

- Setae c2 inserted ventrally; sci borne on individual plates posterolaterad of the prodorsal plate; coxal field IV with 2 setae.....Paravillersia Kuznetzov, 1976

17(1) Coxal field II each with 1 seta; femur I with 4 or 5 setae; genu IV nude; palpal genu with 1 seta.....18

- Coxal field II each with 2 setae; femur I with 6 setae; genu IV with 1 seta; palpal genu with 2 setae.....21

18(17) Pretarsi I-IV each with paired claws and an empodium.....19

- Pretarsi I-IV each without paired claws; arolium and empodium present..... .....Pilonychiopus Meyer, 1969

19(18) Prodorsal region with only 3 pairs

of setae present anterad of c1-c2; 1 pair of suranal plates, each plate with h1, h2.....
.....Parastigmaeus Kuznetzov, 1984

- Prodorsal region with 4 pairs of setae present anterad of c1-c2; 1 pair of suranal plates, each plate with h1, h2.....20

20(19) Dorsal setae on individual platelets except h1, h2.....Storchia Oudemans, 1923

- Dorsal setae not on individual platelets.....Eryngiopus Summers, 1964

21(17) Genu II with 3 setae, genu III with 1 seta; palpgenu with 4 setae; palptarsal eupathidia terminating in a single rod.....Pseudostigmaeus Wood, 1967

- Genu II with 2 setae, genu III nude; palpgenu with 2 setae; palptarsal eupathidia trident shaped.....Summersiella Gonzalez, 1967

Genus Storchia Oudemans

Storchia Oudemans, 1923: 150; Wood, 1973: 88; Ueckermann and Meyer, 1987: 394; Meyer and Ueckermann, 1989: 50.

Type species: Caligonus robustus Berlese, 1885.

Apostigmaeus Grandjean, 1944: 105; Summers, 1964: 184; Summer, 1966: 243; Wood, 1967: 115; Meyer, 1969: 230.

Type species: Apostigmaeus navicella Grandjean, 1944.

Diagnosis. Dorsum with 13 to 14 pairs of dorsal setae (f2 absent or present)(h3 of other authors); dorsal plating confined to an elongate propodosomal plate with setae vi, ve, a divided suranal shield, and individual platelets around bases of most dorsal setae; eyes absent; anal and genital covers with common opening, 3 pairs anal setae, 3 pairs genital setae and 3 pairs aggenital setae; palptarsus with 4 eupathidia on apex.

Remarks. Oudemans (1923) proposed the genus Storchia for two species: Caligonus robustus Berlese, 1910 and Stigmaeodes elongatus var. longipilis G. Canestrini, 1890. The second species is now in the genus Stigmaeus (Wood, 1973). Wood (1973) synonymized Apostigmaeus navicella Grandjean, 1944, with Storchia robustus after he compared Berlese's (1885) illustrations of C. robustus and Grandjean's A. navicella and found them to be conspecific. This genus has been defined by Grandjean (1944), Summers (1964) and Wood (1967).

Currently, the genus has two nominate species: Storchia robusta (Berlese, 1910) and Storchia pacifica (Summers, 1964). S. robusta is known from the Palaearctic, Afrotropical and Australian regions; S. pacifica from the Oriental, Australian and Neotropical regions. Both species are found in the Hawaiian Islands. New Zealand is the only other place where the two species were recorded.

Storchia robusta (Berlese) Figure 91

Caligonus robustus Berlese, 1885: fasc. 22(4).

Stigmaeus robustus (Berlese), Berlese, 1910: 204

Storchia robusta (Berlese), Oudemans, 1923b: 150; Wood, 1973: 89; Ueckermann and Meyer, 1987: 394; Meyer and Ueckermann 1989: 51.

Apostigmaeus navicella Grandjean, 1944: 105; Meyer and Ryke, 1960: 226; Wood, 1967: 115; Meyer, 1969: 231.

Diagnosis. Female. Length of body (excluding gnathosoma, ranges of 3 females) 310-334; width 176-212. Palplength (from trochanter base to tip of tarsus) 62-64; number of setae from palpfemur to palptarsus: 3-2-3-9. Length (excluding coxae) of legs I-IV: 119-126; 95-105; 105-126; 117-119; number of setae on leg segments I-IV (special sensillae in parentheses): tarsi 14(w)-10(w)-8(w)-8(w); tibiae 6(op)-6(op)-6(op)-6(op); genua 5(k)-3-2-2; femora 4-4-3-2; trochanter 1-1-1-1; coxae 2-2-2-1; length of wI-WIV: 14-16; 10-11; 7; 7.

Dorsum striated except elongate propodosomal plating bearing vi and ve and the suranal plate bearing h1 and h2; platelets around bases of dorsal setae; cupule ip present; 14 pairs dorsal setae including c2 and f2 located ventro-lateral of idiosoma; finely pilose dorsal setae; 4 pairs setae on venter; 3a long, flagelliform; 3 pairs aggenital setae; anal opening terminal, ps1-3 finely setose.

Specimens examined. 3. O'AHU I: North Halawa Valley, lower elev., 19.X.1990, ex dry Christmas Berry tree bark, S. Swift (3 females).

Remarks. The genital setae of the Hawaiian specimens vary in number. Of the 3 specimens examined, not one has symmetrical 3 setae on each plate but rather 2 or 4 on one plate and 3 on the other. Tarsus IV has 7 tactile setae and 1 solenidion compared to Grandjean's 8 setae and 1 solenidion. The New Zealand form does not have observable platelets around bases of cl, dl and el (Wood 1967), which the Hawaiian materials possess.

Grandjean (1944) gives an excellent description and illustrations of this species based on specimens from France and Corsica. This species is also known from Namibia, Swaziland, South Africa (Meyer and Ueckermann 1989), New Zealand (Wood 1967), and the Solomon Islands (Wood 1971).

Storchia pacifica (Summers) Figure 91

Apostigmaeus pacificus Summers, 1964: 184.

Holotype: female, INDONESIA (intercepted at Hawaii), Sept. 12, 1961, H.A. Woolford and B.F. Wetzel, on Oryza sativa.

Storchia pacifica (Summers, 1964). Meyer and Ueckermann, 1989: 51.

Diagnosis. Female. Length of body (excluding gnathosoma) 461; width 315. Palplength (from trochanter

base to tip of tarsus) 121; number of setae from palpfemur to palptarsus: 3-2-2-9. Length (excluding coxae) of legs I-IV: 235; 163; 211; 244; number of setae on leg segments I-IV (special sensillae in parentheses): tarsi 14(w)-9(w)-7(w)-7(w); tibiae 6(op)-6(op)-6(op)-6(op); genua 6(k)-5(k)-3-3; femora 4-4-3-3; trochanters 1-1-2-1; coxae 2-2-2-1; length of wI 10.

Dorsum striated except for faintly reticulated rectangular propodosomal plate bearing setae vi, ve anteriorly and suranal plate with h1 and h2; 13 pairs of dorsal setae, plumose, 29-60 long, vi shortest, h2 longest, on individual platelet; f2 absent; cupule ip laterad of f1; 4 pairs aggenital setae (ag1-4); 2 pairs genital setae (g1-2); 3 pairs pseudanal setae (ps1-3), 33-43 long.

Specimens examined. 1. O'AHU I: Honolulu, Alber's Mill, 27.IV.1972, on stored feed, D. Tsuda (1 female).

Remarks. Examination of the type of Storchia pacifica (Summers, 1964) revealed that tibia I has an extra special sensillum (o), which the O'ahu specimen does not possess. Aside from this variation, the condition of dorsal plates and setae, the presence of cupule ip and absence of f2 (h3 of Meyer and Ueckermann 1989), the O'ahu specimen resembles the type specimen.

Storchia pacifica can be separated from S. robusta by the shape of the propodosomal plate (rectangular in S. pacifica, club-shaped in S. robusta), absence of f2, 6-5-3-3

setal formula of femora [5-3(4)-2-2 for S. robusta] and by the plumose dorsal setae.

This is a first record of this species in the Hawaiian Islands. This species was initially intercepted in the Hawaiian Islands (O'ahu I, most likely) from Indonesia, Philippines, France and Tahiti, associated with Oryza sativa, Manihot esculenta, Avena sativa and Polianthus tuberosa. One specimen was collected on a porcupine (Coendu rothschildi) in Curundu, a fortuitous incident, according to Summers (1964). It is more accidental or abnormal than fortuitous.

Genus Eryngiopus Summers

Eryngiopus Summers, 1964: 186; Summers, 1966: 244; Wood, 1967: 111; Meyer, 1969: 231; Wainstein, 1978: 166; Ueckermann and Meyer, 1987: 394; Meyer and Ueckermann, 1989: 51.

Type species: Eryngiopus gracilis Summers, 1964.

Diagnosis. Idiosoma elongate, covered with fine striations, mostly longitudinal; dorsal shields restricted to small raised areas on propodosoma and suranal area on opisthosoma; dorsal setae 12-13 pairs, nude; ventral setae nude, flagelliform; palptarsus with simple or bifid terminal sensillum; empodium a slender shaft with 3 pairs capitate raylets.

Remarks. Vacante and Gerson (1987) provided a key to the 15 world species of Eryngiopus. Since then, Barilo (1987) described E. affinis from Uzbekistan found in soil under lucerne and Ueckermann and Meyer (1987) proposed E. parsimilis from Cape Province collected from various plants. Members of this genus are distributed in North America (California, Arizona, Florida), South Africa, New Zealand, Russia, Thailand, and in the Hawaiian Islands. The description of a new species from the Hawaiian Islands raises the number of species to 18 worldwide.

Tseng (1982) proposed a new genus, Eryngipusopis, very similar to Eryngiopus except for the presence of a sulcus between the propodosoma and hysterosoma and the absence of a propodosomal plate. It is very possible that this new genus is congeneric with Eryngiopus, and the definition of Eryngiopus should be modified to include the absence of propodosomal plate and the presence of a sulcus. Without seeing the type species, Eryngipusopis is placed here under Eryngiopus and is not included in the key to the genera of Stigmaeidae in this study.

Eryngiopus n. sp. A Figures 58, 59, 60, 88

Holotype. Female. HAWAI'I I: Hawaii Volcanoes National Park, Mauna Loa Transect, 2133 m, 16-17.VII.1972, ex Metrosideros bark, F. Haramoto and L. Nakahara.

Diagnosis. Closely related to Eryngiopus vagantis but it differs from it in having ultra long (125-135 microns) ventral setae, 2 pairs aggenital setae in one plate and differences in numbers of setae on coxa, genu and tarsus.

Description. Female (ranges of holotype and 9 female specimens in parentheses). Color in life reddish; length (including gnathosoma) 691(625-710); width 315(216-287).

Gnathosoma. Palplength (from trochanter base to tip of tarsus) 95-109 (Figure 59C); number of setae from palpfemur to palptarsus: 3-1-2-7; palptibial claw well developed, (18-21) long, almost as long as palptarsus, accessory seta slender, setaceous; palptarsus with a simple terminal spike.

Dorsum (Figure 58A). Propodosomal plate integral, longitudinal striae evident only in mid-posterior margin of plate; setae vi, ve, sci on faintly punctate plate; 4 propodosomal setae; dorsal setae ve, sce, c2, d2, f, h1, h2 longer (31-50), thicker than the rest (20-28); on individual platelets except h1 and h2, either on united (Figure 59G) or separated suranal plate (Figure 57A); 1 pair of diamond-shaped platelets between c1 and d1.

Venter (Figure 58B). Infracapitular setae n long 104(101-104), flagelliform; m short (40), aciculate; ventral setae 1a, 3a, 4a ultra long (holotype has 135, 135, 124 respectively)(100-130), flagelliform; endopodal plates on coxae I and II and coxae III and IV faintly punctate; 2 pairs aggenital setae (ag1-2); 4c present, anterior of

anogenital plate; 1 pair genital setae, long 59(56-61); 3 pairs pseudanal setae (ps1-3), shorter than genital setae 25(22-30).

Legs (Figures 59A, 59B). Length (excluding coxae) of legs I-IV: 198(182-214); 164(150-171); 171(148-176); 181(160-188). Number of setae on leg segments I-IV (special sensillae in parentheses): tarsi 14(w)-10(w)-8(w)-8(w); tibiae 6(op)-6(op)-6(op)-6(op); genua 4(k)-2-0-0; femora 5-4-3-2; trochanters 1-1-1-1; coxae 2-2-2-1. Famulus k on genu I minute, spine-like, similar to supracoxal ep, eI; coxal seta 2b ultra long, as long as 1a, flagelliform; tectal (tc) and fastigial (ft) setae on tubercles, wI 14(11-14) long, empodium as in Figure 58A.

Male (Figures 60A-D). 10. Length of body (including gnathosoma) 484-536; width 193. Length (excluding coxae) of legs I-IV: 165-174; 132-136; 127-138; 127-152.

Slightly smaller and as described for female except for sex-associated features: male w present on tarsi I and II, male wI located posteriorly, long, reaching beyond ft; male wII and wII adjacent, male wII slightly longer; dorsal setae h1, h2 on single plate (Figure 60F), same plate extends ventrally, with 2 pairs of aggenital setae (Figure 60E); ps1 short, one-fourth length of ps3 (Figure 60F).

Specimens examined. 29. HAWAI'I I: Hawaii Volcanoes National Park (HAVO), Mauna Loa Transect, 2134 m, 23-24.III.1973, ex Metrosideros leaves, F. Haramoto and L.

Nakahara (14 females, 5 males); HAWAI'I I: HAVO, 2134 m, 23-24.III.1973, ex soil under Metrosideros, F. Haramoto and L. Nakahara (7 females, 1 male). KAUAI'I I.: Hono O Na Pali Natural Area Reserve, upper fringe, 1300 m, 18.II.1991, ex Metrosideros litter with soil, S.F. Swift (1 female); MOLOKA'I I: Kamakou Preserve, Pu'u Kolekole, 1200 m, VI.1990, ex Cibotium litter, R. Rathman (1 female).

Remarks. Eryngiopus n. sp. A is unique for having 2 setae on coxae II and for having ultra long (124-135), flagelliform 1a, 3a and 4a. E. vagantis Summers, 1964, its closest relative, has 1 seta each on coxa I and coxa II, and short 1a. Other differences are 10 setae (9 on E. vagantis) on tarsus II and 2 (1 on E. vagantis) setae on genu II. The relatively distinct punctation on the infracapitulum, chelicerae, coxae, endopodal plates, propodosomal and suranal shields and appendages also seem to be unique to this species.

One specimen from O'ahu I. on Casuarina bark has 1-2-2-2 coxal formula, otherwise it resembles the species in all aspects. Another specimen has a divided suranal plate.

This species is the most prevalent of the two Eryngiopus species in Hawai'i I. The Hawai'i specimens were collected from high elevation (1200-2138 m) transect in great abundance. Materials collected from Kaua'i and Moloka'i Islands are also from moist, high elevation areas but the number of individuals per sample is much lower.

Although collected in soil and in litter of Cibotium, leaves and bark of Metrosideros seem to be preferred habitats of the species; 56% from leaves, 38% from bark and 6% from soil under Metrosideros canopy.

Eryngiopus bifidus Wood Figure 89

Eryngiopus bifidus Wood, 1967: 114.

Holotype female from bark of Leptospermum scoparium, Dun Mountain track, Nelson, NEW ZEALAND, 700 M., 27.vi.1964, T.G. Wood. Vacante and Gerson, 1987: 393.

Diagnosis. Female. Length of body (including gnathosoma) 396-437; width 148-207. Palplength (from trochanter base to tip of tarsus) 55-60; number of setae from palpfemur to palptarsus: 3-1-2-7. Length (excluding coxae) of legs I-IV: 112-131; 100-107; 93-109; 100-114; number of setae on leg segments I-IV (special sensillae in parentheses): tarsi 14(w)-10(w)-8(w)-8(w); tibiae 6(op)-6(op)-6(op)-6(op); genua 4(k)-0-0-0; femora 4-4-2-2; trochanters 1-1-1-0; coxae 2-1-2-1.

Dorsum with two raised elongate propodosomal plates, arranged as inverted V bearing vi, ve and eyes; suranal plate united bearing h1 and h2 pairs of setae; setae vi, c1, d1, e1, e2, 12-18 long; ve, sce, c2, d2, h1, h2, 24-29 long; sci, f1, 16-20 long; dorsal setae simple, aciculate, appearing faintly barbed; infracapitular seta n ultra long

(54), m short (19); 1a 67, 3a 35, 4a, 48 long; 2 pairs paragenital setae, gl 33-38 long, ps1-3 11-21 long, ps3 longest of the range; palptarsus with short, rod-like lateral solenidion and forked terminal eupathidium.

Specimens examined. 18. HAWAI'I I: Hawaii Volcanoes National Park (HAVO), Mauna Loa Transect, 2012 m, IX.1972, ex Metrosideros bark (8 females); HAWAI'I I.: HAVO, Mauna Loa Transect, 2012 m, 23-24.III.1973, ex Metrosideros bark (1 female); HAWAI'I I: HAVO, Mauna Loa Transect, 1890 m, 13-16.VI.1972, ex Metrosideros bark (1 female); HAWAI'I I: HAVO, Mauna Loa Transect, 2133 m, 13-15.VI.1972, ex Metrosideros bark (1 female); HAWAI'I I: HAVO, Mauna Loa Transect, 1676 m, 13-15.VI.1972, ex Metrosideros bark (1 female); HAWAI'I I, HAVO, Mauna Loa Transect, 1676 m, 17-18.XI.1972, ex Metrosideros leaves (1 female); HAWAI'I I: HAVO, Mauna Loa Transect, 1676 m, 23-24.III.1973, ex Metrosideros leaves (1 female); HAWAI'I I: HAVO, Mauna Loa Transect, 2438 m, IX.1972, ex Metrosideros bark (2 females); HAWAI'I I: HAVO, 2438 m, IX.1972, ex Metrosideros leaves (1 female); HAWAI'I I: HAVO, 2438 m, IX.1972, ex duff (1 female). All specimens collected by F. Haramoto and L. Nakahara using Tullgren-Berlese funnels.

Remarks. With the exception of larger body size (396-437), the Hawaiian specimens are as described by Wood (1967) for E. bifidus from New Zealand. Vacante and Gerson (1987) placed a female specimen from Italy in this species but

variation in setal distances in the idiosoma cast some doubts to its placement. Summers'(1964) E. microsetus is very closely related to this species, the only difference is the presence of a spike-like, simple terminal sensillum in contrast to the distinct forked sensillum of E. bifidus. This last character is difficult to discern in poorly oriented specimens.

Genus Agistemus Summers

Agistemus Summers, 1960: 234; Gonzalez, 1965: 24; Summers, 1966: 240; Meyer, 1969: 256; Bolland and Ueckermann, 1984: 201; Ueckermann and Meyer, 1987: 381; Meyer and Ueckermann, 1989: 46.

Type species: Caligonus terminalis Quayle, 1912.

Diagnosis. Characterized by having 7 plates on the dorsum, 2 paired and 3 unpaired plates; propodosomal plate bears vi, ve, sce; median opisthosomal plate bears c1, d1, d2, e1, e2; humeral plate bears c2; intercalary plate bears f1; suranal united bearing h1 and h2; dorsal shields may be smooth or reticulate; 12 pairs of dorsal setae; aggenital setae 1 or 2 pairs; anal and genital covers with one opening; 1 pair genital setae; 3 pairs pseudanal setae (ps1-3); palptarsus with terminal trifid eupathidium. Males with integrated median opisthosomal and intercalary plates; male w present on tarsi I and II, smaller specimens.

Remarks. Gonzalez-Rodriquez (1965) believes the genus Agistemus represents an evolutionary line that probably evolved from the Zetzellia maori group of species, since the ontogeny of the dorsal plates is similar in both Agistemus striolatus Gonzalez and Zetzellia mali (Ewing). Wood (1967) agreed with Gonzalez-Rodriguez that the ontogenetic similarities are sufficient justification to enlarge the definition of Zetzellia to include all species under Agistemus. Meyer (1969) disagreed. She considered the evidence presented by Wood (1967) as proof of the ancestral position of Zetzellia, and Agistemus a derived group, characterized by an entire median hysterosomal plate bearing 5 pairs of setae.

In this study, Meyer's position is followed. Agistemus is an established large homogenous genus in the family Stigmaeidae, including species of agricultural importance. Tseng (1982) described Zetzellia litchii, Zetzellia longanae, and Zetzellia spinosa, all new species. Judging from Tseng's descriptions and illustrations, these Zetzellia species are placed in the genus Agistemus (sensu Meyer) in this study.

Thirty-six species are now known in the genus, distributed worldwide. They are recorded from the Nearctic, Neotropical, Afrotropical, Oriental, Australian, and the Palearctic region. Records from the Palearctic region are from Japan and Cyprus only.

Agistemus species are mostly arboreal. They are associated with prey mites in the families Tetranychidae and Tenuipalpidae, pests of economic plants. Agistemus congolensis Gonzalez-Rodriquez, 1965 is reported for the first time from Hawai'i I on Anthurium being ravaged by a tenuipalpid mite species.

Gonzalez-Rodriguez (1965) and Rossi de Simons (1967) provided keys to the genus Agistemus. Rossi de Simons' key is written in Spanish.

Agistemus terminalis (Quayle) Figure 86

Caligonus terminalis Quayle, 1912: 499; Banks, 1914: 57.

Mediolata terminalis (Quayle, 1912). Nesbitt, 1946: 15; Baker and Wharton, 1952: 205.

Agistemus terminalis (Quayle, 1912). Summers, 1960: 234; Ehara, 1962: 58; Gonzalez-Rodriguez, 1965: 29.

Zetzellia terminalis (Quayle, 1912). Tseng, 1982: 6.

Diagnosis. Female. Length of body (including gnathosoma, ranges of 5 females) 499-540; width 272-331. Palplength (from trochanter base to tip of tarsus) 94-102; number of setae from palpfemur to palptarsus: 3-1-2-7. Length (excluding coxae) of legs I-IV: 218-228; 200-202; 209, 204-216; number of setae on leg segments I-IV (special sensillae in parentheses): tarsi 13(w)-10(w)-8(w)-7; tibiae

6(op)-6(op)-6(op)-6(op); genua 4(k)-1-0-0; femora 5-4-2-2; trochanter 1-1-1-1; coxae 2-1-2-2.

Dorsal plates smooth, without ornamentation; dorsal setae with minute barbs, length 31-57, ve longest (50-57), h2 shortest (31); 2 pairs aggenital setae on single plate, plate with fine striation; 1 pair genital setae, long (33); 3 pairs pseudanals (ps1-3), subequal (18-19); genital and anal openings coalesced.

Specimens examined. 11. HAWAI'I I: Hawaii Volcanoes National Park (HAVO), east slope of Mauna Loa, 2135 m, 18.VII.1972, pitfall associated litter, J. Jacobi (1 female); HAWAI'I I: HAVO, P-0322 (1 female); HAWAI'I I: Mt. View, Hilo, 29.IV.1966, ex Cypress, F.H. Haramoto (1 female); HAWAI'I I: Kamuela, 16.VI.1966, ex Cypress, F.H. Haramoto (1 female); MAUI I: Kula, 9.IV.1960, ex Cupressus sp., F.H. Haramoto (1 female); MAUI I: Waiakea, Kealohou School, 13.VI.1966, ex Cypress, F.H. Haramoto (2 females); HAWAI'I I: Lapahoehoe Forest, 17.IX.1971, ex leaf of Acacia koa, C. Davis (2 females); HAWAI'I I: HAVO, 16.VI.1966, ex Pine conifer, F.H. Haramoto (1 female); HAWAI'I I: Keau Orchard, IV.1972, ex Macadamia flower, E. Raros (1 female).

Other Specimen examined. 1. GEORGIA: Tifton, 30.IX.1976, on Pecan, D. Boethel (1 female).

Remarks. The 2 pairs of aggenital setae seem to appear in a single plate laterad of the anogenital opening but a closer look shows fine striations separating the platelet

ag1 from ag2. Lateral and ventral setae of tibiae and tarsi I and II are not all nude as Gonzalez-Rodriguez maintained; the Hawaiian specimens have sparsely barbed laterals and ventrals.

Agistemus terminalis was recorded from the Hawaiian Is. as early as 1965 when Gonzalez-Rodriguez included materials collected by F.H. Haramoto in his study of the genus Mediolata, Zetzellia and Agistemus. Garrett and Haramoto (1967) and Goff (1987) listed the species from the the islands of Hawai'i, Maui, and O'ahu from Monterey pine, cypress, and Jasminum sp. leaves respectively.

This species is recorded from the Nearctic, Neotropical, Oriental, and Palearctic regions.

Agistemus congolensis Gonzalez-Rodriguez Figure 61, 86

Agistemus congolensis Gonzalez-Rodriguez, 1965: 51.

Holotype female, on Vitex congolensis, Stanleyville, CONGO, April 18, 1955, E.W. Baker; USNM No. 2927. Ueckermann and Meyer, 1987: 383; Meyer and Ueckermann, 1989: 48.

Diagnosis. Female (ranges of 4 females). Length of body (including gnathosoma) 363-508; width 207-282. Palplength (from trochanter base to tip of tarsus) 88-93; number of setae from palpfemur to palptarsus (Figure 60B): 3-1-2-7. Length (excluding coxae) of legs I-IV: 194-221; 148-202; 171-195; 182-207; number of setae on leg segments

I-IV (special sensillae in parentheses): 13(w)-9(w)-8(w)-7; tibiae 6(op)-6(op)-6(op)-6(op); genua 4(k)-1-0-0; trochanters 1-1-1-1; coxae 2-1-2-2.

Smooth plates, without ornamentation (Figure 61A); dorsal setae strong, barbed, blunt-tipped, with bifid or trifid ends, all on tubercles (Figures 61A, 61C); ve longest 67-74, h2 shortest 21-24, h1 38-40, others 48-69; 2 pairs aggenital setae, aciculate, with fine barbs (Figure 61D); g1 slightly longer (16) than ps1-3 (14), all finely barbed; ps1 stronger; femora and genua of legs I and II with strong, barbed mesal setae as in dorsum, laterals short, barbed, but not as developed; anal and genital openings coalesced (Figure 61F). Male smaller in size, length 371; width 197; legs proportionally shorter than female; length of e1, h1 much reduced (21, 12); ps1 reduced to a spike.

Specimens examined. 5. HAWAI'I I: Panaewa, 12.IX.1986, ex Anthurium with tenuipalpid mites, A. Hara (4 females, 1 male).

Remarks. This species is distinctive in that the dorsal setae are strongly barbed with bifid or trifid ends on smooth plates, setae ve longer than other dorsal setae, and most dorsal setae are longer than their next consecutive setae. It is closely similar to A. floridanus Gonzalez-Rodriguez, 1965, in the condition of the dorsal setae and leg chaetotaxy but differs in the shorter, relatively uniform length of the dorsal setae, and that d2 is less than

distance d2 to e2. Figure 61E shows genu I of the female type of A. congolensis.

The Hawaiian specimens vary in that the dorsal setae are longer, bases slightly inflated and the aggenital setae (ag1-2) located on a single plate.

This is the first time this species is reported outside of Zaire (formerly Congo) on Vitex congolensis and Macaranga sp.

Genus Ledermuelleriopsis Willmann

Ledermuelleriopsis Willmann, 1951: 140; Willmann, 1953: 487.

Type species: Ledermulleriopsis triscutata Willmann, 1951 (by original designation).

Ledermuelleriopsis Willmann. Summers, 1957: 53; Summers, 1966: 235; Wood, 1967: 133; Wainstein, 1978: 160; Tseng, 1982: 42; Ueckermann and Meyer, 1987: 390; Meyer and Ueckermann, 1989: 50.

Diagnosis. Dorsum covered with 4 plates: propodosomal, metapodosomal, opisthosomal and suranal plates. Setae vi, ve, sci, sce on propodosomal; c1, d1, d2 on metapodosomal; e1, e2, f1 on opisthosomal and h1, h2 on suranal plates; c2 on humeral plate.

Remarks. According to Summers (1966), the founding of this genus has an unusual chronology. Willmann merely named (not described) the genus and type species, Ledermuelleriopsis triscutata, in his first publication

(1951) but in the same publication the second species listed, L. plumosus, was described. The definition of the genus and the description of the type species did not appear until two years later (1953). This genus is similar to Ledermuelleria (now a synonym of Eustigmaeus) in most characters, the main difference being the divided hysterosomal plate in Ledermuelleriopsis. Application of this character however can only be used with certainty on mature females. Some deutonymphs (E. rhodomela, E. schusteri, E. pectinata) and males of some species (E. parviseta, E. otavii, E. kauaiensis) of Eustigmaeus have a transverse sulcus across the midsection of the hysterosoma dividing the plate as in Ledermuelleriopsis.

Nine species are known currently in the genus. One Afrotropical, 2 Palearctic, 1 Nearctic and Palearctic, 2 Oriental, 2 New Zealand and 2 species from Syria.

Ledermuelleriopsis n. sp. A Figures 62, 63, 64, 89

Holotype. Female. KAUA'I I: Kuia Natural Area Reserve, Nualolo Trail, 890 m, 27.IX.1990, ex litter in Metrosideros tree hole, S.F. Swift.

Diagnosis. This species is unique in having 9 pairs of round to oval anomalous dimples and rod-like dorsal setae with average length spines.

Description. Female (ranges of holotype and 9 female specimens in parentheses) Length of body (including gnathosoma) 372(372-430); width 209(207-224).

Gnathosoma (Figures 63A-B). Palplength (from to trochanter base to tip of tarsus) 68(67-86); number of setae from palpfemur to palptarsus: 3-2-2-7; tibial claw well developed, long 14(15-17); accessory seta modified into a short, stout claw; palptarsus terminates with a eupathidium with long prongs, short stem; infracapitulum as in Figure 63A.

Dorsum (Figure 62A). Ornamentation of dorsum as in Figure 62C; 9 pairs of fossettes or anomalous dimples on propodosomal, metapodosomal and hysterosomal plates; one pair of eyes on propodosoma; 12 pairs of dorsal setae, rod-like and some slightly clavate, covered by whorls of spinules (Figure 62D); lengths of setae fairly uniform: f1, 29-34, c2, h1, h2, 19-27, others, 16-21; supracoxal setae ep, eI spine-like, podocephalic canal (cpc) terminates anteriorly in an opening-like cavity (Figure 63C).

Venter (Figure 62B). Endopodal plates fused in midline, faintly reticulate, setae 1a, 3a, 4a short, subequal (12); 3 pairs aggenital setae on wedge-shaped plate, faintly reticulate; anal and genital openings coalesced, genital setae absent, 3 pairs pseudanal setae.

Legs (Figures 64A-B). Length (excluding coxae) of legs I-IV: 132(131-140; 114(116-123); 123(119-125); 130(129-137).

Number of setae on leg segments I-IV (special sensillae in parentheses): tarsi 14(w)-10(w)-8(w)-7; tibiae 7(o,op)-6(op)-6(op)-6(op); genua 4(k)-4(k)-1-1; femora 6-4-3-1; trochanters 1-1-2-1; coxae 2-2-1-1. wI long (17) reaching beyond bases of tc; w absent on tarsus IV. Empodium as in Figure 64G.

Male (Figures 64C-F). Length of body (including gnathosoma) 232; width 170. Length (excluding coxae) of legs I-IV: 131; 119; 119; 129.

Smaller than female; opisthosoma tapered; some dorsal setae shorter than female; f1 longest dorsal seta (34); 2 pairs aggenital setae on suranal plate extension on venter; ps1 reduced to a spine, ps3 longest; tarsi I-III with w male, enlarged, long (26); tarsus IV with w male, also long (19). Genitalia as in Figure 63D.

Specimens examined. 7. KAUA'I I: Kuia Natural Area Reserve, Nualolo Trail, 890 m, 27.IX.1990, litter in Metrosideros tree hole, S.F. Swift (6 females, 1 male).

Remarks. Ledermuelleriopsis n. sp. A is unique in the possession of anomalous dimples on the dorsal plates and the immediate area along the two idiosomal sutures lack reticulations and dimples much like the anomalous dimples. However, it is similar to L. plumosa Willmann (as redescribed by Summers, 1957) in many respects: scapular c2 is aciculate, covered with barbs, palpal setation is 3-2-2-7, genu II has famulus k, and presence of 3 aggenital setae.

Ledermuelleriopsis spinosa Wood, 1967, from New Zealand is another species that can be mistaken for Ledermuelleriopsis n. sp. A but it can be distinguished by the 3-2-4-7 palpal setation and the absence of k on genu II.

Summers (1957) provided an excellent description of the male genital organ of the genus, which the male of this species resembled.

Ledermuelleriopsis n. sp. B. Figures 65, 66, 89

Holotype. Female. HAWAI'I I: Hawaii Volcanoes National Park, Mauna Loa Transect, 2134 m, IX.1972, ex duff, F. Haramoto and L. Nakahara.

Diagnosis. Resemble closely Ledermuelleriopsis spinosa and L. n. sp. A, but the presence of k on genu II and 3-2-2-7 palpal chaetotaxy separate it from the former and lack of anomalous dimples on the dorsal plates and the clavate dorsal setae distinguish it from the latter.

Description. Female (ranges of holotype and 5 female specimens in parentheses). Length of body (including gnathosoma) 362(362-461); width 182(197-235).

Gnathosoma (Figure 65C). Palplength (from trochanter base to tip of tarsus) 73(73-78); number of setae from palpfemur to palptarsus: 3-2-2-7; tibial claw developed, stout, 14 (14-16) long; accessory seta short, stout; palpfemur slightly inflated, dorsal seta plumose; palptarsus

longer than claw, trifid eupathidium with long prongs at apex.

Dorsum (Figure 65A). Dorsal ornamentation as in Figure 65A; dimples shallow, irregularly shaped; 30-40 punctations or vacuoles in dimples when discernible; 13 pairs dorsal setae, short, clavate, distal end with long whorls of spinules (Figure 65D); f1, h1, h2, 26-35; c2, e1, e2, 18-29; others, 16-26; humeral seta c2 clavate, plumose.

Venter (Figure 65B). Endopodal plates around coxae I and II and coxae III and IV entire, reticulation absent or with faint reticulation; 1a, 3a, 4a short, aciculate setae, subequal (14); 3 pairs aggenital setae, hair-like, short (8-11), on wedge-shaped plate; ps1 thickened, pilose (18), ps2-3 finely barbed, subequal (15).

Legs (Figures 66C-D). Length (excluding coxae) of legs I-IV: 128(128-150); 112(114-129); 128(119-138); 132(123-148). Number of setae on leg segments I-IV (special sensillae in parentheses): tarsi 14(w)-10(w)-8(w)-7; tibiae 7(o,op)-6(op)-6(op)-6(op); genua 4(k)-4(k)-1-1; femora 6-4-3-2; trochanters 1-1-2-1; coxae 2-2-2-2. Dorsals on femora, genua and tibiae of leg I thickened, clavate or rod-like, plumose; famulus k on genua I and II spine-like; one tc on tarsus II.

Male (Figures 66E-H). 5. Length of body (including gnathosoma) 309-371; width 150-188. Length (excluding coxae) of legs I-IV: 123-145; 103-126; 121-132; 123-150.

Slightly smaller than female; opisthosoma tapered; general features of setae and dorsal ornamentation as in female; extension of suranal plate on venter extensive, with 5 aggenital setae (2.5 pairs in drawing, Figure 66B); ps1 < ps2 < ps3, ps1 minute seta; base of aedeagus as shown (Figure 66A), attached to a slender shaft, anterior end expanded; all tarsi with additional w male, long (w male I 32, wI 17) reaching base of tc.

Specimens examined. 16. HAWAI'I I: Hawaii Volcanoes National Park (HAVO), Mauna Loa Transect, 2134 m, IX.1972, ex duff, F. Haramoto and L. Nakahara (1 female, 1 male); HAWAI'I I: HAVO, Mauna Loa Transect, 1676 m, 23-24.III.1973, ex soil under Metrosideros, F.H. Haramoto and L. Nakahara (1 male); HAWAI'I I: Natural Area Reserve, Laupahoehoe, ex moss on Cibotium, 25.IX.1988, M.L. Goff (2 females, 1 male); KAUA'I I: Kokee State Park, Kawaikoi Stream Trail, 1060 m, 27.V.1989, ex moss on Metrosideros stump, S.F. Swift (7 females, 3 males).

Remarks. This species is similar to Ledermuelleriopsis spinosa Wood, 1967, and L. ornata, Tseng, 1982 except that L. spinosa has palpal chaetotaxy 3-2-4-7 and one clavate dorsal seta present on each femora, genua and tibiae whereas in L. n. sp. B, only femora and genua on leg I possess this character, the rest have acicular dorsal setae. It is distinguished from L. ornata by the differences in chaetotaxy of femora, genua and tibiae: L. ornata has 4-4-3-

2 femora, 3-3-1-1 genua, and 6-6-5-5 tibiae while L. n. sp. B has 6-4-3-2 femora, 4-4-1-1 genua, and 6-6-6-6 tibiae.

One specimen from O'ahu I has very distinct punctations on dimples of idiosoma which are less discernible in other specimens. The specimens from Kaua'i I are larger and has proportionately longer dorsal setae. Faint reticulation on the endopodal plates is also discernible.

Genus Eustigmaeus Berlese

Stigmaeus (Eustigmaeus) Berlese, 1910: 206

Type species: Stigmaeus (Eustigmaeus) kermesinus Koch, 1841.

Eustigmaeus Berlese, Oudemans, 1923a: 143; Wood, 1973: 82; Tseng, 1982: 23; Ueckermann and Meyer, 1987: 385; Meyer and Ueckermann, 1989: 48.

Ledermuelleria Oudemans, 1923b: 150; Summers, 1957: 49; Meyer and Ryke, 1960: 216; Summers, 1966a: 233; Wood, 1967: 133; Meyer and Ueckermann, 1989: 48.

Type species: Caligonus segnis Koch, 1836.

Diagnosis. Red to straw-colored, globular, with stout legs and mouthparts; palp 5-segmented, with tridentate terminal eupathidium, palptibial claw well-developed, with small accessory seta at its base; dorsum with 3 unpaired, scultured plates: propodosomal with 4 pairs of setae, opisthosomal with 6 pairs, and suranal plate with 2 pairs; humeral plate triangular or so, usually large, located

ventrolaterally; 13 pairs dorsal setae including humeral and suranal setae; venter with 2 or 4 endopodal shields either entire or divided midventrally; anal and genital apertures united externally; 1 to 3 pairs aggenital setae, 3 pairs pseudanal setae on anogenital plates.

Remarks. For 50 years Eustigmaeus and Ledermuelleria were both recognized genera until Wood (1973) studied the stigmaeid species in the Berlese collection. Two specimens of Stigmaeus (Eustigmaeus) kermesinus (type species of Eustigmaeus) were discovered congeneric with species classified under Ledermuelleria and therefore, Wood synonymized the latter genus with Eustigmaeus. This situation was unfortunate as Ledermuelleria was well-known and was one of the stable genera in Stigmaeidae.

Eustigmaeus is known from every continent. Of the 56 known species, 14 are Nearctic, 9 Palearctic, 6 Neotropical, 7 Afrotropical, 6 Oriental, 3 Oceania and 11 New Zealand. Eustigmaeus microsegnis (Chaudhri, 1965) is a widely distributed species in the Palearctic, Nearctic, Oriental and Neotropical regions; eight other species are found in other geographic areas aside from regions in which they were originally described.

Eustigmaeus contains 4 species that are ectoparasites of phlebotomine flies; Stigmaeus is the only other genus with 3 species associated with the same flies (Chaudhri 1965, Swift 1987). Two species feed and reproduce on mosses

(Gerson 1972, Wood 1972, Flechtmann 1985). Generally, members of this genus are found in soil, litter, lichen, moss, and on bark and leaves of plants.

Eustigmaeus n. sp. A Figures 76, 87

Holotype. Female. HAWAI'I I: Kohala, Waimanu Valley, moss on rocks, 24.IX.1988, M.L. Goff.

Diagnosis. Easily distinguished by its nude long dorsal setae on ornamented idiosoma, distances between dorsal setae e1 farther apart than its closest relative, Eustigmaeus segnis.

Description. Female (ranges of holotype and 7 female specimens in parentheses). Length (including gnathosoma) 320(338-357); idiosoma 249(259-273); width 202(221-235).

Gnathosoma. Palplength (from trochanter base to tip of tarsus) 76(74-86) (Figure 76G); number of setae from palpfemur to palptarsus: 3-2-2-7; palptibial claw well-developed 15(17-19); accessory seta uncinate, curved towards primary claw; palptarsus with trifid, long stalked sensillum; chelicera/stylet ratio 1.5(1.3-1.8).

Dorsum (Figure 76B). Sclerotized, dimples irregularly shaped; condition of dimple as in Figure 76C; 13 pairs (including ventrally displaced c2) of long, nude, recurved, finely-tipped dorsal setae, on tubercles; middorsal setae vi, sci, c1, d1, e1, f1 longest, 64-83; vi, ve, c2, d2, e2,

40-69; h1, h2 shortest, 19-33; e1-e1 farther apart 86(79-100) than d1-d1 55(55-57).

Venter (Figure 76A). Setae 1a, 3a, 4a hairlike; endopodal plates entire around coxae I and II and coxae III and IV; both endopodal plates faintly reticulate, posterior margin of anterior plate with fine longitudinal striation, posterior plate with faint longitudinal striation on reticulated area; 1 pair aggenital setae on edge of indistinct anogenital plate, setae close together; 3 pairs pseudanal setae, ps1 slightly thickened, all faintly pilose. No distinct divisions of dorsal plates from humeral or suranal plates discernible.

Legs (Figure 76D-F). Length (excluding coxae) of legs I-IV: 143(143-155); 124(121-131); 131(133-143); 148(155-159). Number of setae on leg segments I-IV (special sensillae in parentheses): tarsi 14(w)-10(w)-8(w)-7; tibiae 7(o,op)-6(op)-6(op)-6(op); genua 4(k)-3-1-1; femora 6-5-3-2; trochanters 1-1-2-1; coxae 2-2-2-2. Coxal bases faintly reticulate; famulus k on genu II absent; solenidion o, op on tibia I adjacent proximally, wI long, reaching beyond tc; empodium as in Figure 76H.

Specimens examined. 8. HAWAI'I I: Kohala, Waimanu Valley, 24.IX.1988, ex moss on rocks, M.L. Goff (8 females).

Remarks. Eustigmaeus n. sp. A is closely related to E. segnis (as redescribed by Summers and Price, 1961) but is distinguished by the absence of spinules on the falciform

dorsal setae, arrangement of the setae on the hysterosoma and the relative distances of setae el and dl from each other. Compared to E. segnis collected from the Hawaiian Islands in this study, the aggenital setae are closer together, almost the same distance as the pseudanal setae are set from each other in the anogenital plate.

In this species, except for the superficial transverse line separating the propodosoma from the hysterosoma and the natural fold line separating the suranal plate from the opisthosoma, the idiosoma seems to be one piece of ornamented cuticle that includes the humeral and suranal shields. The fine striation around the legs is the only visible clue of the cuticular divisions in the venter (Figure 67A) and the indistinct placement of the small anogenital plate. The definition of the genus Eustigmaeus must then include species with humeral plates integrated to the seemingly fused propodosomal and hysterosomal plates and a suranal plate that appears to be integrated into the posterior opisthosomal plate. Summers and Price (1961) mentioned in their description of E. segnis that the "genital plate is flanked by ventral rami of suranal plate from which it is not distinctly separated." This characteristic of indistinct separation of sclerites is probably prevalent in the Eustigmaeus, only not often mentioned in narrative descriptions.

Eustigmaeus n. sp. B Figure 77, 87

Holotype. Female. O'AHU I: North Halawa Valley, lower elevation, 19.IX.1990, ex dry Christmas Berry tree bark, S.F. Swift.

Description. Female (ranges of holotype and 9 female specimens in parentheses). Length (including gnathosoma) 343(310-353); idiosoma 235(216-240); width 216(193-211).

Gnathosoma. Palplength (from trochanter base to tip of tarsus) 76(62-79) (Figure 77F); number of setae from palpfemur to palptarsus: 3-2-2-7; palptibial claw well-developed 14(15-17); accessory claw, minute; palptarsus longer than claw, with trifid sensillum; sensillum stalk long, prongs short; one strong, barbed dorsal seta on palpfemora.

Dorsum (Figure 77A). Ornamented, dimples irregularly shaped; condition of dimple as in Figure 77C; 13 pairs arcuate, barbed dorsal setae (Figure 77D), more or less uniform in length; h1, h2, 30-36, f1, 47-57, the others 40-52.

Venter (Figure 77B). Setae on venter hairlike; endopodal plate around coxae I and II entire, no reticulation discernible; endopodal plate around coxae III and IV entire except posterior half with longitudinal striation; 4a absent (Figure 77G); 1 pair aggenital setae on rectangular shaped plate anterior of anogenital plate; 3

pairs of pseudanal setae, short, finely barbed; humeral setae seemed fused to dorsal plates.

Legs (Figure 77E). Length (excluding coxae) of legs I-IV: 143(129-136); 129(119-121); 124(121-131); 138(129-143). Number of setae on leg segments I-IV (special sensillae in parentheses): tarsi 14(w)-9(w)-8(w)-7; tibiae 7(o,op)-6(op)-6(op)-6(op); genua 4(k)-3-1-1; femora 6-4-3-2; trochanters 1-1-2-1; coxae 2-2-2-2. Genua II lacking k; femora II with 4 setae; o on tibia I round tipped, sort of clavate, op located posterior of o; wI long, reaching bases of addorsal setae tc.

Specimens examined. 35. O'AHU I: North Halawa Valley, 19.IX.1990, dry Christmas Berry tree bark, S.F. Swift (10 females); KAUA'I I: Kalalau, Hanakapiai Stream Trail, 8.VII.1981, ex moss on rocks, M.L. Goff (7 females); KAUA'I I: Hono O Na Pali Natural Area Reserve, Kalalau Trail, near Waiahuakua Valley, 240 m, 4.IX.1991, ex Metrosideros bark, S.F. Swift (2 females); KAUA'I I: Kalalau Trail, 0-150 m, 20.IX.1990, ex dry Pandanus leaves, S.F. Swift (2 females); HAWAI'I I: Kohala, Waimanu Valley, ex moss on tree, 24.IX.1988, M.L. Goff (4 females); O'AHU I: Keaiwa Heiau State Park, Aiea Loop Trail, 4.VII.1990, ex moss on ground, S.F. Swift (3 females); O'AHU I: Keaiwa Heiau State Park, Aiea Loop Trail, 4.VII.1990, ex Eucalyptus bark, S.F. Swift (7 females).

Remarks. Another member of the "segnis" group (Summers and Price 1961), this species is distinct in the absence of 4a on the endopodal plates of the venter. Another species, Eustigmaeus capella Chaudhri, 1965, from El Salvador, also lacks 4a, but the two species are otherwise very different morphologically.

Certain variations occur in the species. Very faint reticulations on the endopodal plates are discernible in some specimens. Some dorsal setae seem to have a hyaline vane connecting all the spinules giving the setae a smooth lateral edge, feather-like, although the barbs are still visible. Reported from the islands of O'ahu, Kaua'i and Hawai'i, this species probably has state-wide distribution.

Eustigmaeus n. sp. C Figures 78, 79, 87

Holotype. Female. O'AHU I: Mariner's Ridge, 213 m, 3.VI.1990, ex Eragrostis variabilis, J. Strazanac.

Diagnosis. Similar to Eustigmaeus anauniensis (G. Canestrini, 1889)[= E. pectinatus (Oudemans, 1923)] but is separated by the shallow dimples on the dorsum, spinules on the dorsal setae on distal 1/2 to 2/3 of the setae and aciculate humeral setae.

Description. Female. Length (including gnathosoma) 414; idiosoma 306; width 221.

Gnathosoma (Figure 79C). Palplength (from trochanter base to tip of tarsus) 68; number of setae from palpfemur to

palptarsus: 3-2-2-7; segments thick, relatively short; palptibial claw well-developed, 19; accessory seta thick, short; trifid sensillum on palptarsus with long prongs, very short stalk; chelicera twice longer than wide; chelicera/stylet ratio 2.5.

Dorsum (Figure 79A). Ornamented; dimples irregularly shaped (Figure 69C), shallow with vacuoles discernible on lateral slope of idiosoma; 13 pairs dorsal setae (Figure 69D)(including ventrally displaced c2), rod-like except c2, h1 and h2, c2 aciculate, plumose; c2, f1, h1, h2, 26-32; others 17-21.

Venter (Figure 78B). Hairlike ventral setae; endopodal plates entire, reticulation absent or not discernible; 3 pairs hairlike aggenital setae on wedge shape plate, subequal; 3 pairs pseudanal setae, ps1 thick, barbed, ps2-3 hairlike, subequally short.

Legs (Figures 79A, 79B). Length (excluding coxae) of legs I-IV: 136; 114; 121; 131. Number of setae on leg segments I-IV (special sensillae in parentheses): tarsi 14(w)-10(w)-8(w)-7; tibiae 7(o,op)-6(op)-6(op)-6(op); genua 4(k0-4(k)-1-1; femora 6-4-3-2; trochanters 1-1-2-1(2); coxae 2-2-2-2. Famulus k on genu I and II minute; proximodorsals ft on tarsus I eupathidial; single tc on tarsus II, eupathidial.

Specimen examined. 1. O'AHU I: Kahala, Mariner's Ridge, 213 m, 3.VI.1990, ex Eragrostis variabilis, J. Strazanac (1 female).

Remarks. This species belongs to the "pectinata" group of Summers and Price (1961), characterized by having bushy dorsal setae and 3 pairs of genital setae. Actually, this group should be renamed the "anauniensis" group, as Ledermuelleria pectinata (Ewing, 1917) was synonymized with E. anauniensis (G. Canestrini, 1889) by Wood (1973). This species is similar to E. anauniensis (as described by Summers and Price, 1961) in leg chaetotaxy and distribution, relative lengths of dorsal setae, and by the undivided, non-reticulate endopodal shields. Eustigmaeus n. sp. C is separated from E. anauniensis by having irregularly shaped shallow dimples with less discernible vacuoles on each dimple, shorter spinules on rod-like dorsal setae with spinules on the distal 1/2 to 2/3 of setal length, and aciculate humeral setae (E. anauniensis has deep dimples with large vacuoles, dorsal setae club-shaped with longer spinules, and the humeral setae c2 similar to dorsal setae).

Eustigmaeus segnis (Koch) Figure 87

Caligonus segnis Koch, 1836: fasc. 5(10).

Raphignathus ruber Koch, 1842:56.

Raphignathus piger (Schrank). Berlese, 1885: fasc. 22(4).

Ledermulleria segnis (Koch). Oudemans, 1923b: 150; Feider, 1954: 363.

Ledermuelleria segnis (Koch). Summers, 1957: 50; Summers and Price, 1961: 371.

Eustigmaeus segnis (Koch). Wood, 1973: 87; Kuznetzov and Petrov, 1984: 103; Meyer and Ueckermann, 1989: 49.

Diagnosis. Female (ranges of 5 specimens). Length of body (including gnathosoma) 423-456; idiosoma 301-343; width 244-282. Palplength (from trochanter base to tip of tarsus) 69-71; number of setae from palpfemur to palptarsus: 3-2-2-7. Length (excluding coxae) of legs I-IV: 162-246; 157-209; 167-218; 183-246; number of setae on leg segments I-IV (special sensillae in parentheses): tarsi 14(w)-10(w)-8(w)-7; tibiae 7(o,op)-6(op)-6(op)-6(op); genua 4(k)-3-1-1; femora 6-5-3-2; trochanters 1-1-2-1; coxae 2-2-2-2; length of wI 21-24.

Dimples on dorsum circular to oval, with fine vacuoles; dorsal setae barbed, falciform, on short tubercles that appear round when mounted; length of setae long: c1, c2, d1, d2, e1, e2, 76-114; vi, ve, 64-100; sci, sce, 60-93; f1, 90-100; h1, h2, 48-69; palptarsus with sessile eupathidium; endocoxal plates united, plain or with faint reticulation; 1 pair aggenital setae widely spaced (69-72); 3 pairs pseudanal setae on posterior half of anogenital covers, ps1 thick, ps2-3 hairlike, all finely barbed.

Specimens examined. 29. HAWAI'I I: Hawaii Volcanoes National Park (HAVO), Mauna Loa Transect, 1676 m, 21.VII.1972, ex soil under Metrosideros (3 females); HAWAI'I I: HAVO, Mauna Loa Transect, 1676 m, 16-17.VII.1972, ex soil under Metrosideros (5 females); HAWAI'I I: HAVO, Mauna Loa Transect, 1676 m, 17-18.XI.1972, ex soil under Metrosideros (5 females); HAWAI'I I: HAVO, Mauna Loa Transect, 1676 m, 23-24.III.1973, ex soil under Metrosideros (4 females, 3 males); HAWAI'I I: HAVO, Mauna Loa Transect, 1707 m, IX.1972, ex duff (6 females, 3 males). All materials collected by F. Haramoto and L. Nakahara.

Remarks. The specimens from the Hawaiian Islands are as described by Summers, 1961 with 2 exceptions. The two variations noticeable in the materials from Hawaiian specimens are the extra long dorsal setae and the shallower dimples. Summers' measurements of the California materials, for example, are ve 72-80, el 74-80, fl 72-80 whereas the specimens from the islands have ve 71-100, el 86-114 and fl 90-100. The measurements were taken from the base to the tip of the curved seta (exception is el with 114 micron length, a straight setal measurement). A specimen of E. segnis identified by Summers was examined in this study. There are distinctive, deeper dimples in the California specimen than in the Hawaiian specimens as evidenced by pits on the lateral edges of the idiosoma. Generally the dimples are shallower in the studied materials, some specimens

however exhibit deeper pits on certain parts of the idiosoma comparable to Summers' specimen.

Wood (1973) suspected that early mite workers could have confused this species with E. microsegnis, which Berlese labeled also as Raphignathus piger (Schrank). Based on the study of characters of the Hawaiian species of E. segnis and E. microsegnis, these two species are undoubtedly valid species, distinguished by differences in details of dorsal ornamentation and dorsal setation, placement of e1 and e2 on the hysterosoma, length of setae and number of setae on femur II.

Eustigmaeus segnis from Kaua'i and Kure Atoll (Goff 1983, Swift et al. 1985, Goff 1987) are found to be other species in the genus. The specimens from Kure are E. microsegnis and those from Kaua'i are Eustigmaeus n. sp. B.

The type specimen of E. segnis was collected from Somalia (North Africa). North America (California) and the Central-Chernozem, Baltic Region are the other localities aside from the Hawaiian Islands this species has been reported.

Eustigmaeus microsegnis (Chaudhri) Figure 88

Ledermuelleria microsegnis Chaudhri, 1965: 473.

Holotype, female, Gravois Mills (12 mi. S.E.) Camden County, MISSOURI, Oct. 10, 1959, from moss, W.T. Atyeo (USNM). Wood, 1972: 303.

Eustigmaeus microsegnis (Chaudhri, 1965). Wood, 1973: 88; Tseng, 1982: 35.

Diagnosis. Female (ranges of 5 specimens). Length of body (including gnathosoma) 310-367; idiosoma 244-291; width 195-221. Palplength (from trochanter base to tip of tarsus) 64-70; number of setae from palpfemur to palptarsus: 3-2-2-7. Length (excluding coxae) of legs I-IV: 129-136; 112-117; 126-130; 132-140; number of setae on leg segments I-IV (special sensillae in parentheses): tarsi 14(w)-10(w)-8(w)-7; tibiae 7(o,op)-6(op)-6(op)-6(op); genua 4(k)-3-1-1; femora 6-4-3-2; trochanters 1-1-2-1; coxae 2-2-2-2; length of wI 19-21.

Dimples and vacuoles as illustrated by Chaudhri except shallower dimples and vacuoles not easily visible; dorsal setae arcuate, featherlike with wide vanes, on small tubercles; length of setae: vi 48-67; ve 60-74; d1, d2 60-71; e1, e2 52-74; f1 60-64; sci, sce, c1 48-60; c2 40-48; h1 36-45; h2 29; eupathidium on terminal palptarsus with short stalk, long prongs; endocoxal plates with faint reticulation; 1 pair aggenital setae; 3 pairs pseudanal setae.

Male. General features of setae and dorsal ornamentation as in female except for smaller size, shorter dorsal setae, and tarsi I-III with extra solenidion (w male), tarsus IV with a single solenidion (w male) and pseudanal setae on posterior end reduced in length.

Specimens examined. 23. HAWAI'I I: Hawai'i Volcanoes National Park (HAVO), Mauna Loa Transect, 1676 m, 23-24.III.1973, ex soil under Metrosideros, F. Haramoto and L. Nakahara (7 females, 3 males); HAWAI'I I: HAVO, 1707 m, IX.1972, ex duff, F. Haramoto and L. Nakahara (2 females); HAWAI'I I: HAVO, east slope of Mauna Loa, Power Line Area, 1493 m, 29.X.1972, on Acacia koa litter, J. Jacobi (2 females); HAWAI'I I: HAVO, Steam vent #2, Kilauea side, 7 cm, VIII.1984, M.L. Goff (3 females, 2 males); HAWAI'I I: HAVO, Kilauea, "Hot Spot," 22.XI.1970, ex moss on `Ohi`a stump, F. Haramoto (4 females, 1 male); MOLOKA'I I: Pu'u Kolekole, 1204 m, 15.VII.1989, ex pine litter and soil, S.F. Swift (1 female).

Remarks. Like Eustigmaeus segnis, this species from the Islands has shallower dimples but the ornamentation - vacuoles on the reticulation, punctation on the basin of the dimple is similar to the type. The "typical" form described by Chaudhri (1965) has wide vanes, the margins coarsely barbed, and on the vanes are present additional rows of blunt barbs. The Hawaiian specimens however vary in that the vanes are not as broad and although blunt barbs are discernible on the dorsal surface of some setae, the vanes are mostly smooth. Some specimens exhibited smooth vanes, with sparse minute barbs on the featherlike edges as in the "smooth form" (Wood 1972). Variations in the lengths of the various dorsal setae and their distances from each other

were observed from the Hawaiian materials. The endopodal plates are as described by Wood (1973). Femur II of the Hawaiian materials varies in that it does not have consistent number of setae; some specimens have 4 setae on one femur and 5 on the other, some with both femora with 4, most specimens with 5 setae as the North American specimens.

Eustigmaeus microsegnis has also been recorded from Europe, North America (California, Canada), Brazil and Taiwan.

Eustigmaeus kauaiensis Swift, Gerson and Goff Figure 88

Eustigmaeus kauaiensis Swift, Gerson and Goff, 1985. Holotype female (BPBM 13,430), allotype male (BPBM), 27 paratypes (13 females, 14 males), HAWAIIAN IS.: KAUA'I I: Kapaa, moss on Hau tree (Hibiscus tiliaceus L.), 1 m above ground, 26.IX.1980, M.L. Goff.

Eustigmaeus sp. nr. parviseta Goff,1983: ; Swift et al., 1985: .

Diagnosis. Female (ranges of 5 females). Length of body (including gnathosoma) 395-470; idiosoma 268-343; width 221-282. Palplength (from trochanter base to tip of tarsus) 55-67; number of setae from palpfemur to palptarsus: 3-2-2-7. Length (excluding coxae) of legs I-IV: 167-202; 129-162; 133-174; 150-198; number of setae on leg segments I-IV (special sensillae in parentheses): tarsi 14(w)-10(w)-8(w)-

7(w); tibiae 7(o,op)-6(op)-6(op)-6(op); genua 4(k)-4(k)-1-1; femora 6-5-3-2; trochanters 1-1-1-1; coxae 2-2-2-2; length of wI 26.

Details of setae and dorsal ornamentation for female and male as described by Swift, Gerson and Goff (1985).

Specimens examined. 17. O'AHU I: North Halawa Valley, near tunnel, 19.IX.1990, moss on rock in stream, S.F. Swift (1 female); HAWAI'I I: Honolii Stream, N of Hilo, 26.X.1990, moss on wet basalt walls of gorge, D. Polhemus (1 female); HAWAI'I I: Kohala, Kohala Ditch Trail, 24.IX.1988, moss on ground, M.L. Goff (5 females, 2 males); KAUA'I I: Hanakapiai Stream, 25.IX.1980, moss on rocks in stream, M.L. Goff (4 females, 4 males).

Remarks. Eustigmaeus sp. nr. parviseta (Goff 1983, Swift et al. 1985) from Kaua'i I. is actually E. kauaiensis. Some males and 1 female specimens do not possess pleural callosities, only the plates with faint striations are discernible. Eustigmaeus kauaiensis is similar to E. schusteri Summers and Price, 1961, and E. etruscus Berlese, 1910, in details of leg chaetotaxy and distribution, lengths of dorsal setae, and by the males having a reduced dorsomedian seta el. However E. kauaiensis may be distinguished from the two species by the presence of enlarged, irregularly shaped dimples in the median anterior propodosoma and by having a pair of elongated callosities on the pleural region between the eye and seta sce (E.

schusteri and E. etruscus have round or oval slightly raised callosities located between setae sci and sce).

This species is now known in the islands of O'ahu, Hawai'i and Kaua'i. Its habitation in moss whether in rocks at the middle of a stream or moss on a tree bark is indicative of its moisture preference. Specimens collected from moss at north Halawa Valley are green in color, possibly feeding on moss. Eustigmaeus species are known to feed and reproduce on mosses in Canada (Gerson 1972) and in Brazil, the first record of moss feeding Eustigmaeus species was reported by Flechtmann (1985).

Eustigmaeus ornatus Ueckermann and Meyer Figure 88

Eustigmaeus ornatus Ueckermann and Meyer, 1987: 388.

Holotype female from soil, Potchefstroom (Transvaal), SOUTH AFRICA, 20 August 1963, P.G. Olivier.

Diagnosis. Female (ranges of 10 females). Color in life red. Length of body (including gnathosoma) 315-371; idiosoma 249-291; width 188-268. Palplength (from trochanter base to tip of tarsus) 66-76; number of setae from palpfemur to palptarsus: 3-2-2-7. Length (excluding coxae) of legs I-IV: 114-155; 93-124; 95-124; 117-138; number of setae on leg segments I-IV (special sensillae in parentheses): tarsi 13(w)-9(w)-8(w)-7; tibiae 7(o,op)-6(op)-

6(op)-6(op); genua 4(k)-3-1-1; femora 6-5-3-2; trochanters 1-1-2-1; coxae 2-2-2-2; length of wI 19-21.

Dimples on dorsum irregularly shaped, with 20-40 vacuoles; dorsal setae lanceolate, serrate, on small tubercles; setae relatively long: vi 40-62, ve 55-62, sci 48-60, sce 53-60, c1 48-50, c2 48-52, d1 55-62, d2 50-57, e1 60-67, e2 51-55, f1 57-65, h1 36-38, h2 33-36; terminal eupathidium of palptarsus long stalked, prongs shorter; endopodal plates completely separated, plain, without reticulation; 1 pair aggenital setae on aggenital plate; 3 pairs pseudanal setae on anogenital plate, all finely barbed.

Male. General features similar to female only smaller (length of idiosoma 211-216, width 146-160); opisthosoma narrower; suranal plate extends to venter completely bearing 1 pair aggenital setae; pseudanal setae ps1-2 reduced to spikes; tarsi I-IV with w male, long, enlarged.

Specimens examined. 270. HAWAI'I I: Hawai'i Volcanoes National Park (HAVO), Mauna Loa Transect, 2438 m, 16-17.VII.1972, ex soil under Metrosideros (17), 21.VII.1972 (2), 17-18.XI.1972 (7), 23-24.III.1973 (15); 2334 m, 23-24.III.1973 (19); 2133 m, 16-17.VII.1972 (75); 2042 m, 16-17.VII.1972 (5); 2012 m, 17-18.XI.1972 (13), 23-24.III.1973 (7), 21.VIII.1972 (2); 1676 m, 16-17.VII.1972 (16), 17-18.XI.1972 (12), 23-24.III.1973 (3); 1219 m, 16-17.VII.1972 (11), 21.VIII.1972 (1), 17-18.XI.1972 (5), 23-24.III.1973

(2); MOLOKA'I I: Kamakou Preserve, Pu'u Kolekole, 1204 m, 15.VII.1989, grass roots and litter along stream nr. cabin (11), litter and moss along trail (9), moss on Styphelia (6); Kaunakakai, @ 200 m, 16.VII.1989, ex Kiawe bark (3); KAUA'I I: Kokee State Park, Kawaikoi Stream Trail, 1061 m, 27.V.1989, grass litter and soil, Vaccinium litter and soil (1), Pu'u O kila Trail, 1270 m, `Ohi`a bark with moss (1); Kuia Natural Area Reserve, Nualolo Trail, 890-1000 m, 27.XI.1990, ex Metrosideros bark (3). All specimens from Hawai'i I were collected by F. Haramoto and L. Nakahara; specimens from Moloka'i and Kaua'i Is collected by S.F. Swift.

Remarks. Ueckermann and Meyer (1987) described and illustrated this species from South Africa. Eustigmaeus ornatus is distinctive in the presence of 5 setae on femur II compared to 4 in E. mixtus, its closest relative, the lateral positioning of setae e1 and its closer distance to f1 rather than to e2. The last two characters separate it from E. segnis and E. microsegnis in addition to details of dorsal ornamentation and condition of the dorsal setae.

The Hawaiian population of E. ornatus varies from the South African population on the following characters: 8-9 pairs of anomalous dimples (unvacuolated dimples of Wood, 1966) are present on most of the specimens, a little difficult to discern on specimens in deteriorating mounting medium; the males have endopodal plates either completely

separated or fused or incompletely fused, more like the males of E. mixtus; the dorsal setae seem to have whorls of spines along the entire length of the setae instead of bilaterally spinulate setae. The Hawaiian population likely belongs to a separate species but more specimens need to be sampled as variants of this species are numerous in the Islands. The "typical" and other forms of E. mixtus and the type series of E. ornatus need to be re-examined.

This species has the greatest number of specimens (271) collected from the islands of Hawai'i, Moloka'i, and Kaua'i. It seems to have a preference for soil under Metrosideros canopy in Hawai'i I.

Genus Stigmaeus Koch

Stigmaeus Koch, 1836: fasc. 4(9).
Stigmaeodes Canestrini, 1889: 512-513; Oudemans, 1923: 140.
Stigmaeus (Stigmaeus) Berlese, 1910: 205; Oudemans, 1923a: 142; Summers, 1962: 495; Summers, 1966: 240; Wood, 1967: 96; Meyer, 1969: 250; Wood, 1973: 77; Wainstein, 1978: 161; Tseng, 1982: 46; Kuznetzov and Petrov, 1984: 107; Ueckermann and Meyer, 1987: 375; Meyer and Ueckermann, 1989: 45.

Type species: Stigmaeus cruentus Koch, 1836, designated by Berlese, 1910.

Diagnosis. Sclerotized, ovate or delicate, fusiform species; dorsum with 10-16 plates, indistinct plates or lacking plates; chelicerae separated; 13-14 pairs of dorsal

setae, usually barbed, sometimes bi- or trifurcate; terminal eupathidia on palptarsus rod-like or trifurcate; leg tibial formula 7-6-6-6, other segments vary in number of setae among species; empodia with 3 pairs capitate or pointed tenent hairs.

Remarks. The whereabouts of the type specimen of Stigmaeus cruentus Koch, the type species, is unknown. Oudemans (1923a) designated Stigmaeus crassirostris Leonardi (1899) a synonym of S. cruentus. Wood (1973) in his study of Berlese's stigmaeid collection discovered that the 7 specimens of S. crassirostris belong to the genus Zetzellia, not Stigmaeus. Since Oudemans (1923) synonymized crassirostris with cruentus on little or no evidence, Wood merely corrected the synonymy, and like Berlese (1910a) and Summers (1962), based the genus Stigmaeus on S. rhodomelas Berlese, while recognizing cruentus as the nominal type species.

A large genus distributed worldwide, there are 62 species known currently. Previously unknown in the Hawaiian Islands, the 4 species described in this study are the first records of Stigmaeus for the islands. A Stigmaeus floridanus Banks, reported from the islands in 1922, is actually a misidentified Tenuipalpidae, Dolichotetranychus floridanus (Banks, 1900).

Stigmaeus n. sp. A Figures 67, 68, 69, 89

Holotype. Female. HAWAI'I I: Kohala, Kohala Ditch Trail, 24.IX.1988, ex ferns and mosses, M.L. Goff.

Diagnosis. The delicate honey-comb reticulation on the propodosomal, central and marginal plates, unusual long dorsal setae ve, c2, e2 and f1 are diagnostic for the species.

Description. Female (ranges of holotype and 9 female specimens in parentheses). Length (including gnathosoma) 375(370-394); width 278(273-285).

Gnathosoma (Figure 69C). Palplength (from trochanter base to tip of tarsus; number of setae from palpfemur to palptarsus: 3-2-2-7; palptibial claw well-developed; accessory seta stublike; palptarsus with trifid, stalked eupathidium; chelicera oval-shape; infracapitulum densely punctate, with 2 pairs setae, m longer than n (Figure 71B)

Dorsum (Figure 67A). Six paired and 3 unpaired plates on dorsum; reticulation on propodosomal, central and marginal plates delicate, honeycomblike, distinct on middorsal region; ocular area without reticulation; shape of propodosomal plate distinct (Figure 67A); dorsal setae c1, d1 on central plate; 13 pairs of dorsal setae, lengths vary: ve 90-100, sce 64-71, c2 90-102, e2 92-117, f1 78-88, h1, h2 48-71, other setae 21-40; long setae aciculate, short setae tapered to a point but not aciculate, all finely barbed; anogenital plate terminal.

Venter (Figure 67B). Endopodal plates separate medially, plain; 1a, 3a, 4a hairlike, finely barbed; 3 pairs aggenital setae, 4c (ag1?) either absent or with various placements on opisthosomal venter (Figure 68); ag2-3 on a single plate, kidney shape, abutting anterior of anogenital plate; 1 pair genital setae; 3 pairs pseudanals (ps1-3).

Legs (Figures 69A-B). Length (excluding coxae) of legs I-IV: 216-276; 179-223; 188-219; 207-252. Number of setae on leg segments I-IV (special sensillae in parentheses): tarsi 14(w)-10(w)-8(w)-8(w); tibiae 7(o,op)-6(op)-6(op)-6(op); genua 4(k)-4(k)-1-1; femora 6-4-3-2; trochanters 1-1-2-1; coxae 2-2-2-2. Coxal setae 1c and 2b longer than other coxal setae, finely barbed; op on tibiae I and II long, 2.5 times longer than o; wI long, reaching beyond bases of tc', tc''.

Specimens examined. 15. HAWAI'I I: Kohala, Kohala Ditch trail, ex ferns and mosses, 24.IX.1988, M.L. Goff (10 females); MOLOKA'I I: Kamakou Preserve, Peleku Valley Ridge, 1204 m, 16.VII.1989, on `Ohi`a, S.F. Swift (2 females); O'AHU I: Mt. Kaala Summit, 1225 m, 10.X.1989, `Ohi`a tree hole, S.F. Swift (3 females).

Remarks. This species keys to Stigmaeus obtectus Summers, 1962, but differs in the presence of 4 setae on femur II, the smaller and different shapes of idiosomal plates, and the aciculate ve, c2 and e1 dorsal setae. The ventral setae 4c (ag1?) varies within the type series. The

holotype illustrated has 4c absent (68E); the others have 4c present on small individual platelet (Figure 68A); one of the pair on platelet, the other borne out of integumental striations (Figure 68B); the pair on integumental striations, without platelets (Figure 68C); the pair on one plate (Figure 68D) and the pair on an enlarged aggenital plate (68F). This last variation shows the pair of setae are most likely aggenital setae (agl) rather than part of the coxae IV setal complex.

Stigmaeus n. sp. B Figures 70, 71, 90

Holotype. Female. KAUA'I I: Kuia Natural Area Reserve, Nualolo Trail, 890 m, 29.IV.1991, ex Metrosideros bark, S.F. Swift.

Diagnosis. The extensive microtuberculate area on the anterior propodosoma, posterior position of d2 on the median lateral plate, convex dorsal of tarsi I and long, flagelliform 1c, 2b and 2c distinguish this species from the other fusiform species.

Description. Female (ranges of holotype and 3 female specimens in parentheses). Length (including gnathosoma) 489(461-484); idiosoma 357(353-369); width 155(148-155).

Gnathosoma (Figure 71F). Palplength (from trochanter base to tip of tarsus) 67(60-69); number of setae from palpfemur to palptarsus: 3-2-2-7; palptibial claw well-developed 11; accesory seta slender, spinelike; trifid

eupathidium on palptarsus, long stalked, prongs short; 2 pairs infracapitular setae, n long (50), m short (26), n-n > m-m; chelicerae and palpcoxal base punctate.

Dorsum (Figure 70A). Fusiform with marked humeral sulcus, another sulcus between setae d1, e1; anterior to propodosomal area microtruberculate; dorsal plates ill-defined; anterior portion of propodosomal plate smooth, setae vi, ve on smooth area, longitudinal striae posteriorly blending into the lateral longitudinal striae; humeral plate small bearing sce; median hysterosomal plate slightly elevated, with sparse, finer striation, thinly sclerotized with dorsal setae c1, d1; median zonal heart shape with striations on edges forming a single unit, midanterior with longitudinal striae slightly beyond halfway of plate; intercalary and lateral zonal plates abbuting each other on posterior lateral side of median zonal plate; 14 pairs dorsal setae, aciculate; length of dorsal setae varies: ve 38, sce 31, c2 62, h2 34, vi, sci, c1, d1, d2, e1, e2 11, f1 21, f2 26, h1 24; d2 short, on posterior end of marginal lateral plate; 3 pairs setae on suranal plate, h1, h2, f2; eyes absent.

Venter (Figure 70B). Endopodal plates divided, posterior plates large, anterior end reaches transversely striated sulcus; 4 pairs aggenital setae, ag4 29, ag1-3 14-19; 3 pairs genital setae, g1, g2 subequal (10), g3 long (26); pseudanal setae ps1-3 long, aciculate, ps1-2 subequal

(30), ps3 23; anal and genital plates united but openings seem separate.

Legs (Figure 71A-D). Length (excluding coxae) of legs I-IV: 138; 114; 119; 117. Number of setae on leg segments I-IV (special sensillae in parentheses): tarsi 14(w)-9(w)-8(w)-8(w); tibiae 7(o,op)-6(op)-6(op)-6(op); genua 6(k)-4-2-3: trochanters 1-1-2-1; coxae 2-2-2-2. Coxal setae 1c, 2b, 2c long (71-74), flagelliform; wI rod-like, short 9; dorsal of tarsus I along tc', tc'' convex, rounded from top (Figure 75A); venter of tarsus I with pair of sclerotized marks at base of claws (Figure 71E); stalked empodium with 2 pairs of capitate raylets.

Specimens examined. 4. KAUA'I I: Kuia Natural Area Reserve, Nualolo Trail, 890 m, 29.IV.1991, ex Metrosideros bark, S.F. Swift (1 female); HAWAI'I I: Hawai'i Volcanoes National Park (HAVO), Kipuka Ki, 1220 m, 6.VI.1984, ex Koa tree hole, M.L. Goff (1 female); HAWAI'I I: HAVO, Kipuka Ki, 1200 m, 6.VI.1984, ex Koa bark, S.F. Swift and J. Diaz (1 female); O'AHU I: Mt. Kaala, 500 m, 10.X.1989, ex grass and Koa litter, S.F. Swift (1 female); MAUI I: west Maui, above Camp Maluhia, 780 m, 11.III.1989, `Ohi`a bark, S.F. Swift (1, damaged).

Remarks. The plating of this species is subject to the observer's interpretation. Since plates are ill-defined, the faintness of lines, breaks in striations, directions of lines, and how these striations compare with the general

integumental striae are useful criteria in determining if an area can be considered a plate. This species is similar to Stigmaeus elongatus Berlese, 1886 (= S. luteus Summers, 1962) and S. seminudus Wood, 1971, in having ill-defined dorsal plates but may be separated by differences in details of dorsal platings, leg chaetotaxy, dorsal setal differences and their positions on plates.

The holotype has the palptarsal eupathidium with short prongs and long stalk, but the 3 other specimens have short stalk and relatively long prongs. The median propodosomal plate bears a median, refringent apodemal mark which was not illustrated.

Stigmaeus n. sp. C Figures 72, 73, 90

Holotype. Female. O'AHU I: Mt. Kaala Summit, 1225 m, 10.X.1989, ex moss on ground with soil, S.F. Swift.

Diagnosis. The absence of reticulation on the median propodosomal plate, presence of 5 setae on femur II, 4 setae on genu II and 2 on genu III and midlateral position of d2 on the marginal plates separate this species from the rest in the genus.

Description. Female (ranges of holotype and 4 female paratypes in parentheses). Length of body (including gnathosoma) 335(318-371); idiosoma; width 139(133-185).

Gnathosoma (Figure 73F). Palplength (from trochanter base to tip of tarsus) 74; number of setae from palpfemur to

palptarsus: 3-2-2-7; palptibial claw developed, accessory seta slender, spinelike; palptarsus with trifid sensillum, length of stalk subequal with prongs; 2 pairs infracapitular setae, n (25) longer than m (21), m-m < n-n; chelicerae separate (Figure 73G) with narrow sclerotized area where joining occurs; palps, infracapitular base and chelicerae finely punctate.

Dorsum (Figure 72A). Fusiform with two distinct sulci as in Stigmaeus n. sp. B; dorsal plates thinly sclerotized, striation indistinct or absent; propodosomal plate relatively large with vi, ve, sce, posterior of plate with encroaching striation, refringent apodemal mark at middle of finely punctate plate; marginal plate relatively long, d2 positioned at middle of plate; median zonal apple shape, lateral zonal and intercalary plates originate on similar transverse line anterior of suranal plate; lateral zonals elongate, almost as long as median zonal; 14 pairs dorsal setae, aciculate; ve, sce, c2, f1 50-59, long; vi, c1, d1, d2, e1, e2 19; sci 24; h1, f2 28; h2 38; f2 3rd seta on suranal plate; eyes absent.

Venter (Figure 72B). Endopodal plates separated medially, posterior plates extensively large, anterior margin reaches transverse microtuberculate striations of sulcus; intercoxal setae short; coxal margins thickened; anterior margin of coxae I with thickened extended piece over a split from otherwise smooth margin; 4 pairs aggenital

setae, agl-2 on solid plate anterior of anogenital and another aggenital plate; 3 pairs genital setae, g1 9, g2 11, g3 13; 3 pairs pseudanal setae, ps1 38, ps2 31, ps3 26. Anogenital complex seem to have 5 plates. Microtuberculate non-striated area between coxae III and IV present.

Legs (Figures 73A-D). Length (excluding coxae) of legs I-IV: 188(182-188); 142; 147(142-147); 173(165-173). Number of setae on leg segments I-IV (special sensillae in parentheses): tarsi 14(w)-9(w)-8(w)-8(w); tibiae 7(o,op)-6(op)-6(op)-6(op); genua 6(k)-4-2-3; femora 6-4-3-2; trochanters 1-1-2-1; coxae 2-2-2-2. Coxal setae 1c, 2b, 2c longer (46, 57, 47) than rest, aciculate, not flagelliform; wI rod-like with short handle; tarsus II with one tectal seta (tc); empodium as in Figure 73E.

Male. Not known.

Specimens examined. 4. KAUA'I I: Kalalau Lookout, 9.VII.1981, ex `Ohi`a, Banana Poka, M.L. Goff (1 female); KAUA'I I: Kokee State Park, Pu'u O Kila Trail, 1273 m, 27.V.1989, ex moss on `Ohi`a, S.F. Swift (1 female); O'AHU I: Kaneohe, 15.X.1982, ex soil, S.F. Swift (1 female); MOLOKA'I I: Kamakou Preserve, Peleku Valley Ridge, 1200 m, 15.VII.1989, ex `Ohi`a, S.F. Swift (1 female).

Remarks. This species is similar to Stigmaeus n. sp. B, S. elongatus Berlese (= S. luteus Summers, 1962) and S. gracilimus Summers, 1962, in having fusiform body, similar condition of dorsal plates and number of setae on leg

segments but this species may be distinguished from Stigmaeus n. sp. B by the lack of fine striations on the major dorsal plates and the midlateral position of d2 on the marginal plates. It is separated from S. elongatus by the absence of reticulation on the median propodosomal plate and from S. gracilimus in having 4 setae on femur II instead of 5 and genua II and III have 4 and 2 instead of 5 and 3 setae respectively.

Stigmaeus n.sp. D Figures 74, 75, 90

Holotype. Female. KAUA'I I: Kuia Natural Area Reserve, Nualolo Trail, 1000 m, 27.XI.1990, ex Metrosideros bark, S. Swift and P. Cairy.

Diagnosis. The separate position of sce on individual plates anterolaterad of sci on the propodosomal plate, 1 seta on palpgenu, elongate median plate and rod-like terminal sensillum on the palptarsus are diagnostic for the species.

Description. Female (ranges of holotype and 9 female specimens in parentheses). Natural color orange-reddish. Length (including gnathosoma) 461(434-487); idiosoma 334(318-337); width 188(185-201).

Gnathosoma (Figure 75C-D). Palplength (from trochanter base to tip of tarsus) 76(71-78); number of setae from palpfemur to palptarsus: 3-1-2-7: palptibial claw developed; accessory seta slender, aciculate; eupathidium on palptarsus

simple, rodlike (Figure 75D); flagelliform infracapitular setae, m short (23), n long (53); 2 pairs adoral setae, ad1 slightly longer (15) than ad2 (13); infracapitular base and palpal segments punctate.

Dorsum (Figure 74A). Dorsal plates thinly sclerotized, no ornamentation; propodosomal plate with 3 pairs of setae, 1 pair of eyes; sce on individual small plates anterolaterad of sci; elongate median plate without setae, running from level of c2 to e1 with a faint transverse suture anterior of d1; intercalary setae on separate small plates on transverse striations; 13 pairs sparsely barbed, aciculate dorsal setae; setae c1, d1, e1 located along lateral sides of median plate; suranal plate narrow with 2 pairs setae; with exception of sce and f1, other dorsal setae on small platelets on striated integument; c2 longest (53); sce 34; ve, h2 28; f1, h1 22-24; others 10-18.

Venter (Figure 74B). Endopodal plates separated, faintly punctate; 3a situated on anterior margin of posterior plates, 4a situated on striated integument; 3 pairs aggenital setae, ag1 on platelets on striated area, ag2-3 on a single narrow plate laterad of anogenital plate; 1 pair genital setae; 3 pairs pseudanal setae; ventral striation pattern as in Figure B.

Legs (Figures 79A-B). Length (excluding coxae) of legs I-IV: 150(143- 162); 117(113-123); 114(114-123); 121(119-142). Number of setae on leg segments I-IV (special

sensillae in parentheses): tarsi 14(w)-10(w)-8(w)-8(w); tibiae 6(op)-6(op)-6(op)-6(op); genua 4(3)(k)-2-0-1; femora 6-4-3-2; trochanters 1-1-2-1; coxae 2-2-2-2. Coxal setae threadlike; trochanter I and coxal margins thickened, punctate; kI minute, indistinct usually; wI slender, baculiform 16, wI > wII > wIII > wIV; tibial dorsal 2.5 times as long as lateral seta; one tectal seta on tarsus II; empodium with 3 pairs capitate raylets.

Male. Unknown.

Specimens examined. 48. KAUA'I I: Kuia Natural Area Reserve, Nualolo Trail, 1000 m, 27.XI.1990, ex Metrosideros bark, S.F. Swift and P. Cairy (15 females); KAUA'I I: Kalalau Trail, 0-500 m, 20.XI.1990, ex dry Pandanus leaves, S.F. Swift (2 females); KAUA'I I:, Hono O Na Pali Natural Area Reserve, Pihea Trail, 1300 m, 18.II.1991, ex Metrosideros bark, S.F. Swift (5 females); MOLOKA'I I: Kamakou Preserve, Pu'u Kolekole, 1200 m, 15.VII.1989, on abandoned nest on Cheirodendron, 15 m E. of cabin, S.F. Swift (5 females); MOLOKA'I I: Kamakou Preserve, Pu'u Kolekole, 1200 m, 15.VII.1989, litter and moss along trail, S.F. Swift (6 females); MAUI I: west Maui, above Camp Maluhia, 780 m, 11.III.1989, `Ohi`a bark, S.F. Swift (8 females); MAUI I: Hana, Waianapanapa State park, sea level, 27.XI.1992, bark of Terminalia catappa, .5 m above ground, S.F. Swift (1 female); O'AHU I: Keiawa Heiau State park, Aiea Loop Trail, 4.VII.1990, moss on ground, S.F. Swift (1

female); O'AHU I: Mt. Kaala Summit, 542 m, 10.X.1989, on tree fern, S.F. Swift (1 female); O'AHU I: North Halawa Valley, 9.IX.1990, moss on `Ohi`a bark, S.F. Swift (4 female).

Remarks. Stigmaeus n. sp. D is similar to the New Zealand species Stigmaeus confusus Wood, 1967, in having an elongated median plate, rod-like terminal sensillum on the palptarsus, kI short and absence of sensillum o on tibia I. However, this Hawaiian species is easily distinguished by the presence of axillary plates bearing sce alongside the propodosomal plate whereas S. confusus has sce integrated with the propodosomal plate. Other characters that separate the two are the lengths of dorsal setae, number of genital setae, punctations and thickenings on the coxal margins.

This species is the most abundant in the Hawaiian Islands. It is found on various plants in 5 islands but seems to have a preference for Metrosideros. This may be so as more samples from Metrosideros were collected.

The holotype has agl with 2 aggenital setae on one side and 1 seta on the other.

Stigmaeus elongatus Berlese Figure 91

Stigmaeus elongatus Berlese, 1886: fac. 30(7); Wood, 1973: 80.

Stigmaeodes elongatus, G. Canestrini, 1889: 448.

Stigmaeus luteus Summers, 1962: 516.

Diagnosis. Female (measurements taken from 2 specimens). Fusiform species; length of body (including gnathosoma) 542; idiosoma 409; width 200. Palplength (from trochanter base to tip of tarsus) 76; number of setae from palpfemur to palptarsus: 3-2-2-7. Length (excluding coxae) of legs I-IV: 173; 140; 145; 170; number of setae on leg segments I-IV (special sensillae in parentheses) tarsi 14(w)-9(w)-8(w)-8(w); tibiae 7(o,op)-6(op)-6(op)-6(op); genua 6(k)-5-3-3; femora 6-6-3-2; trochanters 1-1-2-1; coxae 2-2-2-2; length of wI 9.

Dorsal plates absent except for reticulated propodosomal plate bearing vi, ve, small paired intercalary plates and single suranal plate with 3 pairs setae. Setae el on striated triangular median zonal, striations indicate a separate plate or area; anterior endopodal plates faintly reticulate; leg segments with sparse apodemal markings or lines that resemble reticulation; 4 pairs aggenital setae on inverted U-shape plate, 1 extra seta on anterior clump of setae; posterior endopodal plates relatively large, anterior extends close to transverse sulcus; most dorsal setae faintly pilose.

Specimens examined. 2. O'AHU I: Honolulu, Univ. Hawaii Manoa Campus, 26.IX.1965, ex soil litter, F.H. Haramoto.

Remarks. Wood (1973) synonymized Stigmaeus luteus Summers, 1962, with S. elongatus Berlese, 1886, in his

revision of the Stigmaeidae in the Berlese collection. The specimens examined from the the Hawaiian Islands agree in detail with the descriptions and illustrations of Wood (1973) and Summers (1962) of S. elongatus except for the faint reticulation on the anterior endopodal plates and what seems to be reticulations on the leg segments. Wood and Summers did not mention these characters or punctations that ornament the infracapitular base exhibited in the Hawaiian specimens. Wood (1973) reported 5 pairs of aggenital setae; Summers (1962) reported 4 or 5 pairs; the Hawaiian specimens have 5 setae on the bottom base of the U plate and the usual 2 pairs posterior of the plate. Like the Argentina specimen of Summers (1962), these variations are classed as intraspecific.

RAPHIGNATHOID COMPOSITION AND DISTRIBUTION

The superfamily Raphignathoidea is composed of 9 families worldwide. Six of these families are established in the Hawaiian Islands: Caligonellidae Grandjean,1944, Camerobiidae Southcott, 1957, Cryptognathidae Oudemans, 1902, Eupalopsellidae Willmann, 1952, Raphignathidae Kramer, 1877, and Stigmaeidae Oudemans, 1931. A seventh family, Barbutiidae Robaux, 1975, was reported by Goff (1985) from Hibiscus from Foster Gardens, O'ahu I. but the single specimen could not be located and therefore is not included in this study. The families Homocaligidae Wood, 1969, and Xenocaligonellidae De leon, 1959 were not collected. Members of Homocaligidae inhabit aquatic and moist habitats. Since no particular efforts were taken to collect from the above mentioned habitats, the absence of homocaligids could not be interpreted that they are not found on the islands. The family Eupalopsellidae is reported on the islands for the first time.

With the exception of the genus Caligonella Berlese, 1910, in the family Caligonellidae, the 3 other genera are found in the islands: Coptocheles Summers and Schlinger, 1955; Molothrognathus Summers and Schlinger, 1955; and Neognathus Willmann, 1952. Coptocheles has 3 new species; Molothrognathus has 2 and Neognathus spectabilis (Summers and Schlinger, 1955), a North American species, represents

the genus. Camerobiidae is represented by 5 species in 2 genera: Tycherobius Bolland, 1986, with one species and Neophyllobius Berlese, 1886, with 3 new species and Neophyllobius consobrinus De Leon, 1958, described from Mexico. The genera Decaphyllobius Bolland, 1986; Camerobia Southcott, 1957; and Tillandsobius Bolland, 1986, are not found in the islands. The genus Favognathus, Luxton, 1973, in the family Cryptognathidae has 3 new species and a previously described species from the Galapagos I., Favognathus pictus Summers and Chaudhri, 1965; the genus Cryptognathus Kramer, 1879, was not collected. The family Eupalopsellidae is represented by the genera Exothorhis Summers, 1960 and Saniosulus Summers, 1960 with E. caudata Summers, 1960 and the monotypic Saniosulus nudus Summers, 1960 both collected from O'ahu. The genera Paraeupalopsellus Smiley and Moser, 1968; Eupalopsis Canestrini, 1886; Peltasellus Meyer and Ueckermann, 1984; and Eupalopsellus Sellnick, 1949 were not represented. The genus Raphignathus Duges, 1834, of the family Raphignathidae is well represented with 9 species (8 are new) distributed throughout the island chain. Raphignathus aethiopicus Meyer and Ryke, 1960, described from South Africa was the only previously described species collected. Stigmaeidae, the largest family with 20 species, is represented by 6 of the 22 known genera: Agistemus Summers, 1960; Eustigmaeus Berlese, 1910; Eryngiopus Summers, 1964; Ledermuelleriopsis

Willmann, 1951; Stigmaeus Koch, 1836; and Storchia Oudemans, 1923. Of the 20 species, 11 are new and 9 are previously known from various geographic areas (Table 3).

Forty-six species in 16 genera of raphignathoids are now known from the Hawaiian Islands. Hawai'i has the highest number of species (23), followed by O'ahu (21), Kaua'i (12), Molokai (7), Maui (3) and Lanai (1). The Northwestern Hawaiian Islands (Midway, Nihoa, Pearl and Hermes) have a total of 7 species; Nihoa alone has 5 species (Table 2). The discovery of more species from Hawai'i I. was expected due to intensive collection by F. Haramoto and L. Nakahara in connection with the International Biological Program in 1971-73. On O'ahu I., more habitats were sampled prompted by the various collection requirements in the University of Hawaii entomology courses and thus more mites were recovered. However, 3 litter samples from Nihoa I. in the Northwestern Hawaiian Islands revealed 5 new species of Caligonellidae, Camerobiidae and Raphignathidae, significantly more than the 11 species in 4 families recorded from 90 habitat samples from Kaua'i I. (Swift 1991). Of the 5 species, only Tycherobius n. sp. A was collected from O'ahu I., the other 4 new species only found on Nihoa I.

Nineteen species (41%) inhabit more than one island, while 27 species (59%) are found singly in one particular island within the chain (Table 1). Eustigmaeus kauaiensis,

originally described from Kaua'i I., has new island record, O'ahu and Hawai'i Islands. Eustigmaeus n. sp. B, Eustigmaeus ornatus, Stigmaeus n. sp. A, Stigmaeus n. sp. B, Stigmaeus n. sp. C and Eryngiopus n. sp. A probably occur in all the islands. They are the dominant and frequently occurring raphignathoid species in their habitats.

HABITATS

The habitats of the Hawaiian raphignathoids can be divided into a) soil, moss and litter, b) bark of trees, and c) leaves and flowers. The first category of soil, moss and litter was lumped because of difficulty in separating these microhabitat types. Moss and litter are often mixed with soil during collection. Of the 46 species recorded from these habitats, 30 species were recorded from soil, moss and litter, 16 from bark and 5 from foliage (including one flower sample from Macadamia nut tree). Eustigmaeus kauaiensis Swift et al., 1985 collected from moss on rocks and on the ground is probably the first moss-feeding species in the genus Eustigmaeus found in the islands. Green coloration of guts during development, as observed in life history studies of Eustigmaeus frigida (Habeeb, 1958) (Gerson 1972), confirmed initial suspicion of the species being a moss-feeder. The fact that the species in Hawai'i, Kaua'i and O'ahu is collected from moss only confirmed the

moss-feeding habit of E. kauaiensis. Eustigmaeus n. spp. A, B and C are collected also from moss habitats but it is not known if they are moss feeders. Other moss-feeding species of Eustigmaeus are E. rhodomela (Koch, 1841), E. clavata (Canestrini and Fanzago, 1876), E. schusteri (Summers and Price, 1961), E. frigida (Habeeb, 1958) and E. bryonemus (Flechtmann 1985).

Limited collecting from leaves and flowers (mostly from Metrosideros polymorpha) yielded 5 species, indicative of possible diverse leaf-dwelling raphignathoids associated with mite pests and other small arthropods, e.g., scale insects and white flies on plants of economic importance. Agistemus congolensis (Gonzalez-Rodriguez, 1965) was found on Anthurium leaves being ravaged by a tenuipalpid mite and Saniosulus nudus Summers, 1960 was on Cactus feeding on scale insects. The genus Neophyllobius alone has 79% (67) of the species found on plants while 21% (18) are from other habitats such as bark, soil and litter (Bolland 1991). Association of raphignathoid mites with coccids on economic plants is well documented (Gerson 1967, 1973; Gerson & Blumberg 1969; Muma & Selhime 1971; Zaher & Gomaa 1979), that a thorough survey of both ornamental and economic plants in the islands will possibly reveal additional species.

The genus Stigmaeus according to Wood (1967) is litter-inhabiting genus although in New Zealand there are 2

arboreal species, S. coprosmae Wood, 1967, and S. loadmani Wood, 1967. In this study, only one species, Stigmaeus n. sp. B was found in litter and one species, Stigmaeus n. sp. C was arboreal.

Ten species were collected from Metrosideros bark, the largest number of taxa recorded in a single habitat, followed by 7 species on soil under Metrosideros canopies. Moss attached on rocks, tree stumps and barks of trees and other plants, mixed with leaf litter, and on ground produced 9 species however, the delineation as to specific microhabitat is unclear. It seems that vertical movements of species between microhabitats occur. Prey abundance in adjacent habitat and changes in environmental conditions may cause the movement of species from one habitat to another. With the exception of Ledermuelleriopsis n.sp. A from Kaua'i I. collected only from Metrosideros tree hole, several species (Neognathus spectabilis (Summers and Schlinger, 1955), Raphignathus n.sp. F and Stigmaeus n.sp. B collected in Hawai'i I. from Acacia koa tree holes) probably dropped from the bark where they are also found or species movement also occurs. Fauna of soil and bark crevices overlaps to some extent as in pseudoscorpions (Wallwork 1970).

One litter sample of Chenopodium oahuense from Nihoa I., uncovered 4 new species in 4 genera and in 3 families. The family Caligonellidae was represented by the genera Coptocheles and Molothrognathus with one species each;

Camerobiidae was represented by one new species in the genus Tycherobius; and Raphignathidae with one new species in the genus Raphignathus. This sample took several days in transport in a muslin bag before extraction. The survival of the mites in the sample and the relatively species rich habitat from a relatively old island (approx. 7 mya) with sparse vegetation raise interesting questions concerning ability of these mites to survive in adverse conditions, species richness of mites or other arthropods in older islands with sparse plant species, island area, endemicity and phylogeny.

AFFINITIES OF THE HAWAIIAN ISLANDS FAUNA

The oceanic birth and extreme isolation of the Hawaiian Archipelago present interesting questions on the occurrence of terrestrial fauna and flora, their origins and their phylogenies. This is especially true for mites as the group is composed of small, non-volant arthropods found in soil and litter and arboreal habitats. As Hawaiian mite groups are studied, clues of where they originate begin to surface. Strandtmann and Goff (1978) in their study of the eupodoids discovered 8 of the 11 species (73%) are boreal forms with holarctic distribution. One new species also occurs on the Ivory Coast of West Africa, and therefore of austral origin. The Hypoaspidinae (Tenorio 1982) seemed to be composed of

mostly boreal species (75%) with exception of two species, of Australian origin. Swift (1986) in her study of Hawaiian bdellids disclosed a predominance of known species from North America, Central America and Australia. Two African species were later found in Australia and then in the Hawaiian Islands. In known species of Raphignathoidea, occurring in the Hawaiian Islands (Table 3), 50% (7 species) are North American/European or Palaearctic species. Agistemus congolensis Gonzalez-Rodriguez, 1965, Eustigmaeus ornatus Ueckermann and Meyer, 1987, and Raphignathus aethiopicus (Meyer and Ryke, 1960) are African species now known only from Africa and the Hawaiian Islands. Storchia robusta (Berlese, 1885) was previously recorded from Europe (Grandjean 1944), South Africa (Meyer and Ryke 1959), New Zealand (Wood 1967) and the Solomon Islands (Wood 1971). Storchia pacifica (Summers, 1964) known from a single specimen from Panama was reported from Indonesia, Philippines, Tahiti and France from quarantine interceptions in the Hawaiian Islands (Summers 1964). From the Galapagos Is., Favognathus pictus (Summers and Chaudhri, 1965) is the sole representative of Favognathus in the Hawaiian Islands.

Jacot (1934) concluded that no Hawaiian species of oribatids were European unless recently introduced by man. He believed that mites could not have gotten to the islands by wind or ocean drifts, but only through human intervention when plants and animals were introduced. Although at this

time it appears that the majority of the acarine fauna in the islands have Northern Hemisphere affinities, it will be of no surprise if the fauna is an assemblage of mite lineages both boreal and austral in origin once the mite fauna of Oceania and outlying areas are studied.

SUMMARY AND CONCLUSIONS

Approximately 250 habitat samples of soil, soil with moss, soil and leaf litter, leaf and plant litter, bird's nests, bark, flowers, leaves, lichen and moss from the islands of Hawai'i, Maui, Moloka'i, Lana'i, O'ahu, Kaua'i, Nihoa, Midway, Pearl and Hermes provided approximately 600 specimens of Raphignathoidea used in this study. The six families found are: Caligonellidae, Camerobiidae, Cryptognathidae, Eupalopsellidae, Raphignathidae and Stigmaeidae. These families have 46 species in 16 genera; 30 species are new to science and 12 are new records for the Hawaiian Islands (Table 3). Eustigmaeus microsegnis (Chaudhri, 1965), Eustigmaeus segnis (Koch, 1836), Eustigmaeus kauaiensis Swift et al., 1985 and Agistemus terminalis (Quayle, 1912) are the previously reported species from the islands (Goff 1987).

Compared to New Zealand with a total raphignathoid fauna of 62 species (mostly Stigmaeidae) (Wood 1964, 1966, 1967, 1971a, 1971b, 1981), Campbell Island with 5 (Wood 1972), Solomon Island with 12 (Wood 1971), Africa with 99 (Meyer and Ueckermann 1989) and North America with 142 (Summers and colleagues, 1955-1966; Gonzalez-Rodriguez 1963-1978; Robaux 1975, 1976; Atyeo 1960, 1963 and others), the raphignathoid fauna of the Hawaiian Islands is relatively diverse in terms of families and genera represented,

especially considering the size and geographic isolation of the Hawaiian Islands.

The islands of Hawai'i and O'ahu have the most diverse raphignathoid fauna (Table 1) with 23 and 21 species respectively. Kaua'i has 12, Moloka'i has 7, Maui has 4 and Lanai has one species. The Northwestern Hawaiian Islands of Pearl and Hermes, Nihoa and Midway have 7 species, all new. The higher numbers for Hawai'i and Oah'u are not unexpected because of the extensive collecting done in those islands. However, the species composition in the 2 islands are quite different. For example, Tycherobius n. sp. A, Favognathus pictus, Saniosulus nudus, Storchia pacifica and Storchia robusta are some of the species found in O'ahu but not in Hawai'i. Between O'ahu and Hawai'i is a 26% similarity of fauna, i.e., 6 of the 21 species are found on both islands.

Kaua'i, the oldest of the main islands (5 mya) (Howarth et al. 1988), has 12 compared to 23 species from Hawai'i. (0.4 mya). This difference could be partly as a collecting artifact. On the other hand, comparable numbers of samples from Metrosideros habitats from the two islands reveal 17 species associated with Metrosideros (includes soil under its canopy and moss on its bark). Of these 17 species, Neognathus spectabilis, Neophyllobius n. sp. A, Favognathus n.sp. B, Eustigmaeus segnis, Eustigmaeus microsegnis, Eryngiopus bifidus and Ledermuelleriopsis n.sp. A, (41%) do not occur on Metrosideros on Kaua'i, but occur on Hawai'i.

Can we say that their absence in Kaua'i is due to extinction (island age factor) or limited ecological opportunity because of island size or that the species present in Hawai'i are relatively newly introduced species? Are the species present in Kaua'i endemic to the island? Some species are found on both islands, e.g., Stigmaeus n.sp. B, Eustigmaeus ornatus and Raphignathus n.sp. F but their habitats are slightly different. In Kaua'i, Raphignathus n.sp. F and Stigmaeus n.sp. B were collected from the bark of Metrosideros while in Hawai'i, they are found in Koa tree holes; Eustigmaeus ornatus was on bark with moss on Kaua'i while on Hawai'i, it was in soil under Metrosideros canopy. Only Eustigmaeus kauaiensis is found in both islands in the same moss habitat. This species is probably widespread in all the islands where this type of moss habitats thrives.

The first habitat category of soil, moss and litter yielded 65% of the raphignathoid species, followed by tree bark with 35% and leaves and flowers with 10%. The remarkable species diversity on soil, litter and moss is generally expected because of the tremendous number of microhabitats available ranging from decomposing plant parts to moisture saturated mineral soil. In these habitats, prey (food) is probably abundant. It is then probable that the distribution of mite predators is more likely governed by distribution and abundance of prey animals than by the type of organic material or ground vegetation. The distribution

of moss-feeders, on the other hand, is governed by vegetation. Swift (1991) documented a similar diversity of mites on the island of Kaua'i.

Five of the 7 species of Eustigmaeus in the family Stigmaeidae are found on mosses. The presence of a moss-feeding species, Eustigmaeus kauaiensis, on the islands of O'ahu, Kaua'i and Hawai'i, with an evolved feeding strategy (from predatory feeding strategy) raises interesting ecological and phytological implications. Moss-Eustigmaeus associations probably occur wherever the mites are found and the association is probably far from recent. Moss being a relictual plant, a moss-Eustigmaeus relationship may be of more than an acarological interest (Gerson 1972). Greater knowledge of moss taxonomy and colonization is essential to fully understand this relationship.

Nihoa Island in the Northwestern Hawaiian Islands, is home to 5 new species in 4 genera belonging to 3 families of raphignathoids. These species are suspected to be endemic to Nihoa, not merely because of the degree of isolation of this island but also due to the derived familial characters of these species. Raphignathus n.sp. B from Pearl and Hermes Atoll also belongs in this category. The genus Raphignathus in the family Raphignathidae has 9 species, 8 of which are new; Eustigmaeus has 7, 3 new; Neophyllobius has 4, 3 new and Favognathus has 4, 3 are new species. If these new species are found to be endemic to the Hawaiian

Islands, their occurrence suggests that adaptive radiation has occurred at the species rather than the generic level as is the case in Hawaiian fish fauna (Hourigan and Reese 1987). New species in mites cannot at present be equated to endemism. Until the mite faunas of the Hawaiian Islands and that of outlying areas, especially of the southwest Pacific Rim are better known, the issue of acarine endemism cannot be satisfactorily resolved.

Although the raphignathoid fauna of Asia, Australia, South America and the Oceanic Islands of the Pacific are poorly studied and the fauna of most regions imperfectly known, the ocurrence of the families Caligonellidae, Camerobiidae, Cryptognathidae, Eupalopsellidae, Raphignathidae and Stigmaeidae in the Hawaiian Islands and other parts of the world suggests that the superfamily Raphignathoidea may have a worldwide distribution.

Results presented here on the Raphignathoidea from the Hawaiian Islands help clarify some aspects of the largely unknown Hawaiian Acari. Swift (1991) reported a highly diverse bark and soil mite fauna from Kaua'i. Similar raphignathoid species diversity from the same habitats are found in this study. A logical continuation of the present work would be examination of the soil arthropod communities from different ecosystems of the islands. Since most raphignathoids are predaceous, knowledge of other arthropods in the ecosystem will give clues to their possible food

source (prey) as well as possible movement and migration in soil and adjacent microhabitats.

Large, well-studied genera like Agistemus, Stigmaeus, Neophyllobius and Eustigmaeus are prime taxa for revisionary work using phylogenetic techniques of character analysis (sensu Hennig). These genera are known predators of phytophagous mites such as Tetranychidae, Tenuipalpidae and Eriophyiidae, some scale insects and coccids. Their potential as biological control agents against phytophagous mites or insects have been recognized; however, taxonomic revision of these groups are rare. Correct identification of these predators through taxonomic revisionary treatments insures more effective biocontrol strategies.

Table 1. Island Distribution of Hawaiian Raphignathoidea

Taxa	Haw	Mau	Lan	Mol	Oah	Kau	NWHI*
CALIGONELLIDAE							
Coptocheles n. sp. A					x		
Coptocheles n. sp. B	x						
Coptocheles n. sp. C							Ni
Molothrognathus n.sp. A	x	x					
Molothrognathus .sp. B							Ni
Neognathus spectabilis	x						
CAMEROBIIDAE							
Tycherobius n.sp. A					x		Ni
Neophyllobius n.sp. A	x						
Neophyllobius n.sp. B	x				x		
Neophyllobius n.sp. C	x						
Neophyllobius consobrinus					x		
CRYPTOGNATHIDAE							
Favognathus n.sp. A				x	x		
Favognathus n.sp. B	x				x		Md
Favognathus n.sp. C						x	

Table 1. (continued) Island Distribution of Hawaiian Raphignathoidea

Taxa	Haw	Mau	Lan	Mol	Oah	Kau	NWHI*
Favognathus pictus					x		
EUPALOPSELLIDAE							
Exothorhis caudata					x		
Saniosulus nudus					x		
RAPHIGNATHIDAE							
Raphignathus n.sp. A	x						
Raphignathus n.sp. B							PH
Raphignathus n.sp. C					x	x	
Raphignathus n.sp. D							Ni
Raphignathus n.sp. E							Ni
Raphignathus n.sp. F	x					x	
Raphignathus n.sp. G		x					
Raphignathus n.sp. H			x				
Raphignathus aethiopicus	x			x			
STIGMAEIDAE							
Agistemus congolensis	x						

Table 1. (continued) Island Distribution of Hawaiian Raphignathoidea

Taxa	Haw	Mau	Lan	Mol	Oah	Kau	NWHI*
Agistemus terminalis	x	x					
Eustigmaeus n.sp. A	x						
Eustigmaeus n.sp. B	x				x	x	
Eustigmaeus n.sp. C					x		
Eustigmaeus segnis	x						
Eustigmaeus microsegnis	x			x			
Eustigmaeus kauaiensis	x				x	x	
Eustigmaeus ornatus	x			x		x	
Eryngiopus n.sp. A	x			x	x	x	
Eryngiopus bifidus	x						
Ledermuelleriopsis n.sp.A						x	
Ledermuelleriopsis n.sp.B	x					x	
Stigmaeus n.sp. A	x			x	x		
Stigmaeus n.sp. B	x	x			x	x	
Stigmaeus n.sp. C				x	x	x	

Table 1. (continued) Island Distribution of Hawaiian Raphignathoidea

Taxa	Haw	Mau	Lan	Mol	Oah	Kau	NWHI*
Stigmaeus n.sp. D						x	
Stigmaeus elongatus					x		
Storchia pacifica					x		
Storchia robusta					x		
46 taxa	23	4	1	7	21	12	7

* - Haw-Hawai'i, Mau-Maui, Lan-Lana'i, Mol-Moloka'i, Oah-O'ahu, Kau-Kaua'i, NWHI-Northwest Hawaiian Islands: Ni-Nihoa, Md-Midway, PH-Pearl and Hermes Atoll.

Table 2. Island Habitats of Hawaiian Raphignathoidea

Taxa	Islands	Habitats
CALIGONELLIDAE		
Coptocheles n.sp. A	O'ahu	Kiawe litter
Coptocheles n.sp. B	Hawai'i	lichen on lava
Coptocheles n.sp. C	Nihoa	*Chenopodium oahuense* litter
		Solanum nelsoni litter
Molothrognathus n.sp. A	Maui	pitfall trap
	Hawai'i	*Styphelia* litter
		pitfall assoc. with soil
Molothrognathus n.sp. B	Nihoa	*Chenopodium oahuense* litter
Neognathus spectabilis	Hawai'i	*Metrosideros* bark
		Koa bark
		Koa tree hole
CAMEROBIIDAE		
Tycherobius n.sp. A	Nihoa	*Chenopodium oahuense* litter
		Eragrostis sp.
	O'ahu	ground litter
		duff
		Koa litter, soil
Neophyllobius n.sp. A	Hawai'i	*Metrosideros* leaves
Neophyllobius n.sp. B	Hawai'i	lichen on lava
	O'ahu	Norfolk pine litter
Neophyllobius n.sp. C	Hawai'i	Mamane forest litter
Neophyllobius consobrinus	O'ahu	Norfolk pine litter
CRYPTOGNATHIDAE		
Favognathus n.sp. A	O'ahu	*Casuarina* litter
		Koa and grass litter
		Koa litter
		Eucalyptus bark
		Panicum litter
	Moloka'i	grass roots and litter
Favognathus n.sp. B	O'ahu	soil and grass roots
	Hawai'i	soil under *Metrosideros*
	Midway	nest of *Diomedea nigripes*
Favognathus n.sp. C	Kaua'i	*Metrosideros* bark

Table 2. (continued) Island Habitats of Hawaiian Raphignathoidea

Taxa	Islands	Habitats
Favognathus pictus	O'ahu	*Eucalyptus* bark
		Casuarina litter
		Christmas Berry tree bark
		litter, *Araucaria* leaf
EUPALOPSELLIDAE		
Exothorhis caudata	O'ahu	moss
Saniosulus nudus	O'ahu	soil with litter
		feeding on Cactus scale insects
		grass litter
		Eragrostis variabilis
		Kiawe litter
RAPHIGNATHIDAE		
Raphignathus n.sp. A	Hawai'i	grass and litter
Raphignathus n.sp. B	Pearl & Hermes	litter under *Eragrostis*
Raphignathus n.sp. C	Kaua'i	*Metrosideros* bark
		Metrosideros litter
		soil under *Metrosideros*
	O'ahu	*Casuarina* bark
Raphignathus n.sp. D	Nihoa	*Chenopodium oahuense* litter
Raphignathus n.sp. E	Nihoa	*Eragrostis* sp.
Raphignathus n.sp. F	Kaua'i	*Metrosideros* bark
	Hawai'i	Koa tree hole
Raphignathus n.sp. G	Maui	pitfall trap
Raphignathus n.sp. H	O'ahu	soil
		soil under haole koa
		cow dung
		leaf litter
	Lanai	Kiawe litter
Raphignathus aethiopicus	Moloka'i	Kiawe bark
	Hawai'i	pitfall trap
STIGMAEIDAE		
Agistemus congolensis	Hawa'i	*Anthurium* with tenuipalpid mites

Table 2. (continued) Island Habitats of Hawaiian Raphignathoidea

Taxa	Islands	Habitats
Agistemus terminalis	Hawai'i	pitfall assoc. litter
		leaves of Acacia koa
		pine conifer
		Macadamia flower
	Maui	Cypress
Eustigmaeus n.sp. A	Hawai'i	moss on rocks
Eustigmaeus n.sp. B	O'ahu	Christmas Berry tree bark
		moss on ground
		Eucalyptus bark
	Kaua'i	moss on rocks
		Metrosideros bark
		dry Pandanus leaves
	Hawai'i	moss on tree
Eustigmaeus n.sp. C	O'ahu	Eragrostis variabilis
Eustigmaeus segnis	Hawai'i	soil under Metrosideros duff
Eustigmaeus microsegnis	Hawai'i	soil under Metrosideros duff
		Acacia koa litter
		steam vent
		moss on `Ohi`a stump
	Moloka'i	pine litter & soil
Eustigmaeus kauaiensis	O'ahu	moss on rock
	Hawai'i	moss on ground
	Kaua'i	moss on rocks
Eustigmaeus ornatus	Hawai'i	soil under Metrosideros
	Moloka'i	Kiawe bark
		grass roots and litter
		litter and moss
		moss on Styphelia
	Kaua'i	grass litter and soil
		Vaccinium litter
		`Ohi`a bark with moss
		Metrosideros bark
Eryngiopus n.sp. A	Kaua'i	Metrosideros litter with soil
	Hawai'i	Metrosideros leaves
		soil under Metrosideros
	Moloka'i	Cibotium litter
	O'ahu	Casuarina bark
Eryngiopus bifidus	Hawai'i	Metrosideros bark
		Metrosideros leaves
		duff

Table 2. (continued) Island Habitats of Hawaiian Raphignathoidea

Taxa	Islands	Habitats
Ledermuelleriopsis n. sp. A	Kaua'i	Metrosideros tree hole
Ledermuelleriopsis n. sp. B	Hawai'i	duff
		soil under Metrosideros
		moss on Cibotium
	Kaua'i	moss on Metrosideros stump
Stigmaeus n.sp. A	Hawai'i	ferns and mosses
	O'ahu	`Ohi`a tree hole
	Moloka'i	on `Ohi`a
Stigmaeus n.sp. B	Kaua'i	Metrosideros bark
	Hawai'i	Koa tree hole
		Koa bark
	O'ahu	grass and Koa litter
	Maui	`Ohi`a bark
Stigmaeus n.sp. C	O'ahu	soil
		moss with soil
	Kaua'i	`Ohi`a, banana poka
		moss on `Ohi`a
	Moloka'i	`Ohi`a
Stigmaeus n.sp. D	Kaua'i	Metrosideros bark
Stigmaeus elongatus	O'ahu	soil litter
Storchia pacifica	O'ahu	stored animal feed
Storchia robusta	O'ahu	Christmas Berry tree bark

Table 3. Known species of Raphignathoids Occurring in the Hawaiian Islands and their Geographic Distribution

Genera and Species	Geographic Distribution	Selected References
Agistemus congolensis Gonzalez-Rodriguez,1965	Africa (Zaire)	Gonzalez-Rodriguez,1965
Agistemus terminalis (Quayle,1912)	USA (CA), Japan India, Mexico Guatemala Hawaiian Is.	Summers,1960 Ehara,1964,1985 Ehara & Wongsiri, 1984;Goff,1987
Eryngiopus bifidus (Wood, 1967)	New Zealand Italy	Wood,1967 Vacante & Gerson, 1987
Eustigmaeus kauaiensis Swift,Gerson & Goff,1987	Hawaiian Is.	Swift, Gerson & Goff,1985
Eustigmaeus microsegnis (Chaudhri, 1965)	Europe (Italy) USA (CA), Taiwan Brazil	Chaudhri,1965 Tseng,1981 Flechtmann,1981
Eustigmaeus ornatus Ueckermann & Meyer,1987	South Africa	Ueckermann & Meyer,1987
Eustigmaeus segnis (Koch, 1836)	Europe (Germany) Africa, USSR USA CA) Hawaiian Is.	Summers,1957 Wood,1973,1987 Kuznetzov& Petrov 1987; Goff,1987
Stigmaeus elongatus (Berlese, 1886)	Europe (Italy) USA (CA)	Summers,1962
Storchia pacifica (Summers, 1964)	Panama, Tahiti Indonesia,Brazil Philippines France,Guadalcanal	Summers,1964 Wood, 1971 Flechtmann,1981
Storchia robusta (Berlese, 1885)	Europe (Italy) France, Corsica New Zealand, British Solomon I., So. Africa	Grandjean,1944 Wood, 1967,1971 Ueckermann & Meyer,1987
Exothorhis caudata Summers, 1960	USA (FL)	Summers, 1960

Table 3. (continued) Known Species of Raphignathoids Occurring in the Hawaiian Islands and their Geographic Distribution

Genera and Species	Geographic Distribution	Selected References
Saniosulus nudus Summers, 1960	Mexico USA (TX) India, Egypt Israel	Summers, 1960 Gerson, 1968 Rakha & McCoy, 1985
Neophyllobius consobrinus DeLeon, 1958	Mexico	DeLeon, 1958
Favognathus pictus (Summers & Chaudhri,1965)	Galapagos Is.	Summers & Chaudhri, 1965
Raphignathus aethiopicus Meyer & Ryke, 1960	South Africa	Meyer & Ryke, 1960
Neognathus spectabilis (Summers & Schlinger, 1955)	USA (CA)	Summers & Schlinger, 1955

Figure 1

Peritreme of representatives of some families of Raphignathoidea

A. Raphignathidae (*Raphignathus* n.sp.)

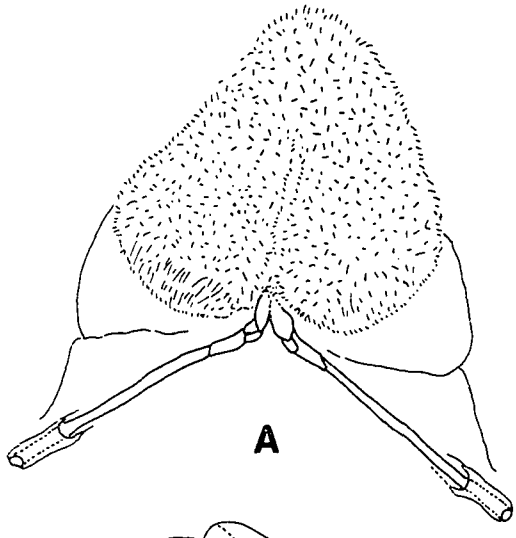
B. Caligonellidae (*Neognathus spectabilis* (Summers & Schlinger)

C. Caligonellidae (*Coptocheles* n.sp.)

D. Cryptognathidae (*Favognathus* n.sp.)

E. Xenocaligonellidae (*Xenocaligonellidus tecleae* (Meyer))

F. Camerobiidae (*Tycherobius* n.sp.)



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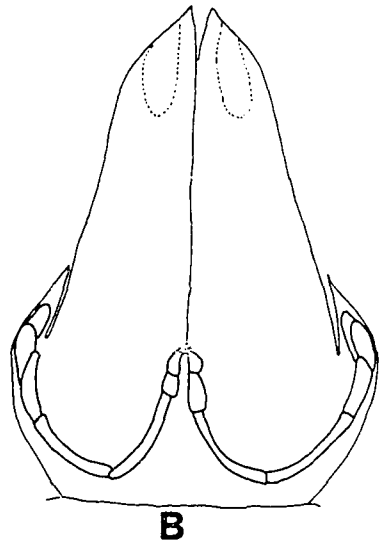
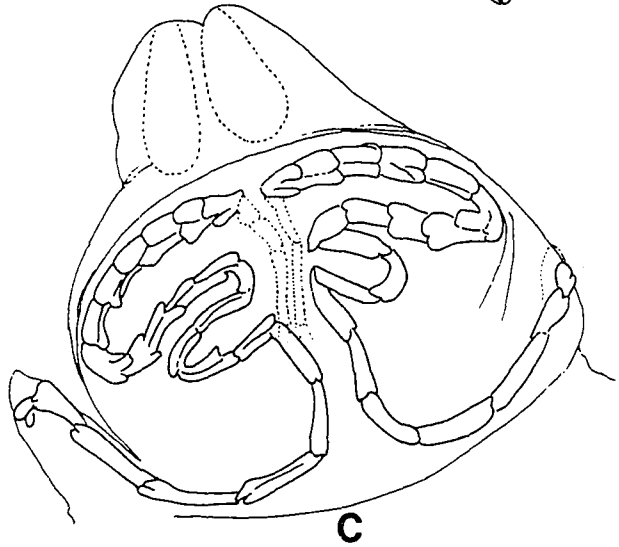
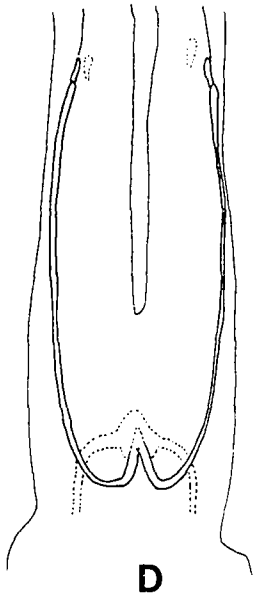


B



C



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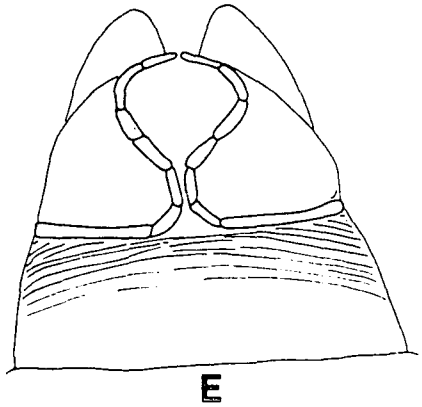
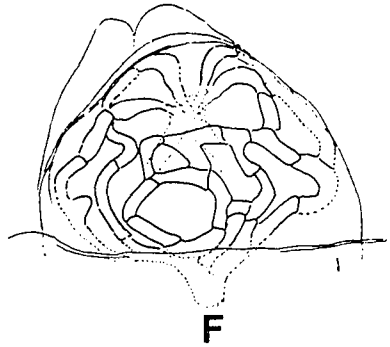


E



F

Figure 2

Palpus of representatives of families of Raphignathoidea

A. Camerobiidae (*Tycherobius* n.sp.)

B. Caliognellidae (*Coptocheles* n.sp.)

C. Cryptognathidae (*Favognathus* n.sp.)

D. Raphignathidae (*Raphignathus* n.sp.)

E. Stigmaeidae (*Eustigmaeus* n.sp.)

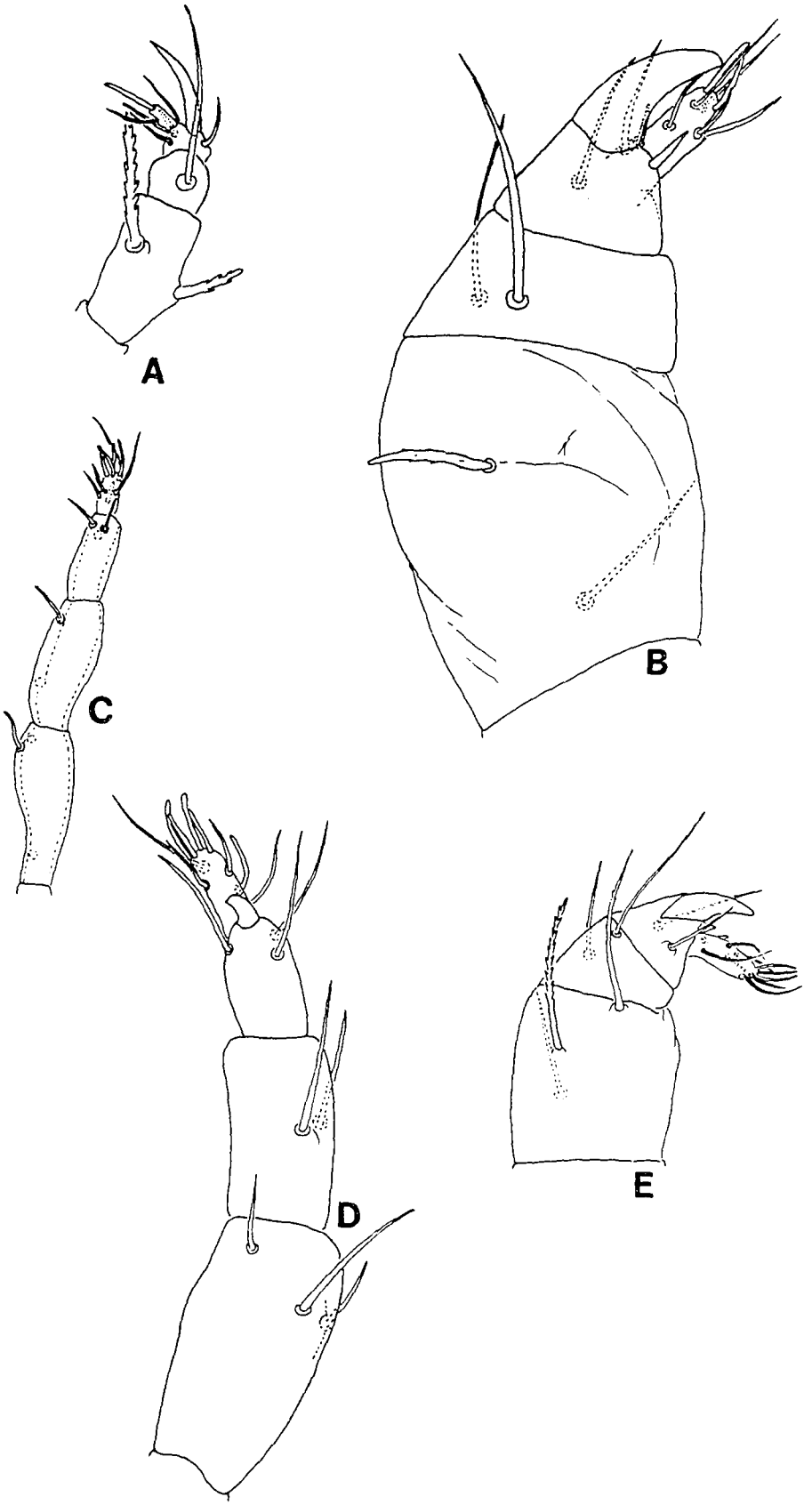

A
B
C
D
E

Figure 3

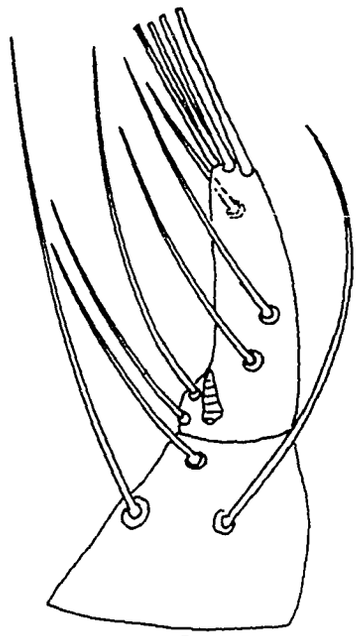
Palpus of representatives of families of Raphignathoidea

A. Xenocaligonellidae (Xenocaligonellidus tecleae (Meyer))

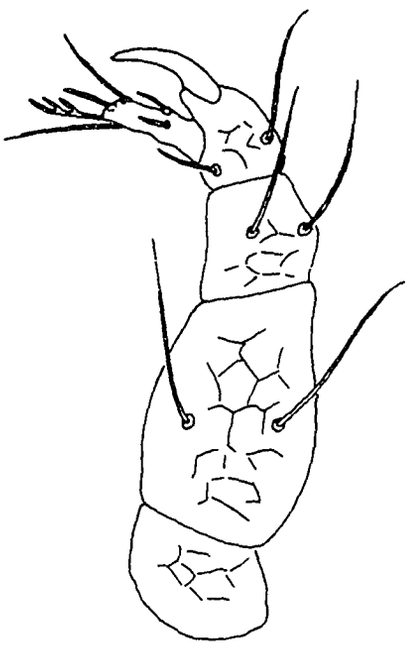
B. Homocaligidae (Annerosella pacifica Wood)

C. Barbutiidae (Barbutia perretae Robaux)

D. Eupalopsellidae (Saniosulus nudus Summers)

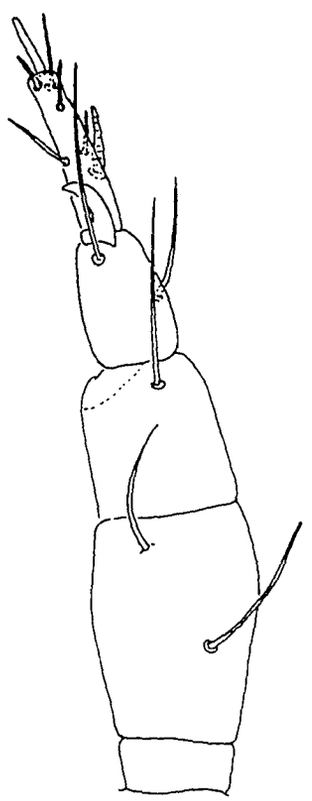


A



B

C



D

Figure 4

Coxal arrangements of some representatives of families of Raphignathoidea

A. Raphignathidae (*Raphignathus* n.sp.)

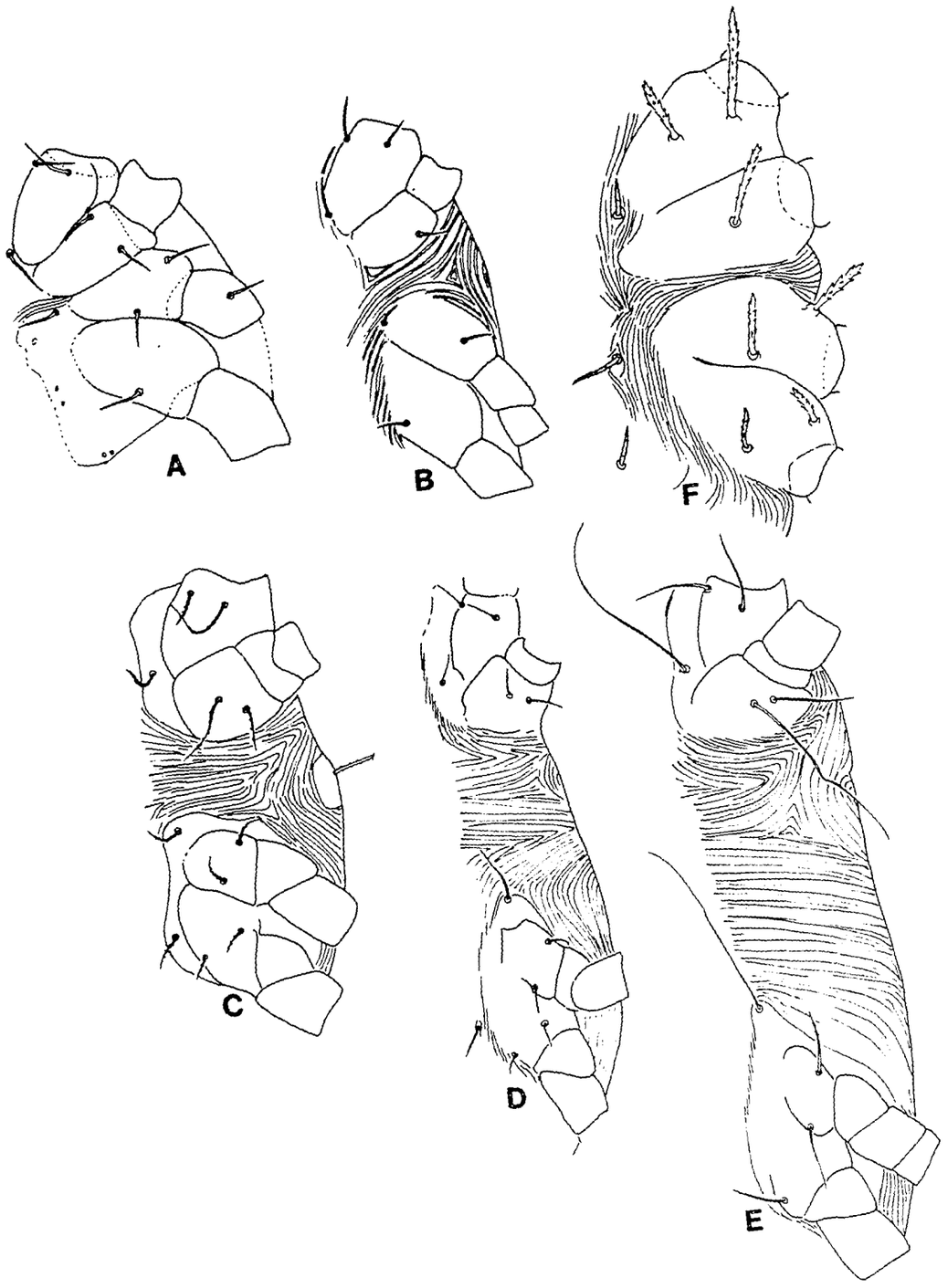
B. Caliognellidae (*Molothrognathus* n.sp.)

C. Stigmaeidae (*Stigmaeus* n.sp.)

D. Stigmaeidae (*Stigmaeus* n.sp.)

E. Stigmaeidae (*Eryngiopus* n.sp.)

F. Camerobiidae (*Tycherobius* n.sp.)


A
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C
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E

Figure 5

Coptocheles n.sp. A, female

A. Dorsal habitus

B. Ventral habitus

C. Dorsal setae

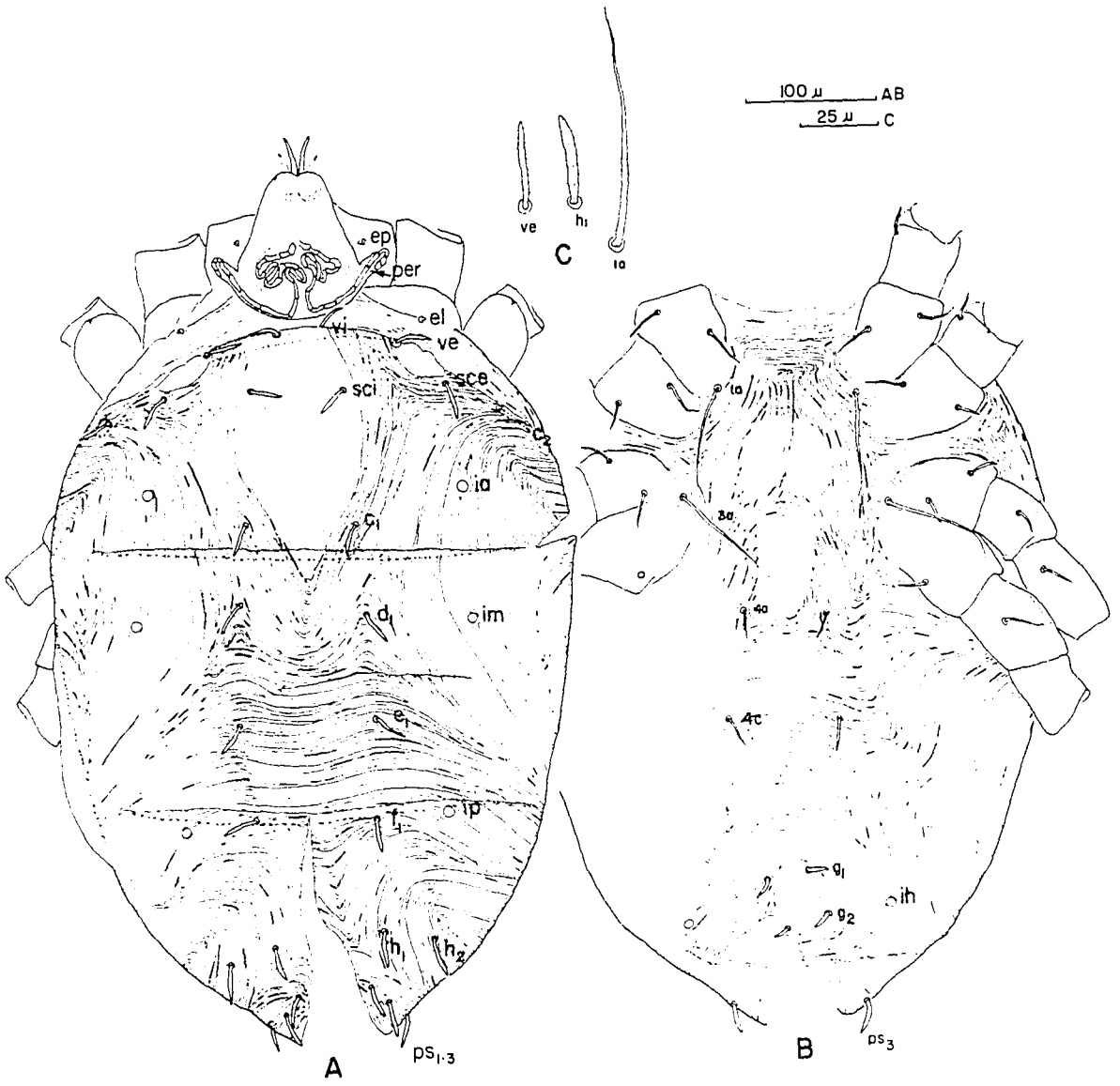
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Figure 6

Coptocheles n.sp. A, female

A. Dorsal aspect of leg I

B. Dorsal aspect of leg II

C. Empodium

D. Palpus

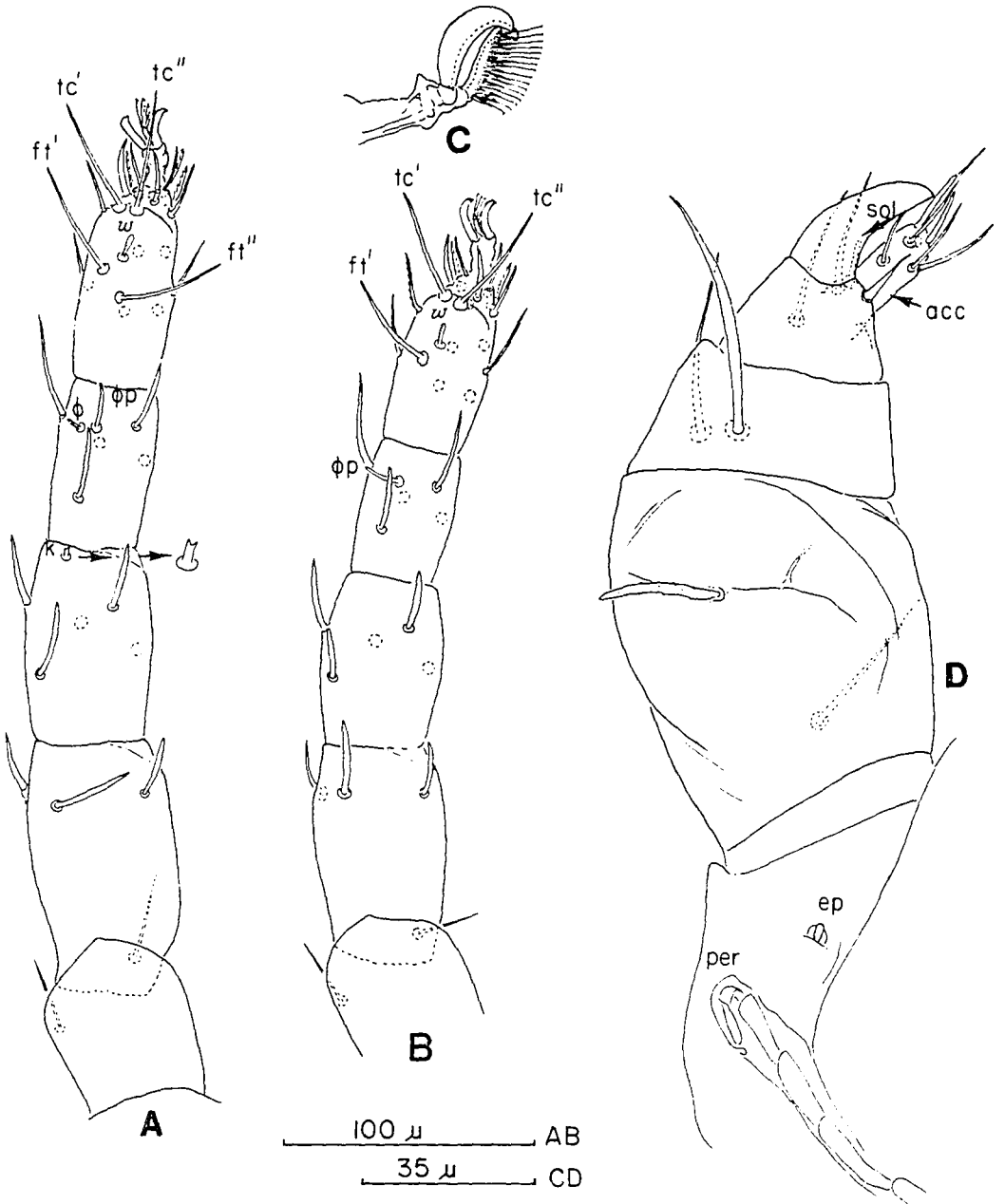
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Figure 7

Coptocheles n.sp. A

A. Leg I, male

B. Leg II, male

C. Leg III, male

D. Pseudanal plates of male, dorsal aspect

E. Dorsal opisthosomal aspect of male showing aedeagus

F. Infracapitulum, female

G. Tracheae, peritremes, podocephalic canals and supracoxal setae eI

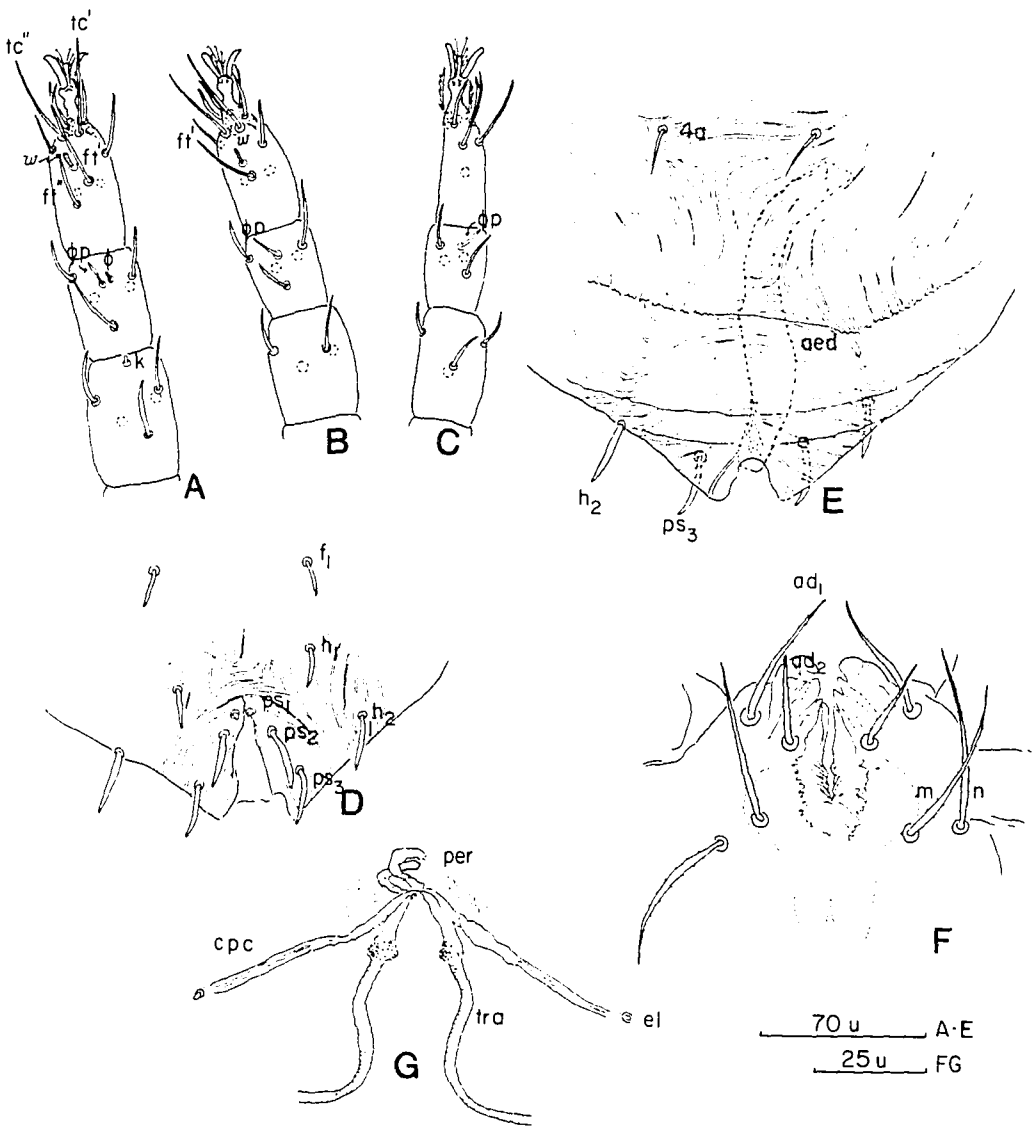
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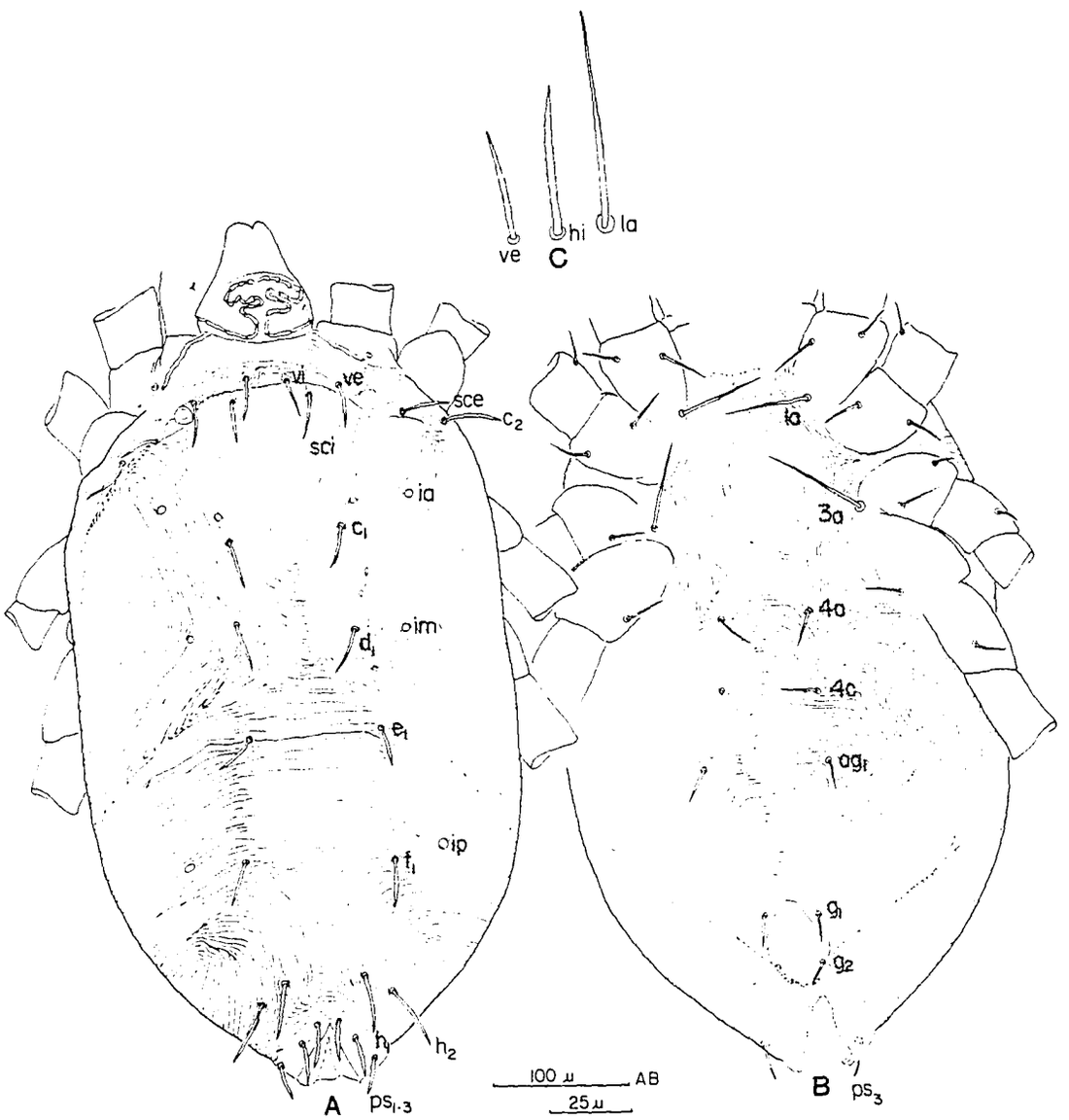
Figure 8

Coptocheles n.sp. B, female

A. Dorsal habitus

B. Ventral habitus

C. Dorsal setae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3a
4a
4c
og1
g1
g2
ps3
B

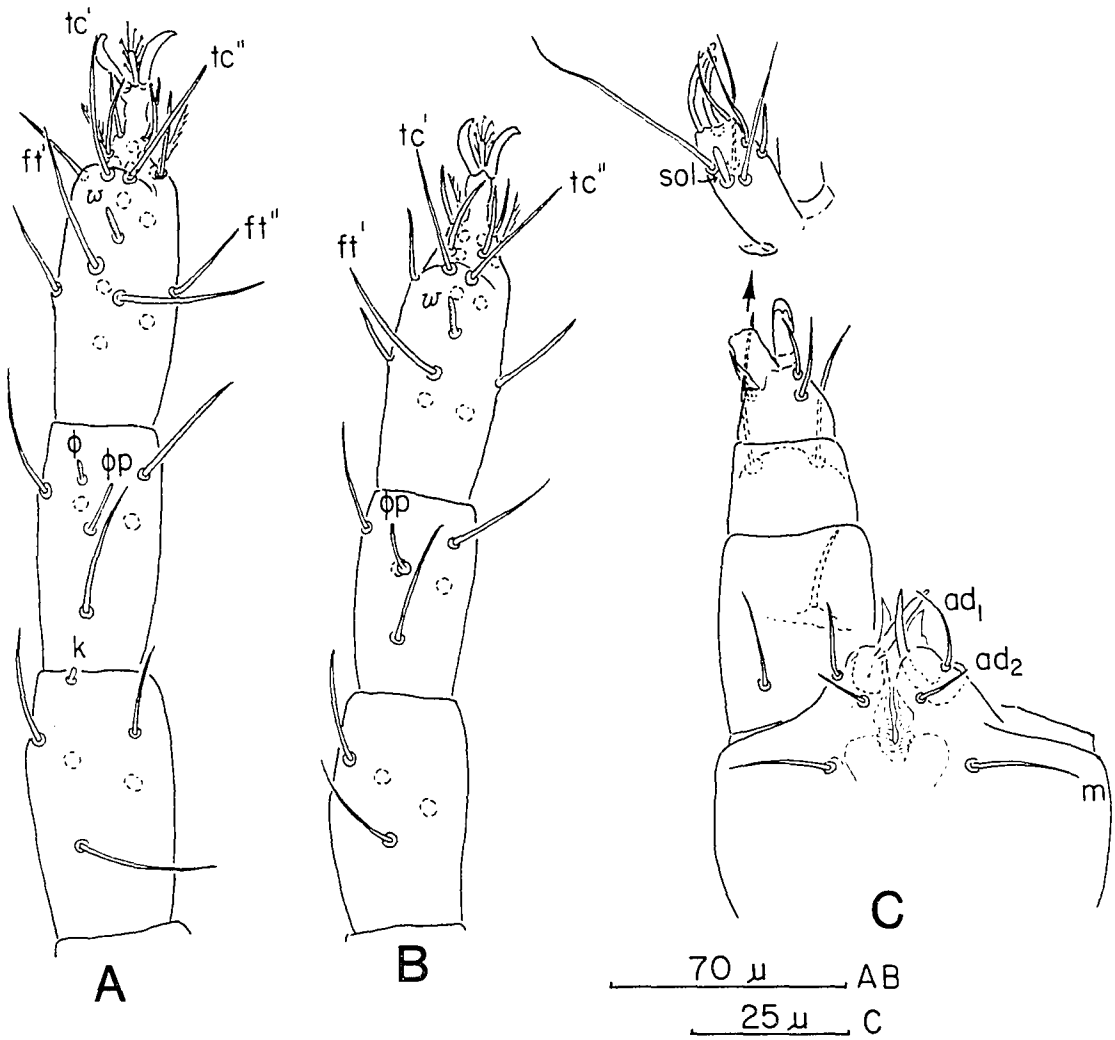
Figure 9

Coptocheles n.sp. B, female

A. Leg I

B. Leg II

C. Gnathosoma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ad1
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m
C
70 μ
AB
25 μ
C

Figure 10

Coptocheles n.sp. C, female

A. Dorsal habitus

B. Ventral habitus

C. Dorsal setae

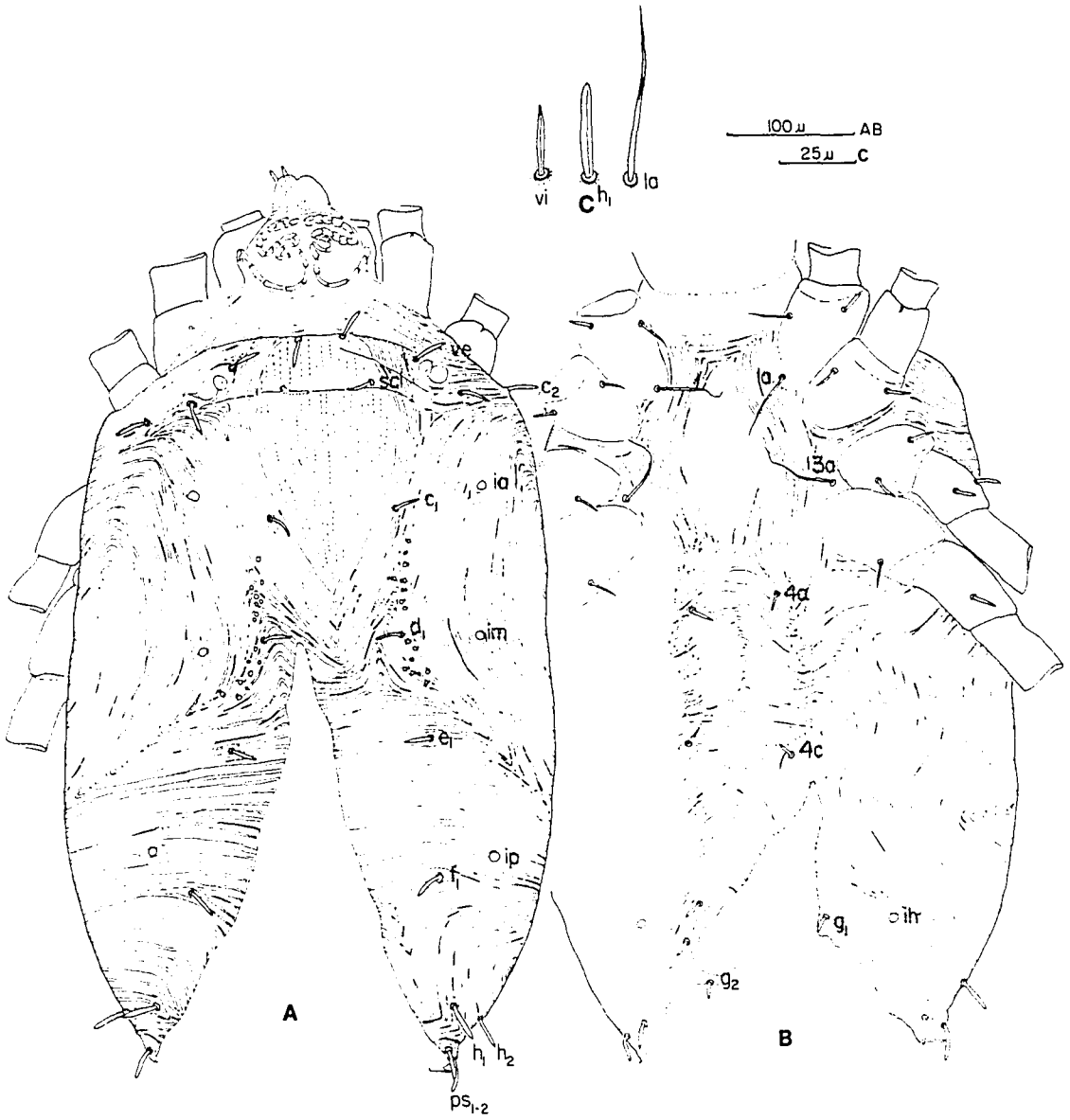

100 μ AB
25 μ C
vi
Ch1
la
ve
sc
c2
ia
c1
d1
aim
e1
ip
f1
h1
h2
ps1-2
A
la
13a
4a
4c
g1
iih
g2
B

Figure 11

Coptocheles n.sp. C, female

A. Stylophore

B. Infracapitulum

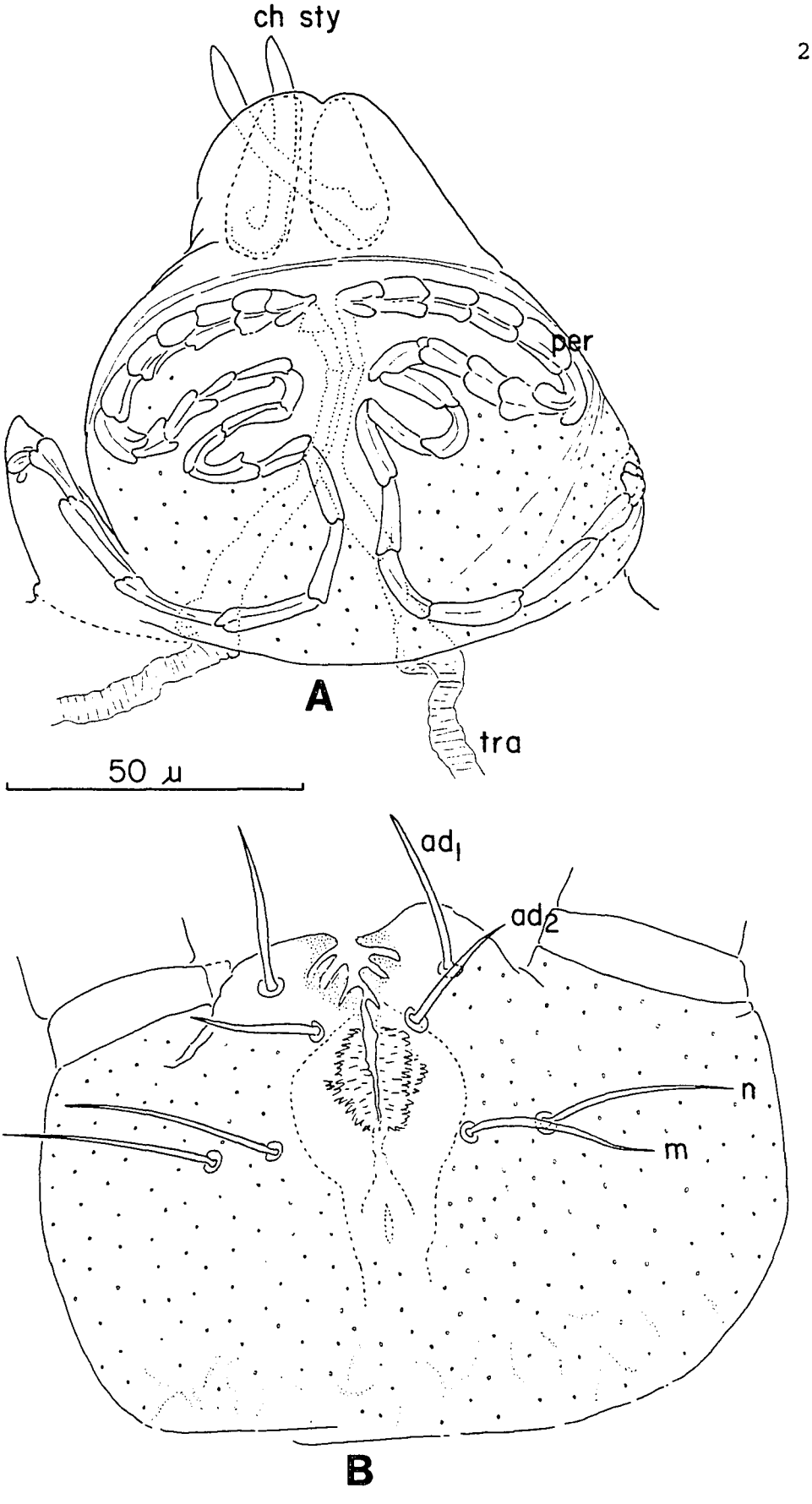

ch sty
per
A
tra
50 μ
ad1
ad2
n
m
B

Figure 12

Coptocheles n.sp. C, female

A. Leg I

B. Leg II

C. Palpus

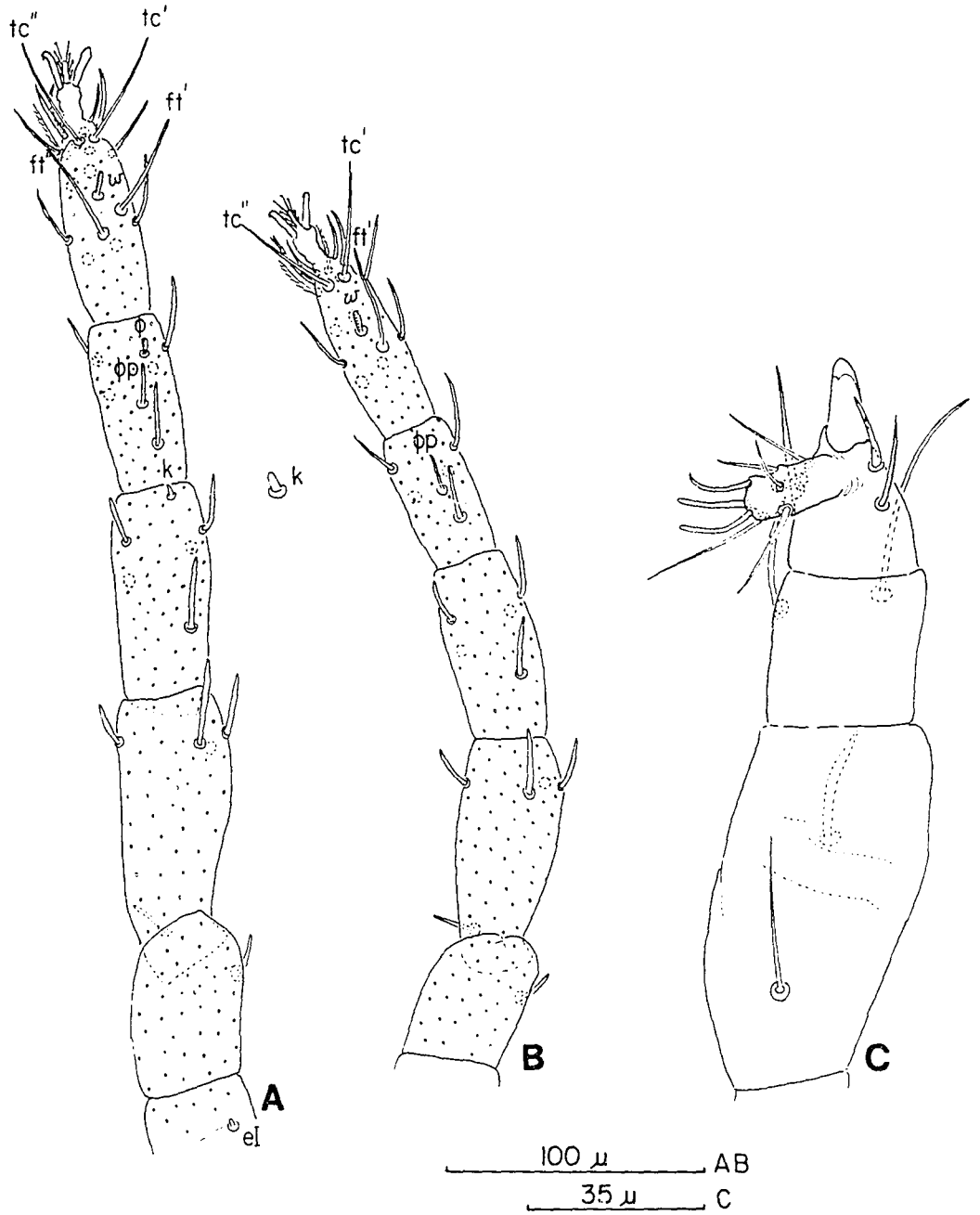

tc''
tc'
ft'
ft''
ω
φ
φp
k
eI
A
tc'
tc''
ft'
ω
φp
k
B
C
100 μ
AB
35 μ
C

Figure 13

Molothrognathus n.sp. A, female

A. Dorsal habitus

B. Ventral habitus

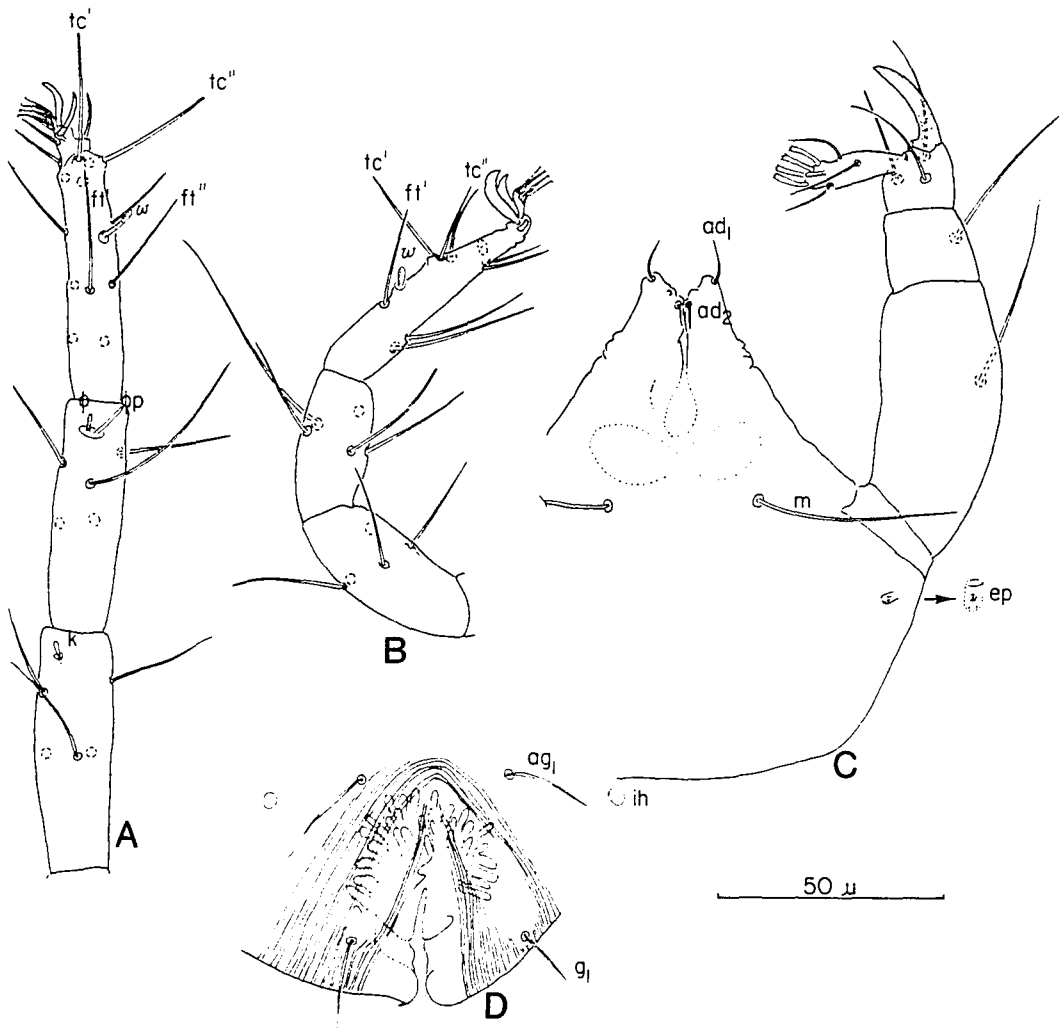

tc'
tc''
ft'
ft''
ω
φ
φp
k
A
tc'
ft'
tc''
ω
B
ad$_1$
ad$_2$
m
ep
C
ag$_1$
ih
g$_1$
D
50 μ

Figure 14

Molothrognathus n.sp. A, female

A. Leg I

B. Leg II

C. Gnathosoma, ventral view

D. Anogenital area, showing female organ

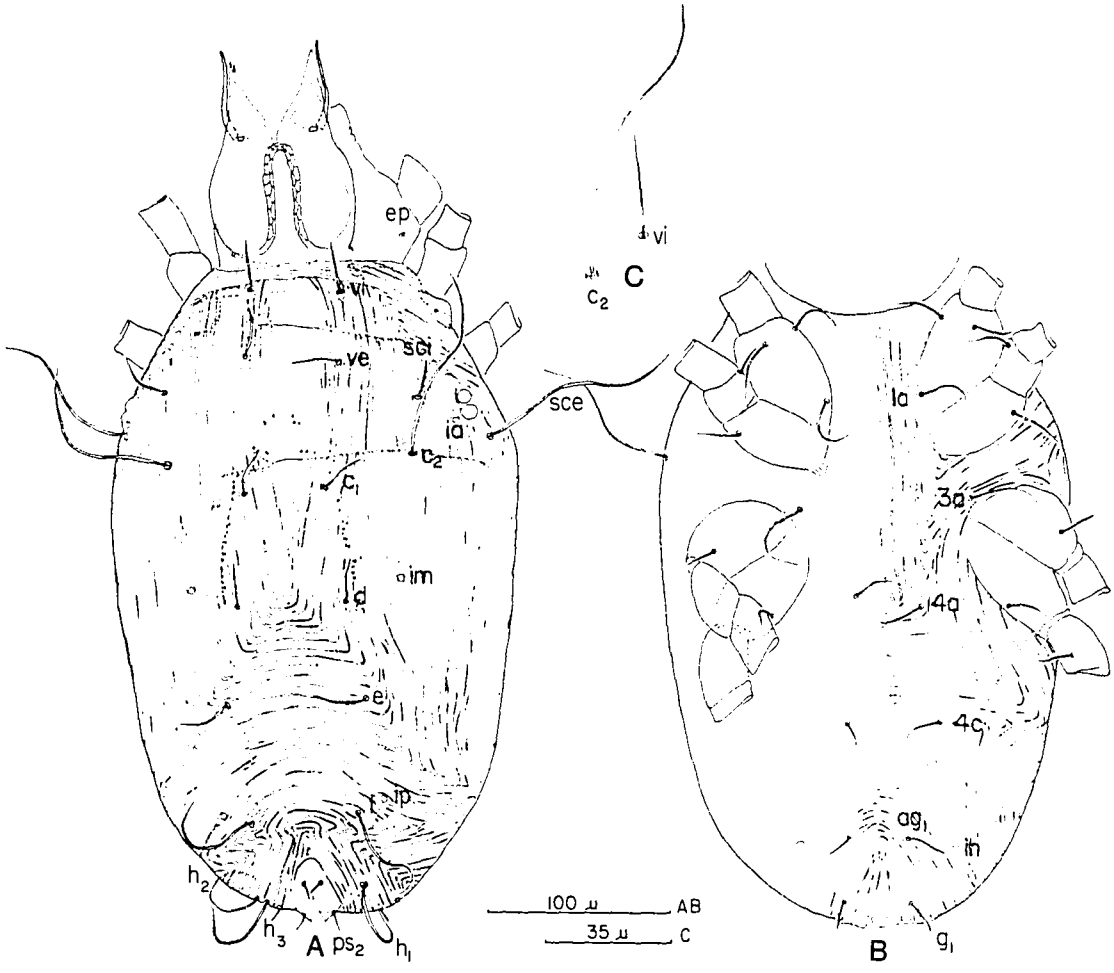

ep
vi
C
c_2
vi
ve
sci
sce
ia
c_2
c_1
im
d
e
ip
h_2
h_3
A
ps_2
h_1
100 μ
AB
35 μ
C
la
3a
4a
4c
ag_1
ih
B
g_1

Figure 15

Molothrognathus n.sp. B, female

A. Dorsal habitus

B. Ventral habitus

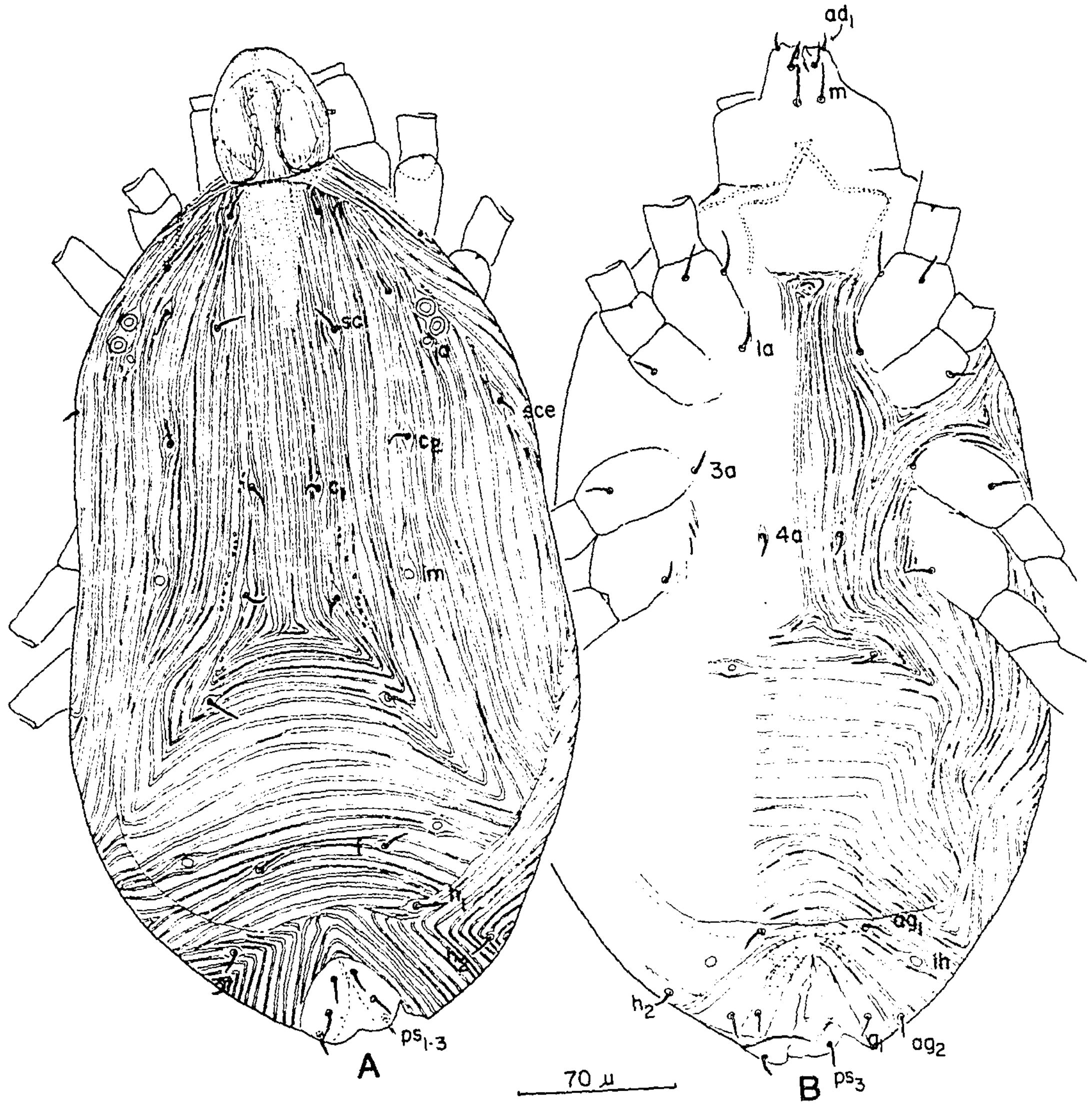

ad1
m
sc
ia
sce
ce
c1
la
3a
4a
im
h1
h2
ps1-3
ag1
ih
h2
a1
ag2
ps3
A
B
70 μ

Figure 16

Molothrognathus n.sp. B, female

A. Leg I

B. Leg II

C. Leg III

D. Gnathosoma

E. Dorsal opisthosoma

F. Ventral opisthosoma of male

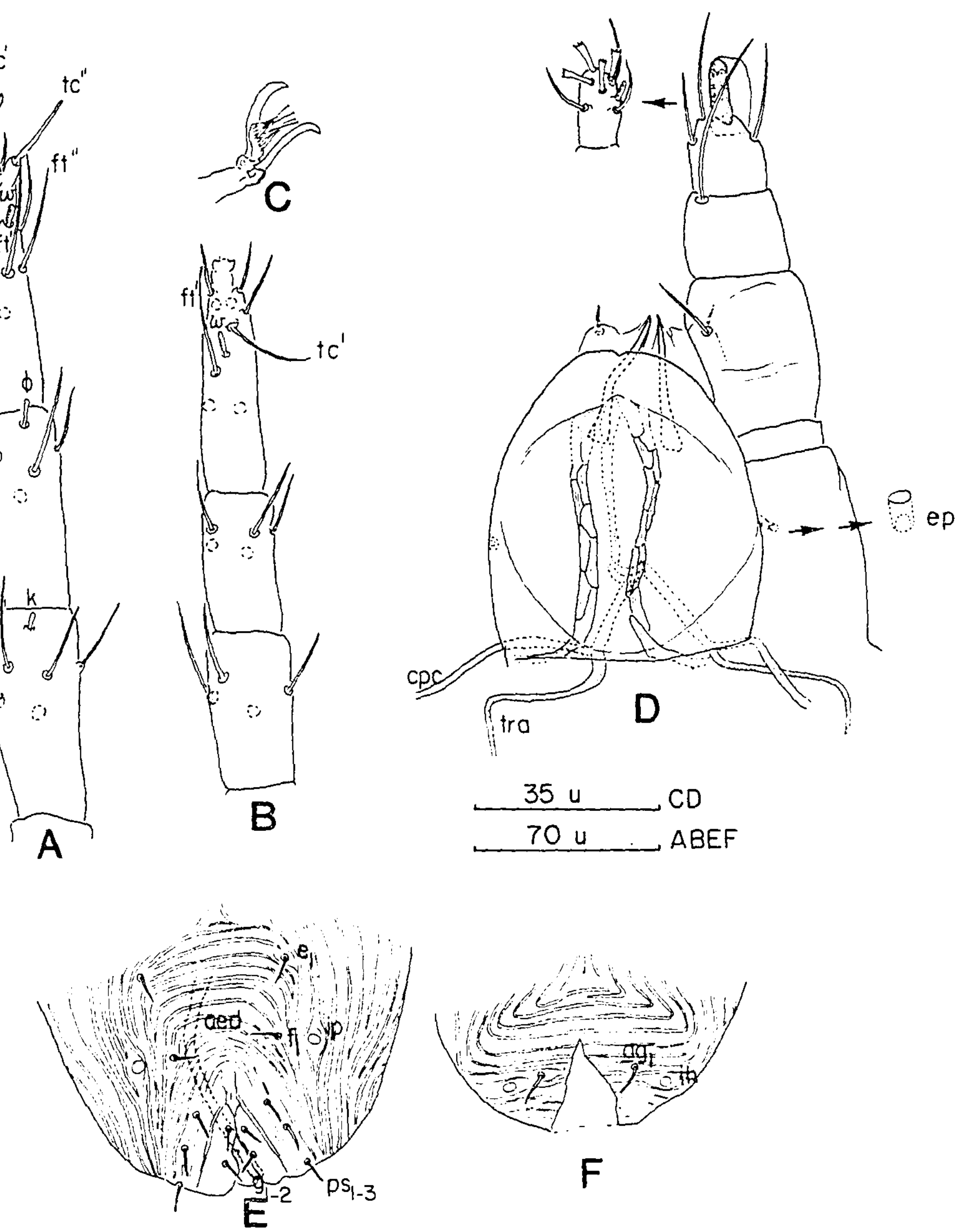

tc'
tc"
ft"
ω
ft'
φ
k
A
C
ft'
ω
tc'
B
ep
cpc
tra
D
35 u CD
70 u ABEF
e1
aed
f1
ip
ps1-3
g1-2
E
ag1
ih
F

Figure 17

Tycherobius n.sp. A, female

A. Dorsal habitus showing setal notations

B. Peritreme

C. Palpus

D. Dorsal seta

E. Anogenital area

F. Coxae I and II

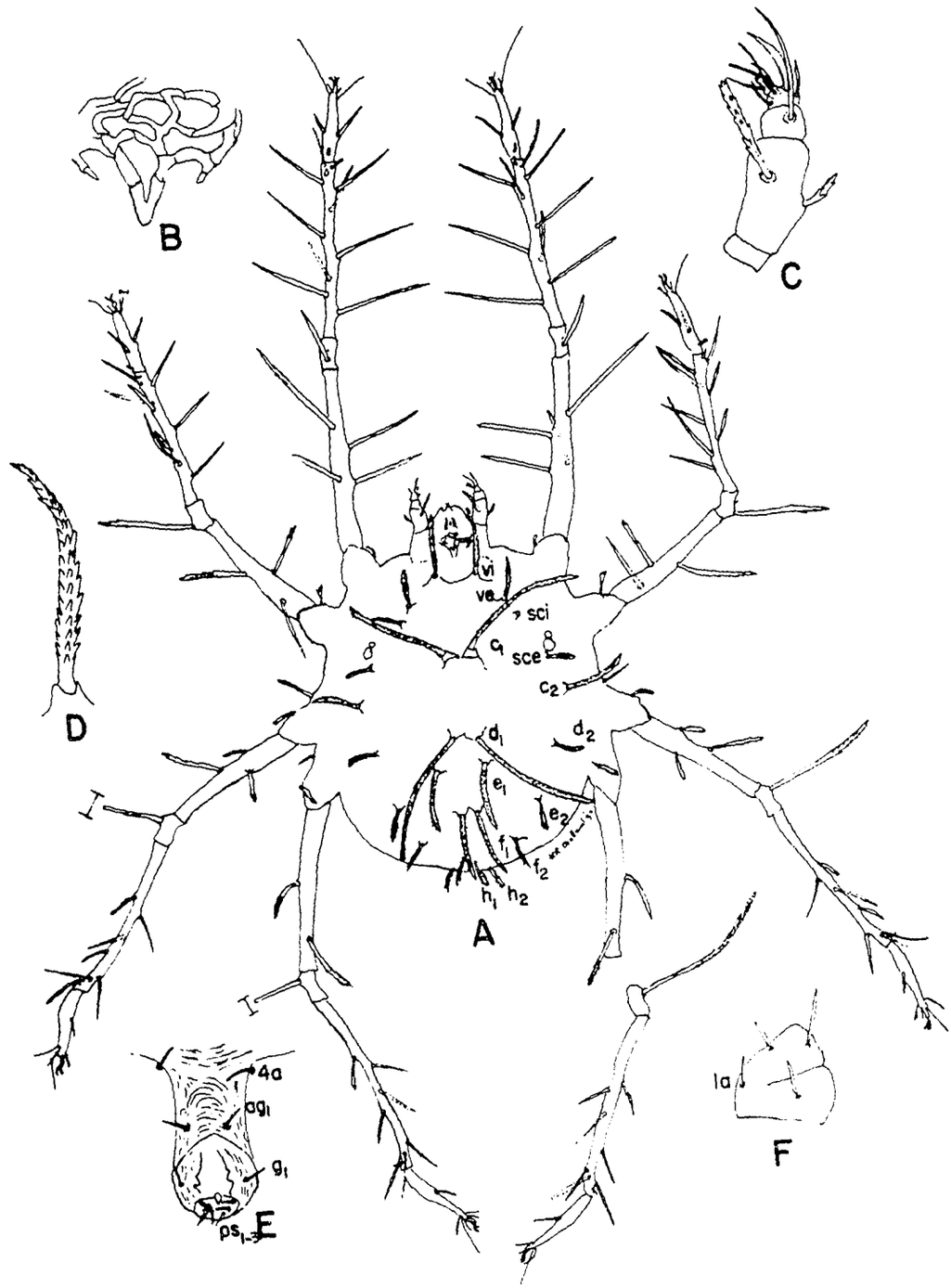

B
C
D
A
E
F
vi
ve
sci
sce
c_1
c_2
d_1
d_2
e_1
e_2
f_1
f_2
h_1
h_2
4a
ag_1
g_1
ps_{1-3}
Ia

Figure 18

Tycherobius n.sp. A, male

A. Dorsal habitus showing setal notations

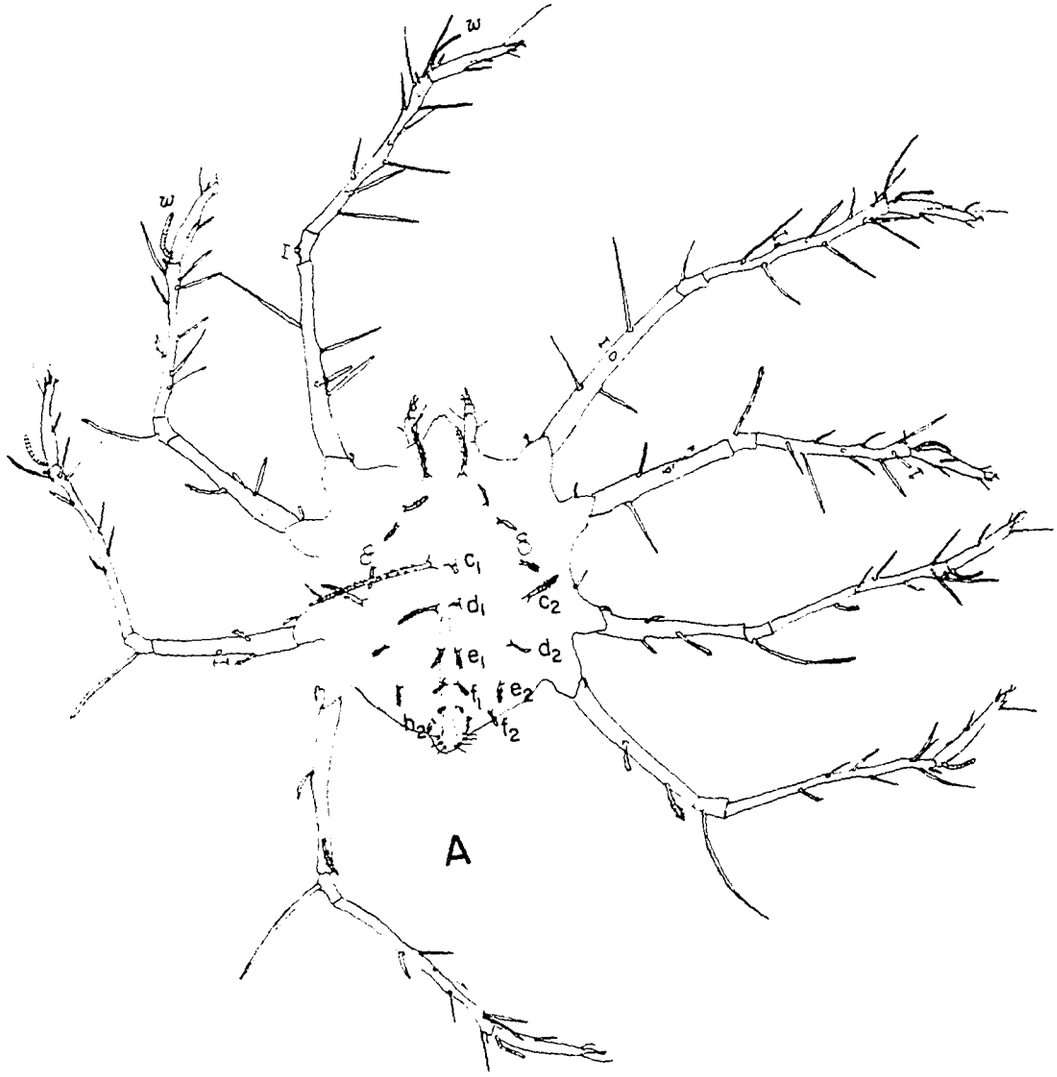

w
w
c_1
c_2
d_1
d_2
e_1
e_2
f_1
f_2
A

Figure 19

Tycherobius n.sp. A

A. Protonymph, dorsal habitus

B. Larva, dorsal habitus


A

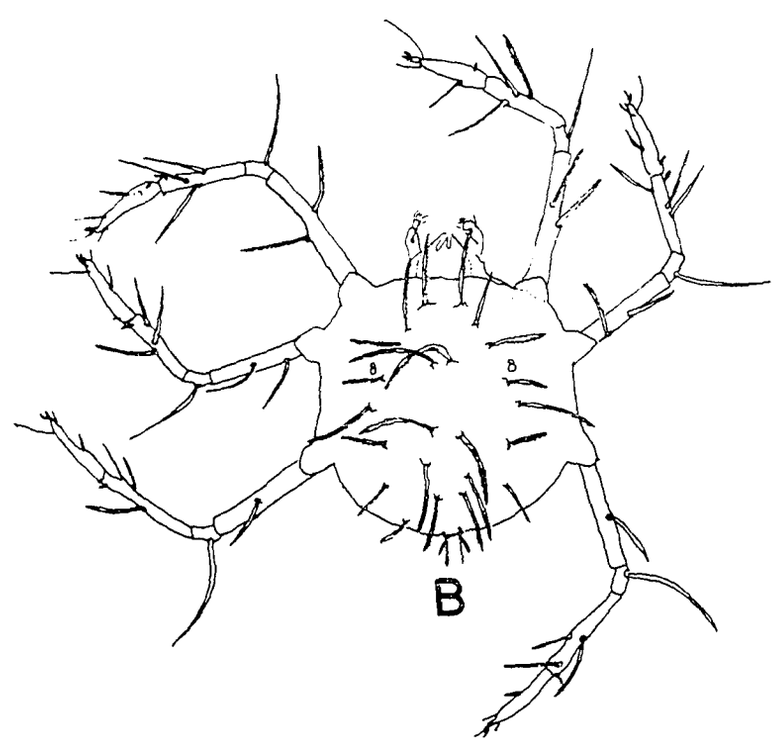

B

Figure 20

Neophyllobius n.sp. B, female

A. Dorsal habitus showing cuticular ornamentation

B. Detail of integument with mushroom-like caps

C. Palpus

D. Coxae I and II

E. Dorsal seta


B
C
pdx
f_1
h_1
h_2 f_2
A
D
E

Figure 21

Neophyllobius n.sp. B, female

A. Dorsal habitus

B. Palpus

C. Coxae I and II

D. Dorsal seta

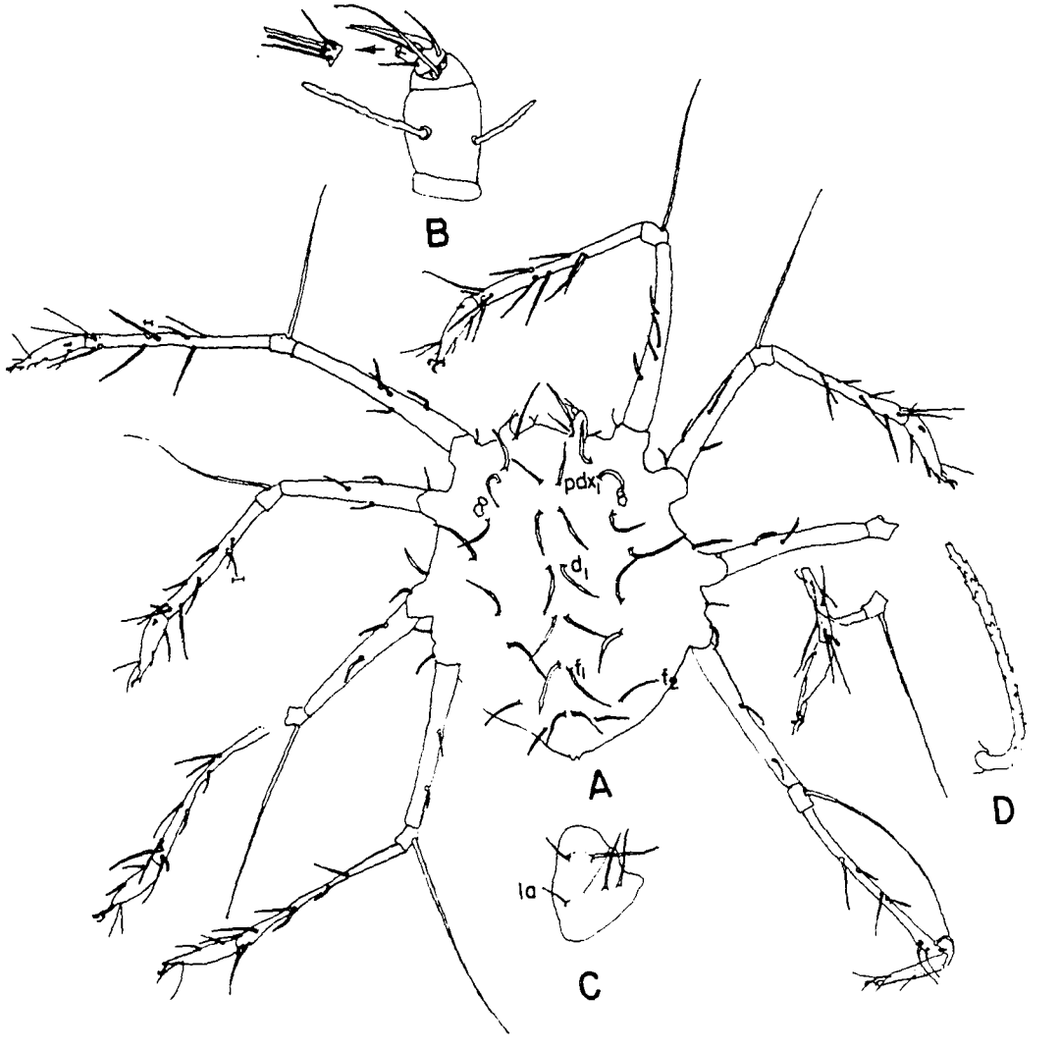

B
pdx1
d1
f1
f2
A
D
1a
C

Figure 22

Neophyllobius n.sp. B, protonymph

A. Dorsal habitus

B. Coxae I and II

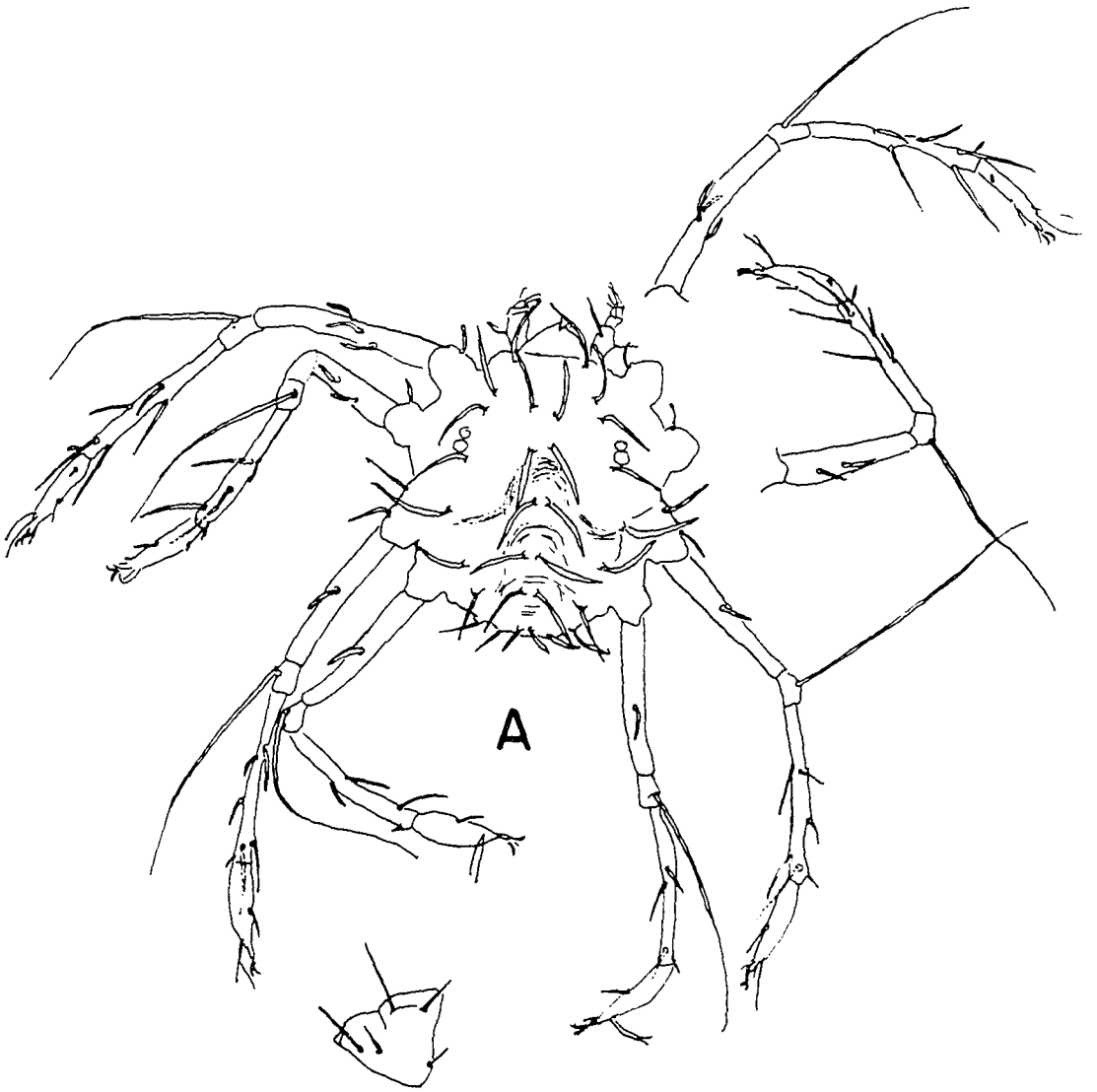

A
B

Figure 23

Neophyllobius n.sp. C, female

A. Dorsal habitus showing setal notations

B. Palpus

C. Dorsal seta

D. Coxae I and II


B
vi
ve
pdx1
sci
sce
c1
c2
d1
d2
e1
e2
f1
f2
h1
h2
C
A
la
D

Figure 24

Neophyllobius consobrinus De Leon, female

A. Dorsal habitus

B. Palpus

C. Dorsal seta

D. Coxae I and II

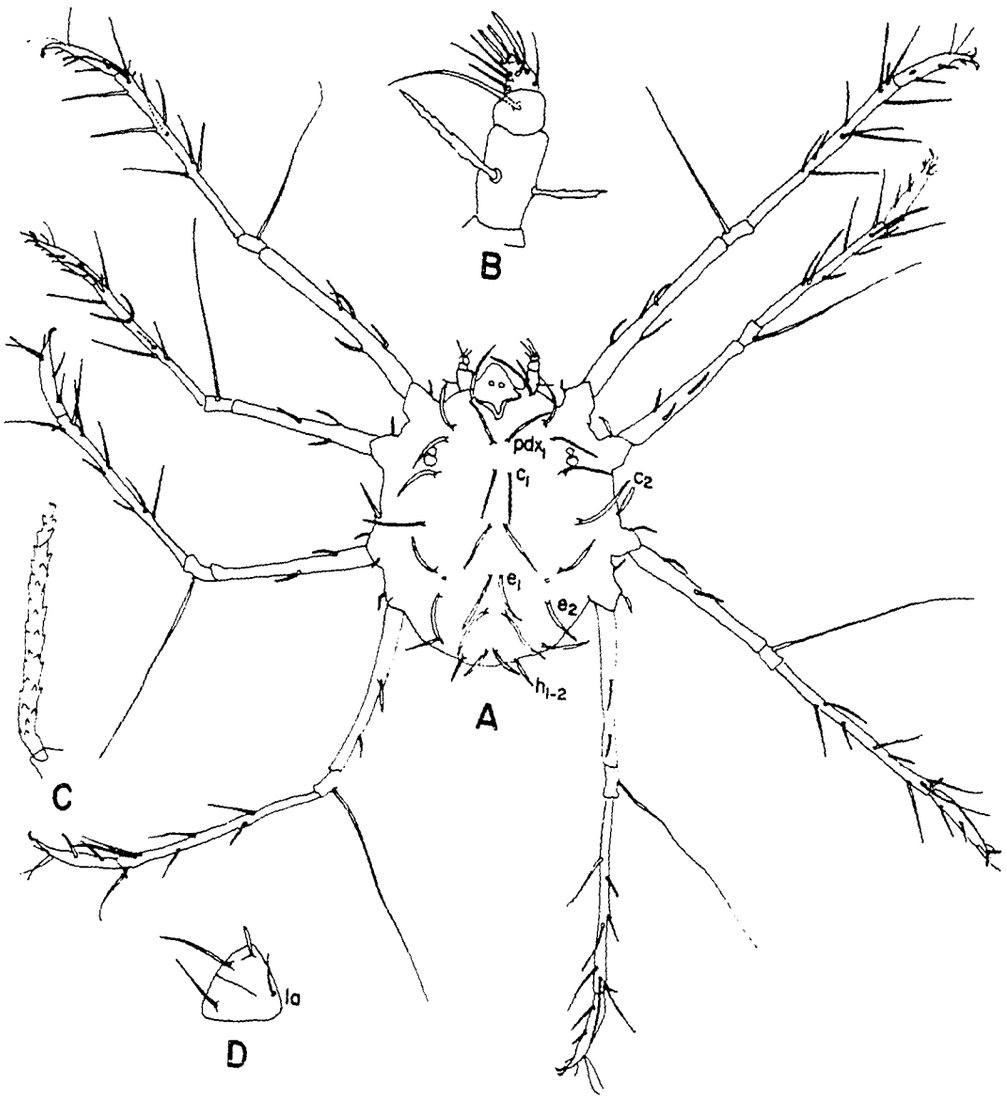

B
pdx1
c1
c2
e1
e2
h1-2
A
C
1a
D

Figure 25

Favognathus n.sp. A, female

A. Dorsal habitus

B. Ventral habitus

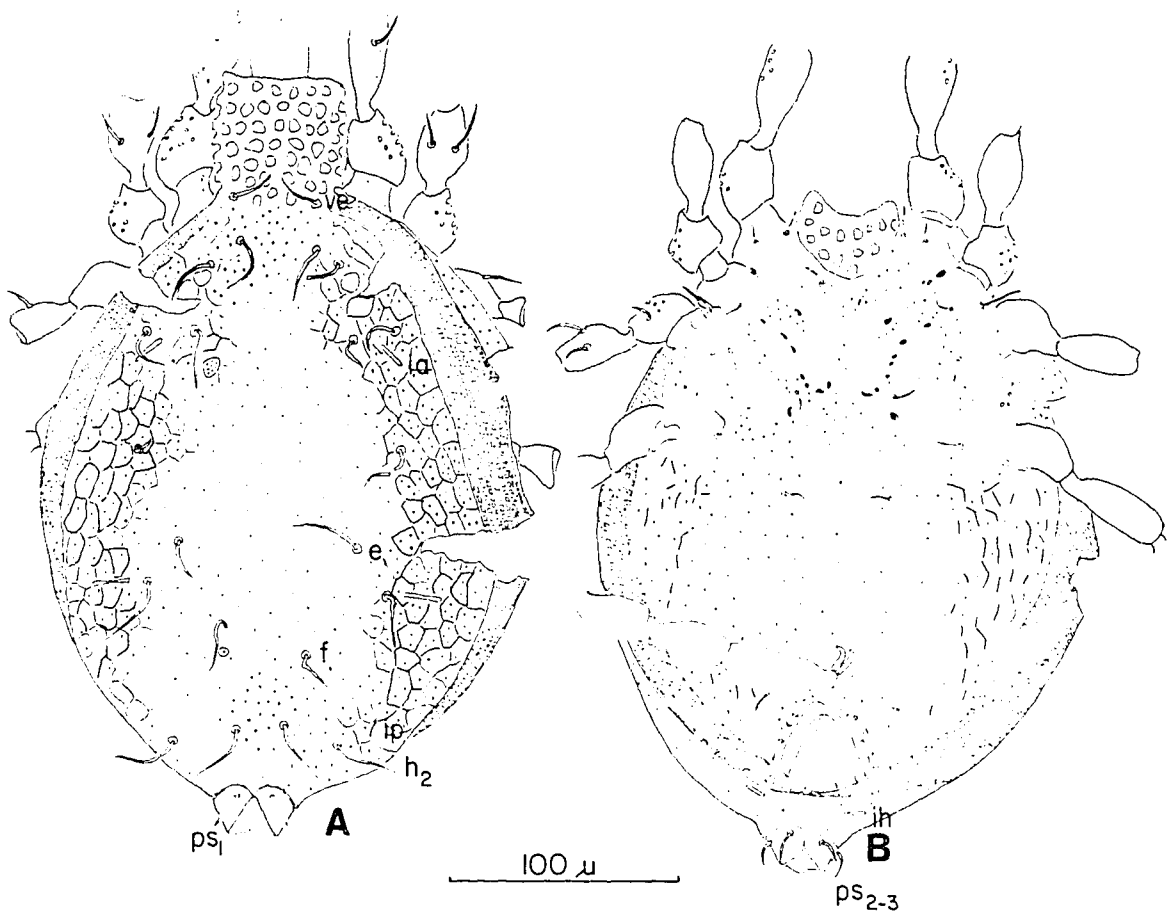

ve
la
e
f
ip
h_2
ps_1
A
100 μ
ih
B
ps_{2-3}

Figure 26

Favognathus n.sp. A, female

A. Leg I

B. Leg II

C. Leg III

D. Leg IV

E. Dorsal habitus of gnathosoma showing peritreme on chelicera, supracoxal seta ep and infracapitulum

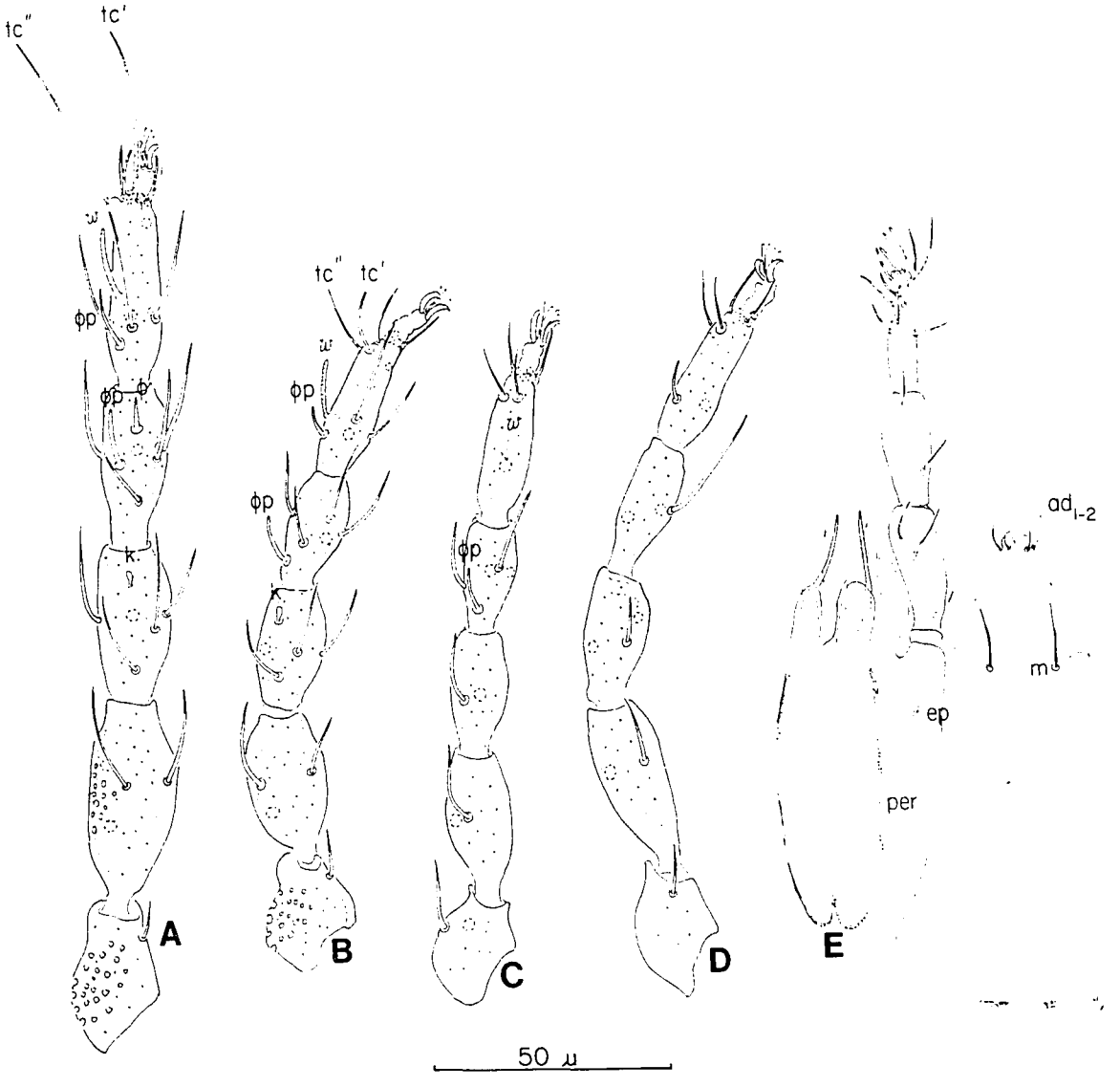

tc''
tc'
ω
φp
φp
φ
k
A
tc''
tc'
ω
φp
φp
k
B
ω
φp
C
D
ad1-2
m
ep
per
E
50 μ

Figure 27

Favognathus n.sp. B, female

A. Dorsal habitus

B. Ventral habitus

C. Lateral ornamentation showing vacuoles on reticular cells

D. Lateral condition of Favognathus ochraceus (Summers and Chaudhri)

E. Detail of hood showing dimples and denticulate edge

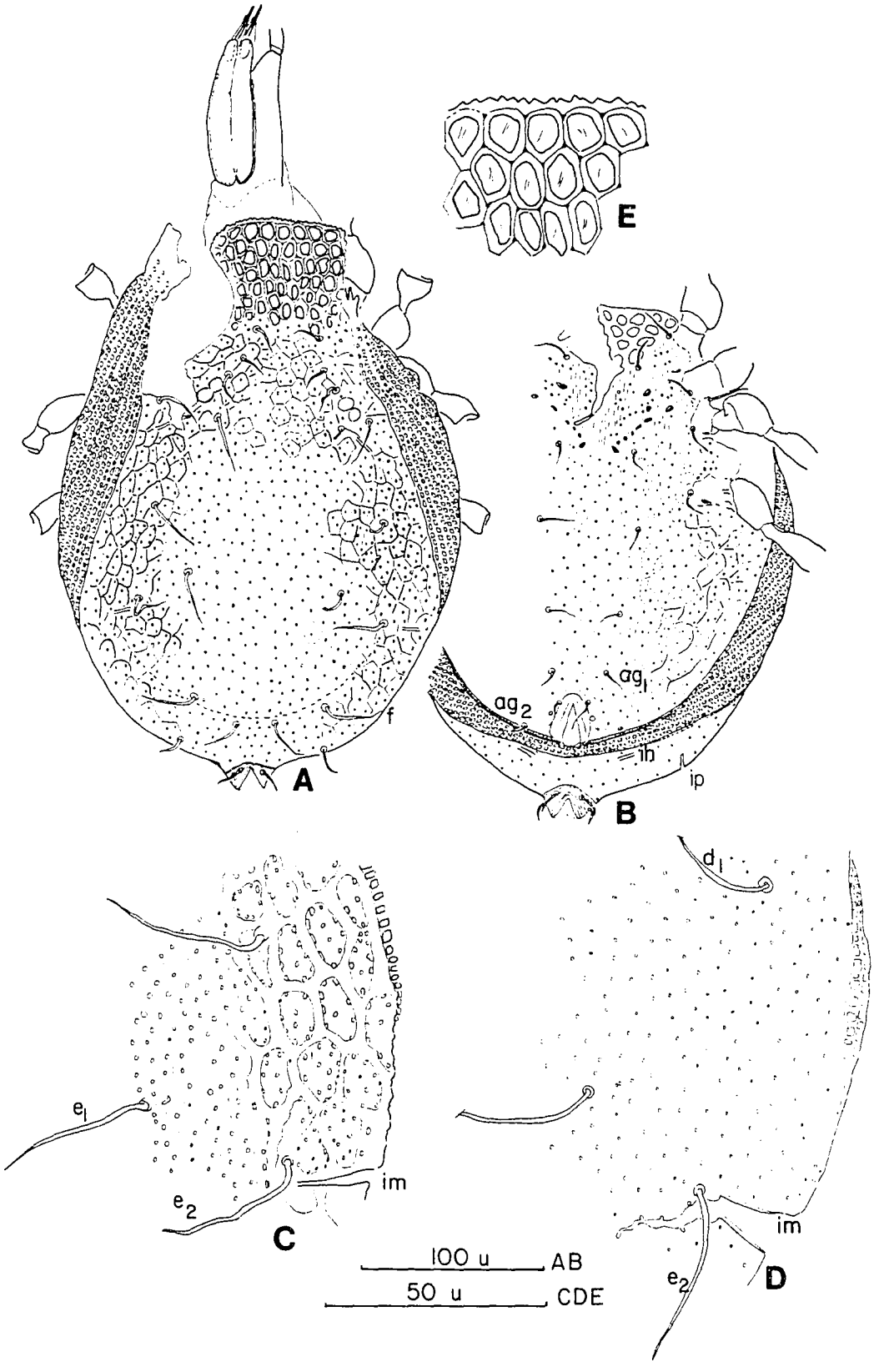

E
A
B
f
ag2
ag1
ih
ip
C
D
e1
e2
im
d1
100 u
AB
50 u
CDE

Figure 28

Favognathus n.sp. B, female

A. Leg I

B. Leg II

C. Empodium

D. Tarsus I of male

E. Tarsus II of male

F. Tarsus III of male

G. Tarsus IV of male

H. Palpus

I. Dorsal opisthosoma

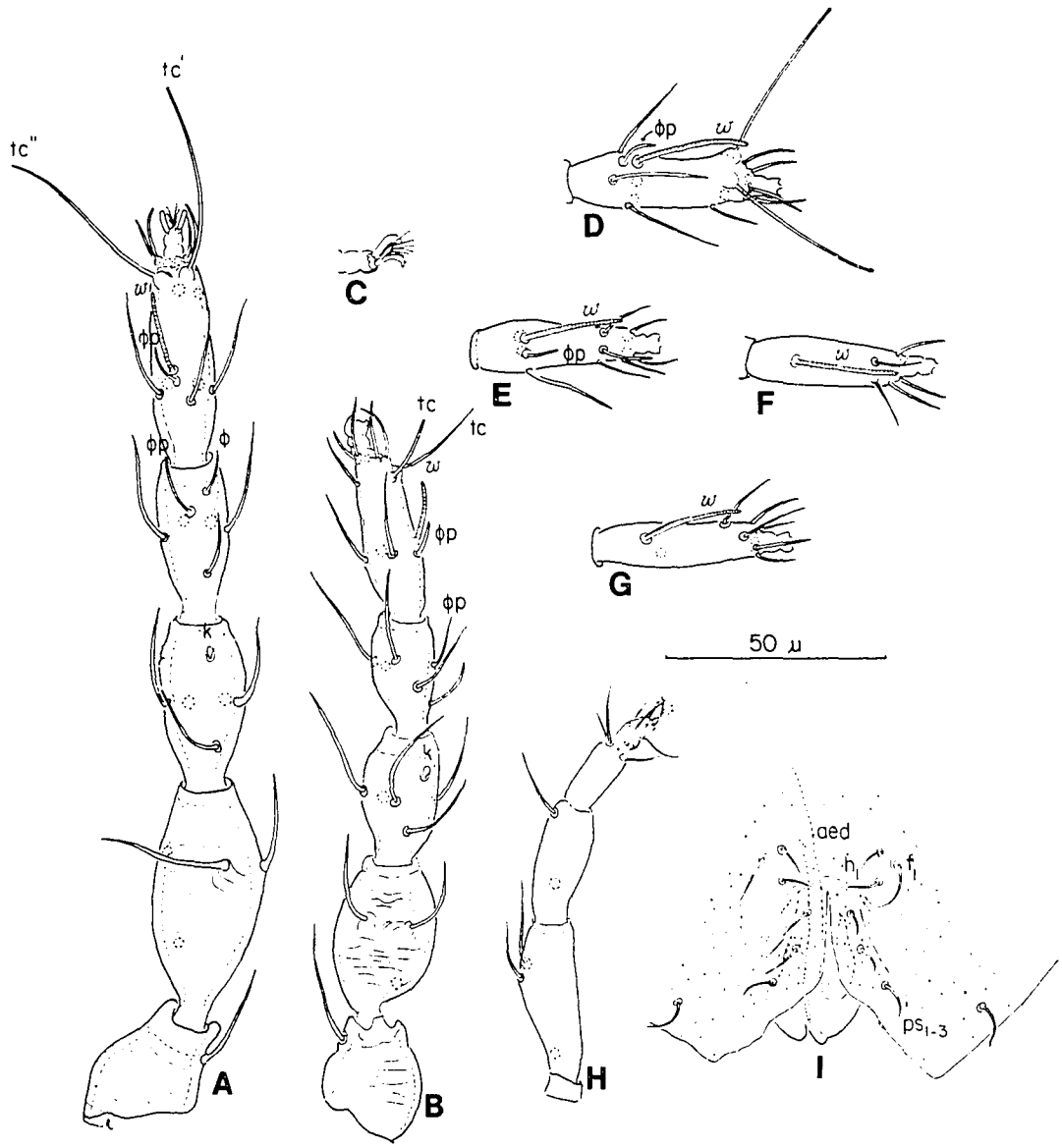

tc'
tc"
ω
φp
φp
φ
κ
A
C
tc
tc
ω
φp
φp
B
φp
ω
D
ω
φp
E
ω
F
ω
G
50 μ
H
aed
h1
f1
ps1-3
I

Figure 29

Favognathus n.sp. C, female

A. Dorsal habitus showing setal notations

B. Ventral habitus showing setal notations

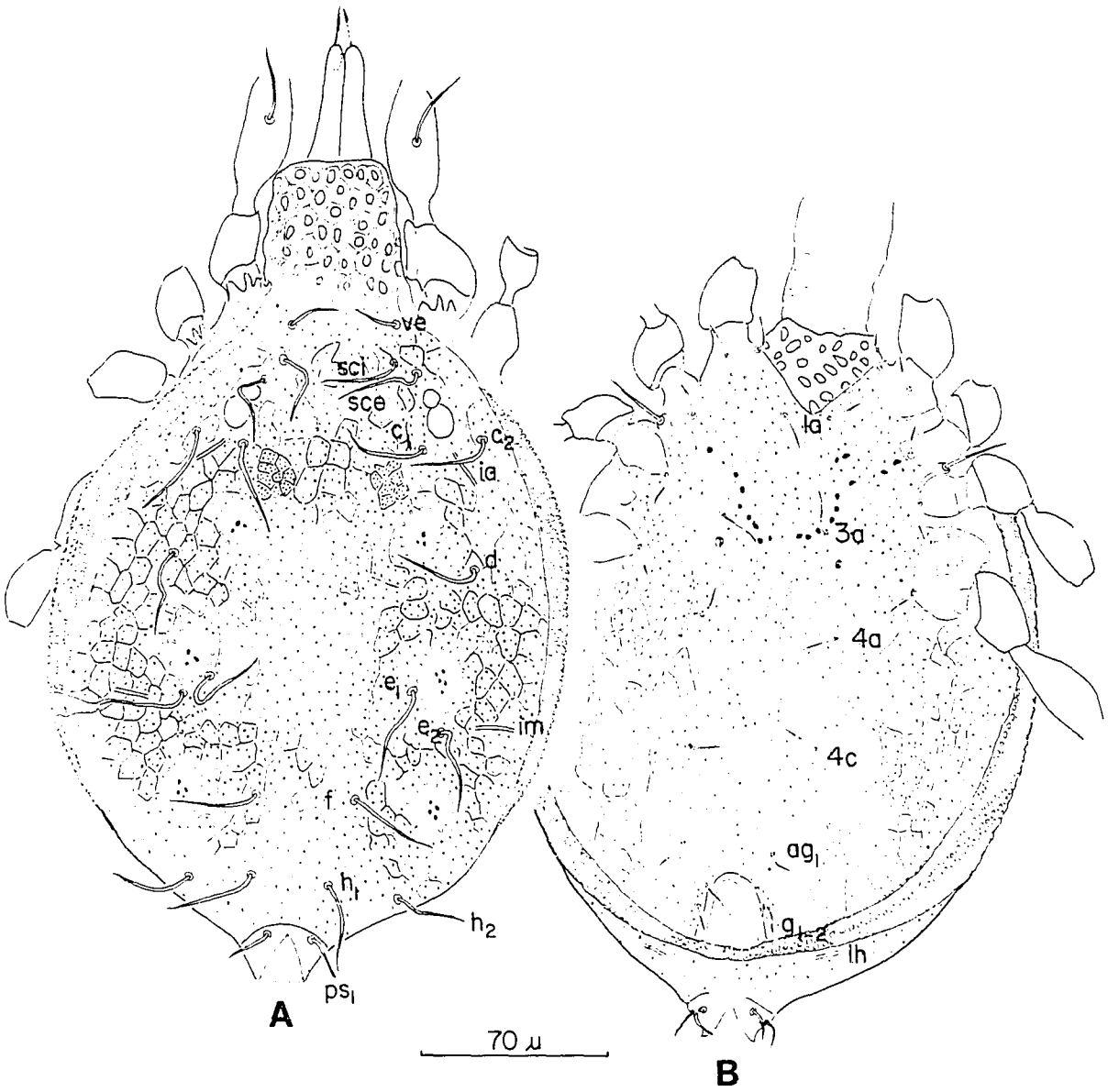

ve
sci
sce
c_1
c_2
ia
d
e_1
e_2
im
f
h_1
h_2
ps_1
A
70 μ
la
3a
4a
4c
ag_1
g_{1-2}
lh
B

Figure 30

Favognathus n.sp. C, female

A. Distal 3 segments of leg I

B. Distal 3 segments of leg II

C. Chelicerae showing peritremes

D. Peritreme, tracheal and podocephalic junction

E. Ventral gnathosoma

F. Detail of hood

G. Detail of dorsal ornamentation showing non-porous area with apodemal marks at center

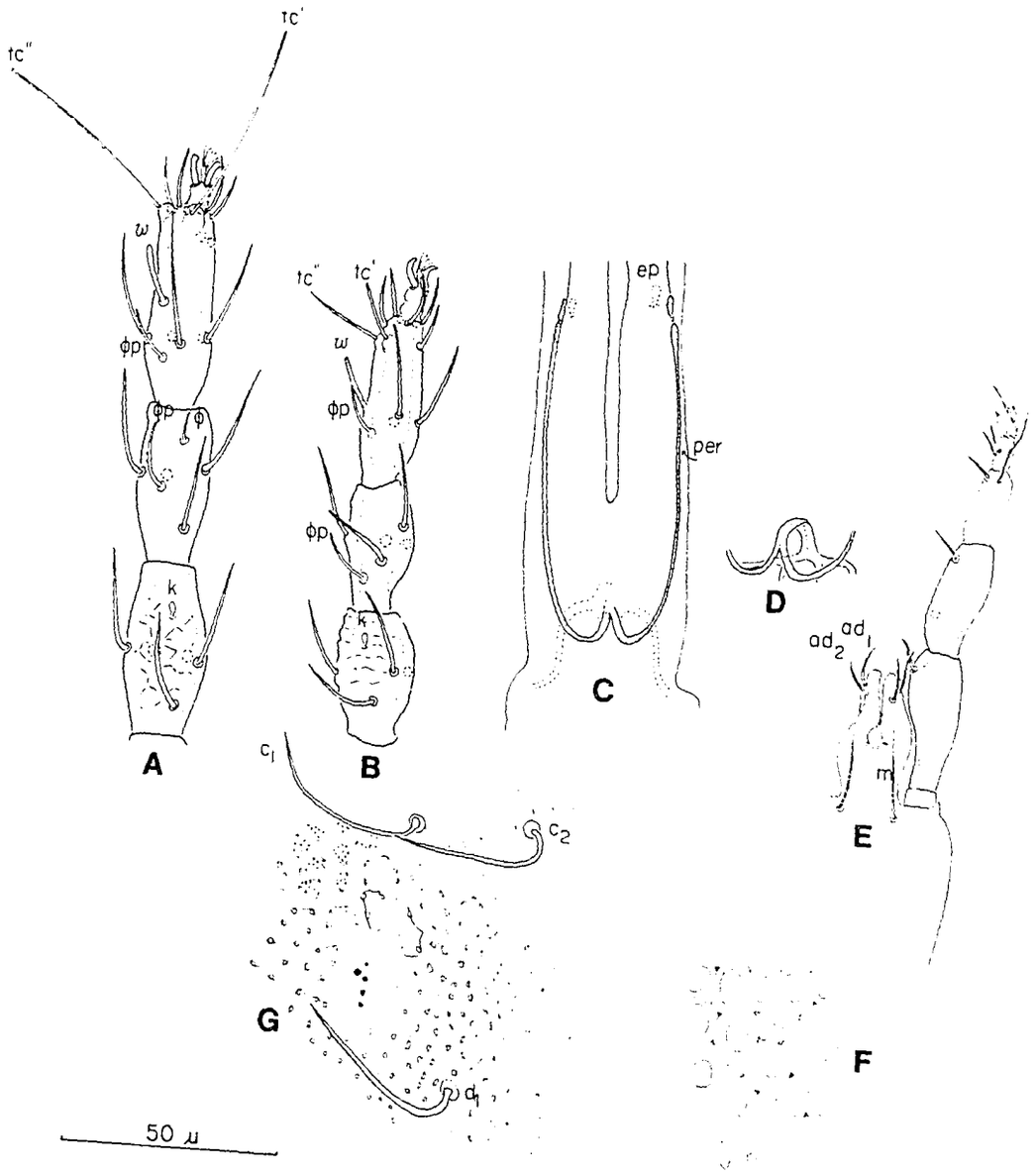
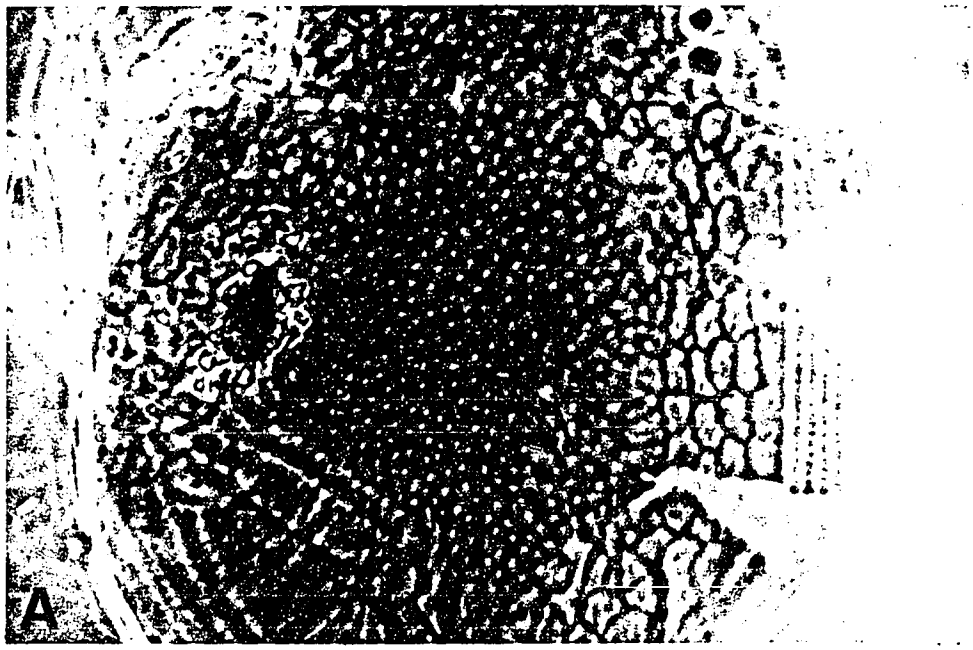

tc'
tc''
ω
φp
φp
φ
k
A
tc''
tc'
ω
φp
φp
k
B
ep
per
C
D
ad2
ad1
m
E
c1
c2
G
F
50 μ

Figure 31

Favognathus n.sp. A, photomicrographs

A. Dorsum, 400X

B. Venter, 400X


A

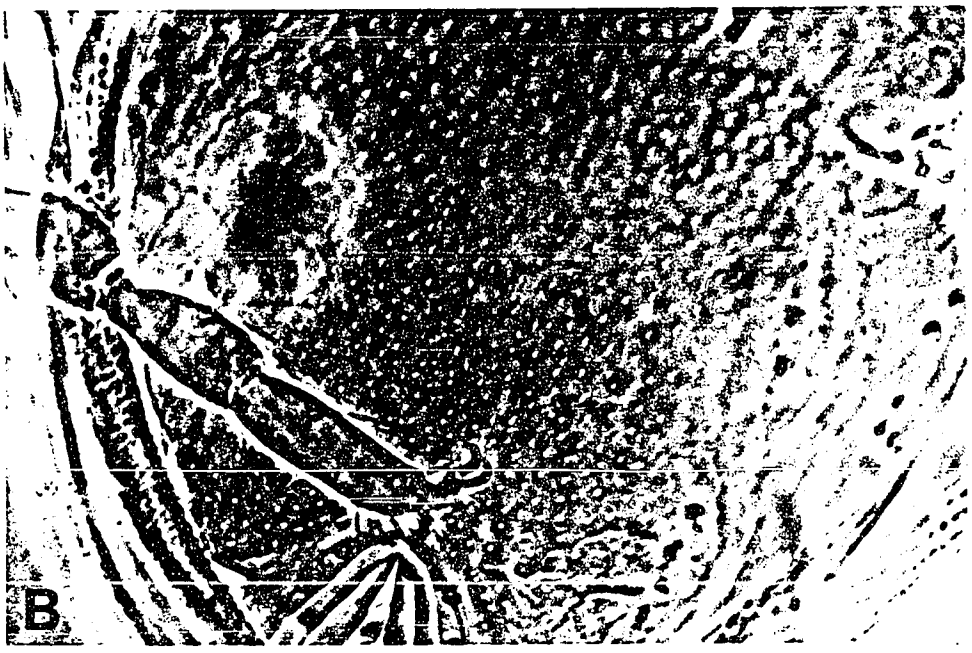

B

Figure 32

Favognathus n.sp. B, photomicrographs

A. Dorsum, 400X

B. Venter, 400X

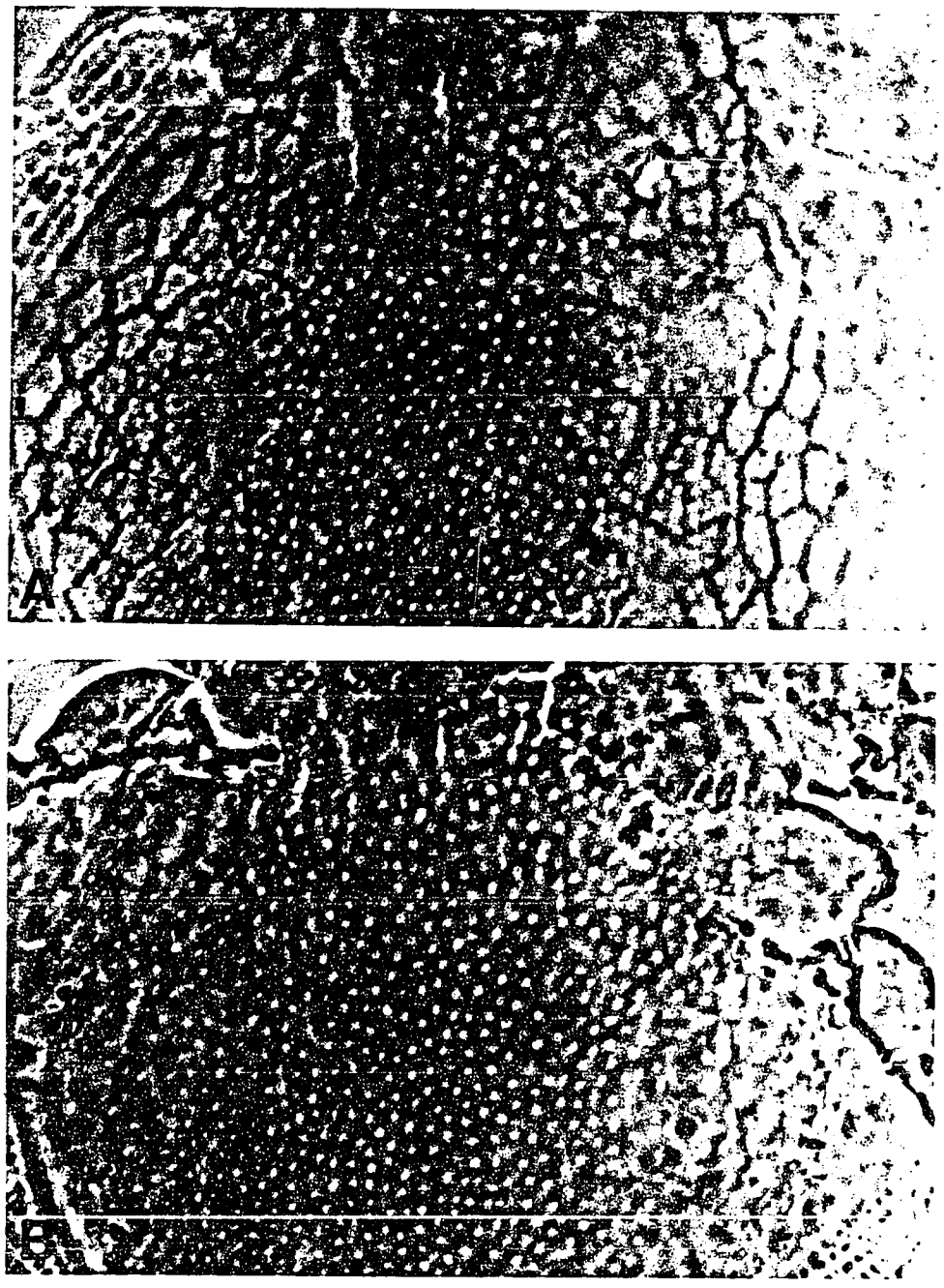

A
B

Figure 33

Favognathus n.sp. C, photomicrographs

A. Dorsum, 400X

B. Venter, 400X

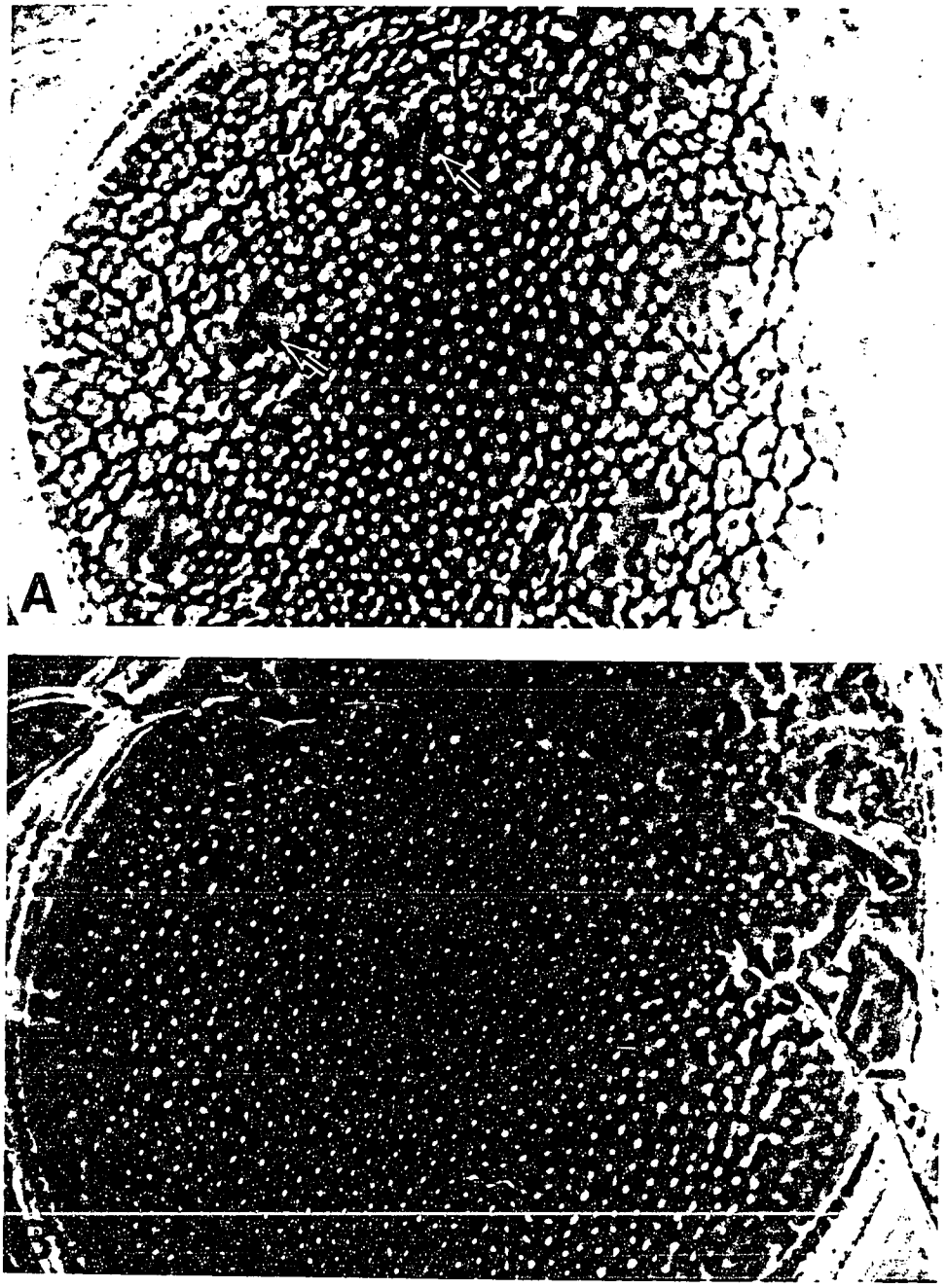
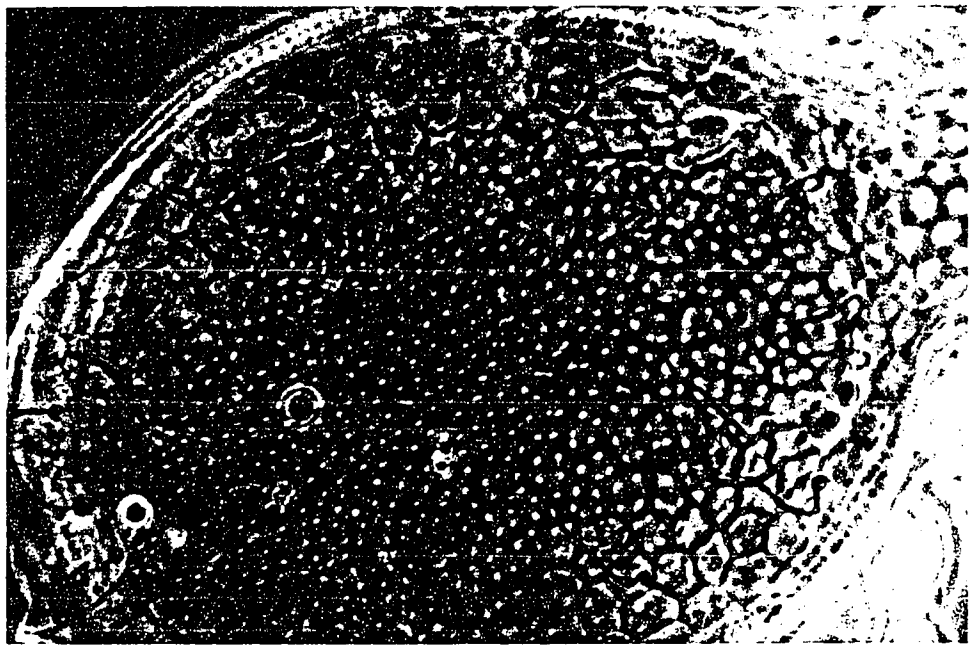

A
B

Figure 34

Favognathus pictus Summers, photomicrographs

A. Dorsum, 400X

B. Venter, 400X



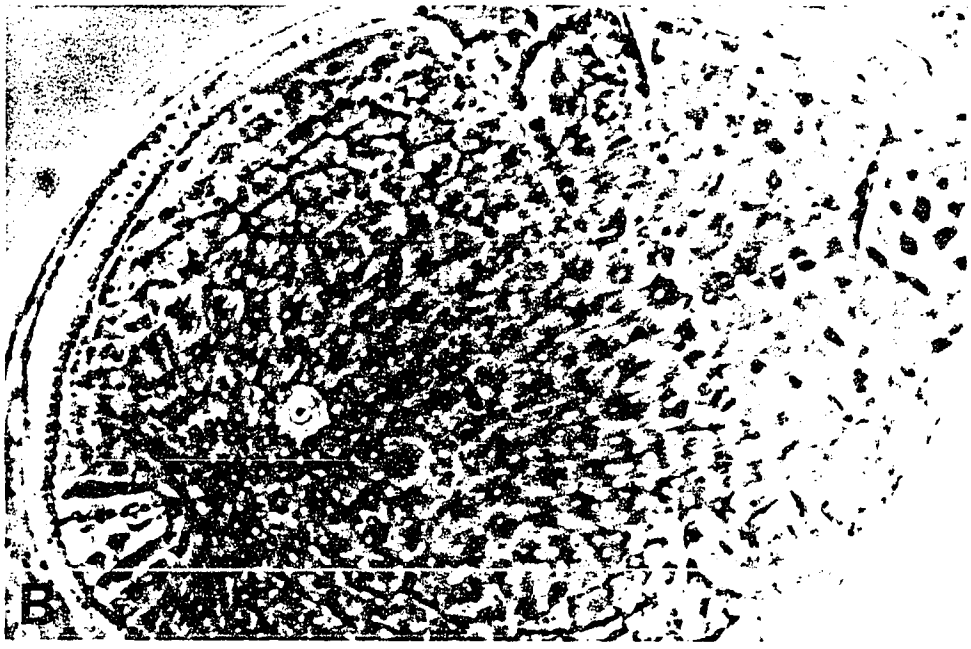

B

Figure 35

Raphignathus n.sp. A, female

A. Dorsal habitus

B. Dorsal seta

C. Coxal arrangement

D. Ventral opisthosoma showing genital plate with missing genital setae

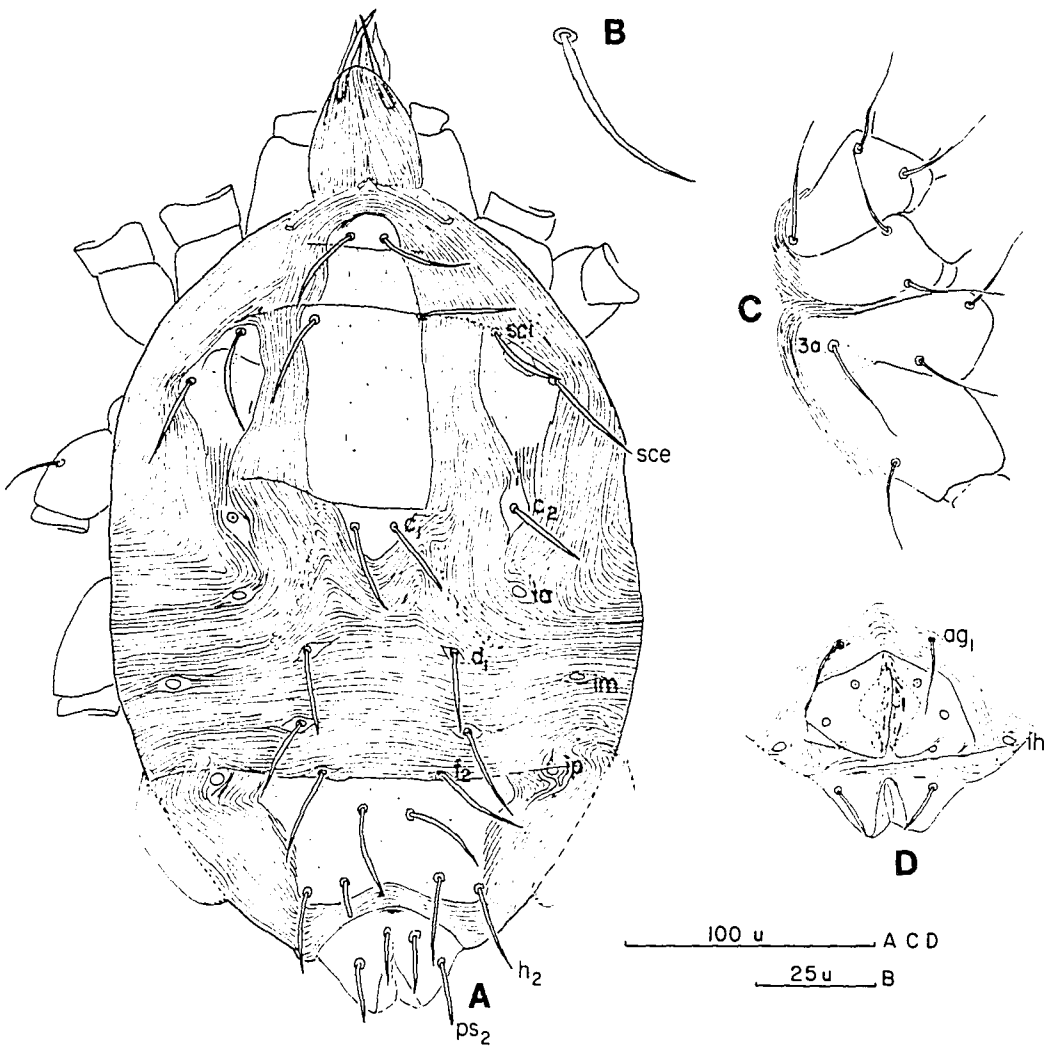

B
C
D
A
sci
sce
c_2
c_1
1a
d_1
im
f_2
ip
h_2
ps_2
3a
ag_1
ih
100 u
A C D
25u
B

Figure 36

Raphignathus n.sp. A, female

A. Distal 3 segments of leg I

B. Empodium

C. Femora IV

D. Palpus

E. Base of chelicerae showing peritremes and tracheae

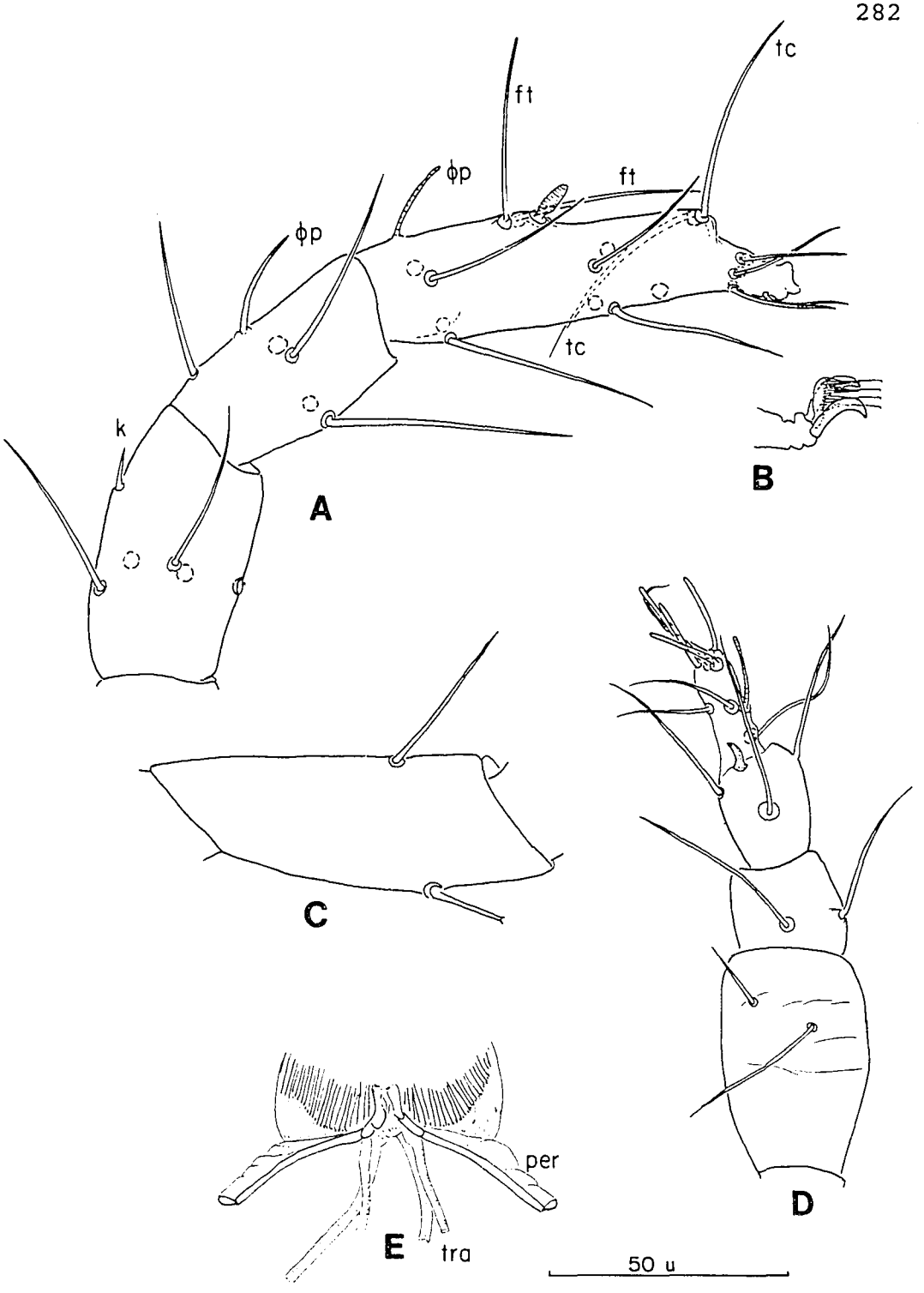

tc
ft
ft
φp
φp
tc
k
A
B
C
D
per
E
tra
50 u

Figure 37

Raphignathus n.sp. B, female

A. Dorsal habitus

B. Ventral habitus

C. Dorsal setae

D. Tarsus I without empodium

E. Tarsus II

F. Tarsus III

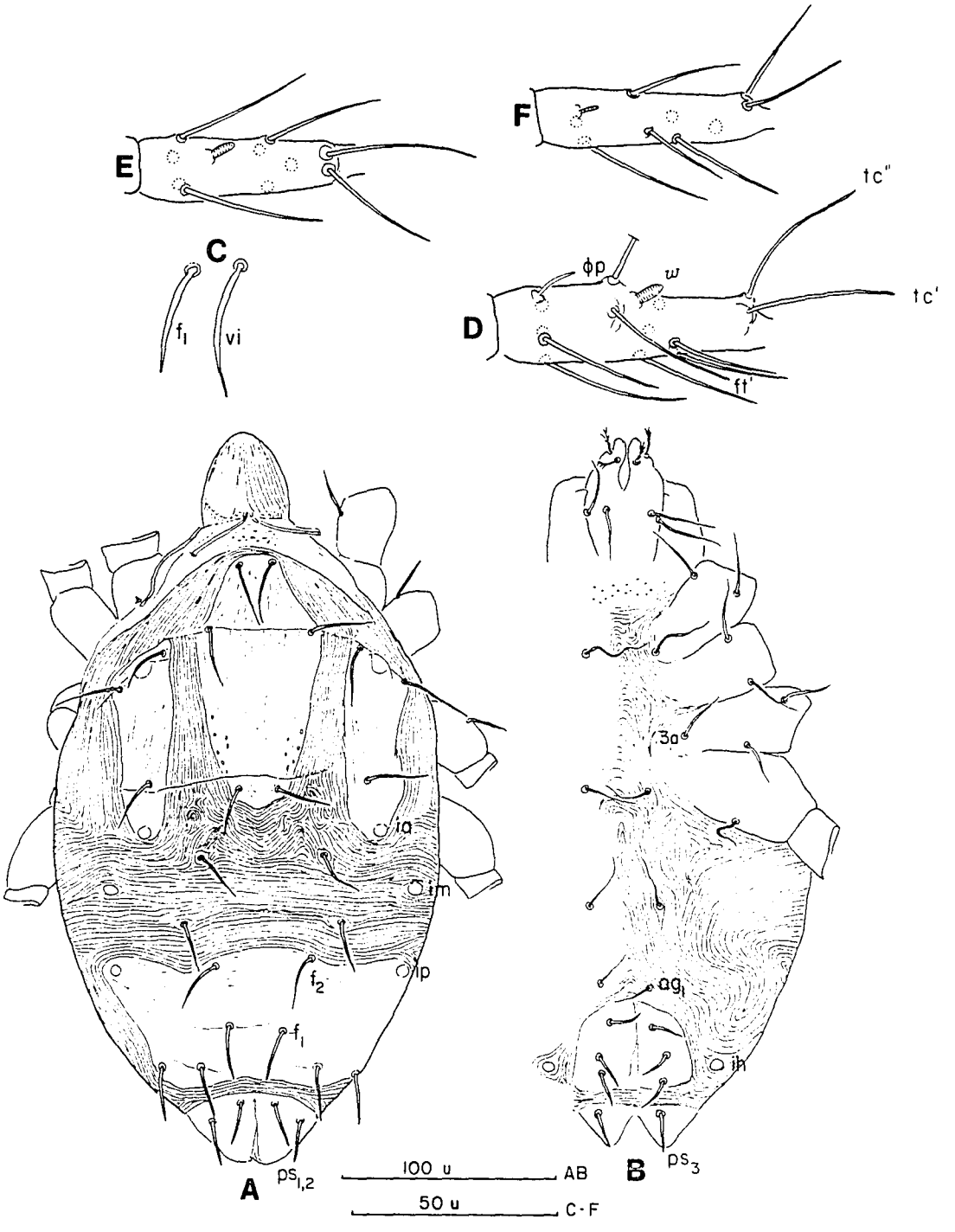

E
F
tc"
C
f_1
vi
φp
ω
tc'
D
ft'
3a
ia
im
ip
f_2
f_1
ag
ih
$ps_{1,2}$
A
100 u
AB
50 u
C-F
B
ps_3

Figure 38

Raphignathus n.sp. B, male

A. Dorsal habitus

B. Ventral habitus

C. Tarsus I

D. Tarsus II

E. Tarsus III

F. Tarsus IV

G. Aedeagus

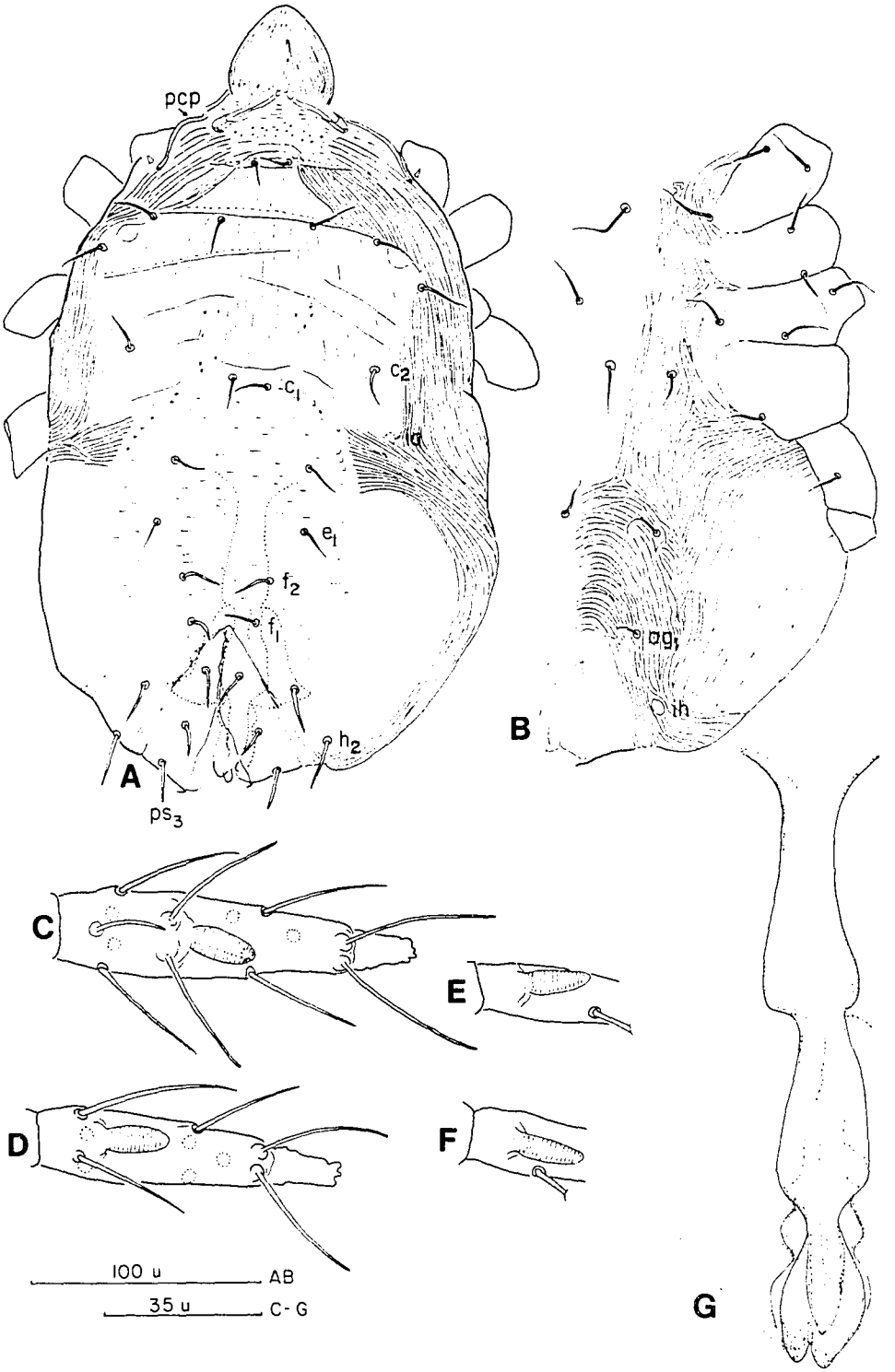

pcp
c_1
c_2
e_1
f_2
f_1
h_2
ps_3
A
B
ag
ih
C
D
E
F
G
100 u
AB
35 u
C-G

Figure 39

Raphignathus n.sp. B, larva

A. Dorsal habitus

B. Distal 4 segments of leg I

C. Leg II

D. Leg III

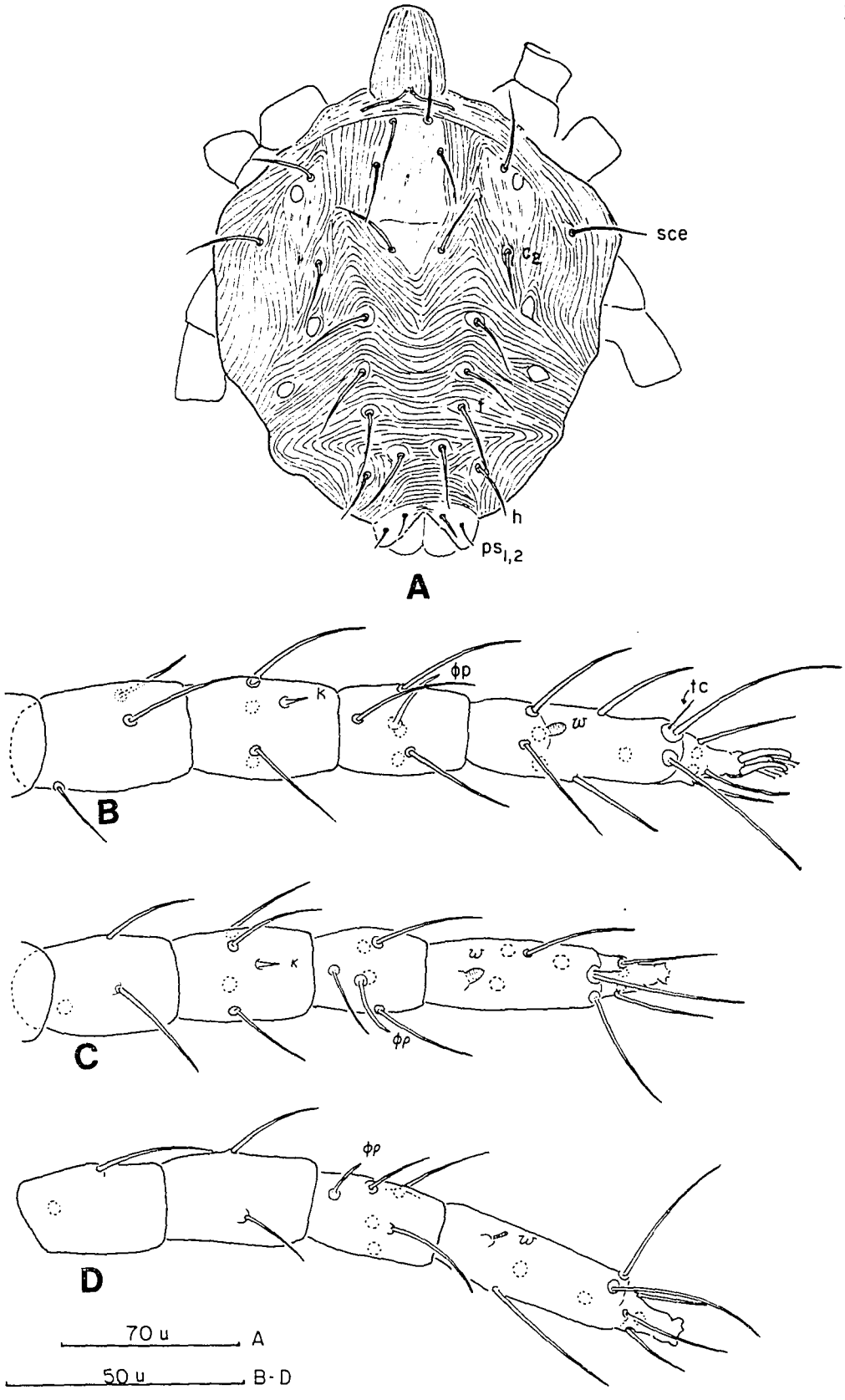

sce
cg
f
h
ps1,2
A
φp
κ
ω
tc
B
κ
ω
φp
C
φp
ω
D
70 u
A
50 u
B-D

Figure 40

Raphignathus n.sp. C, female

A. Dorsal habitus

B. Ventral habitus

C. Dorsal seta

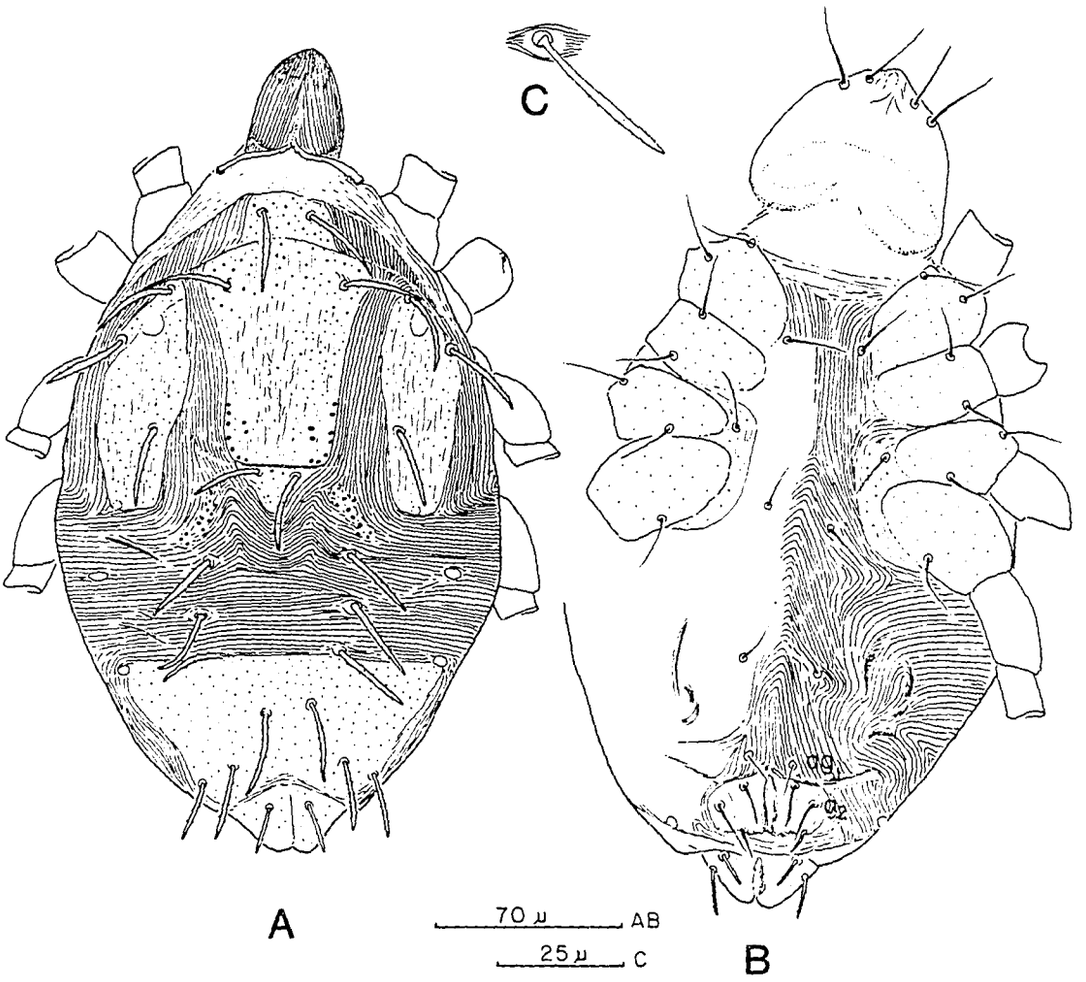

C
A
B
70 µ
AB
25 µ
C

Figure 41

Raphignathus n.sp. C, female

A. Distal 3 segments of leg I

B. Leg II

C. Infracapitulum

D. Palpus

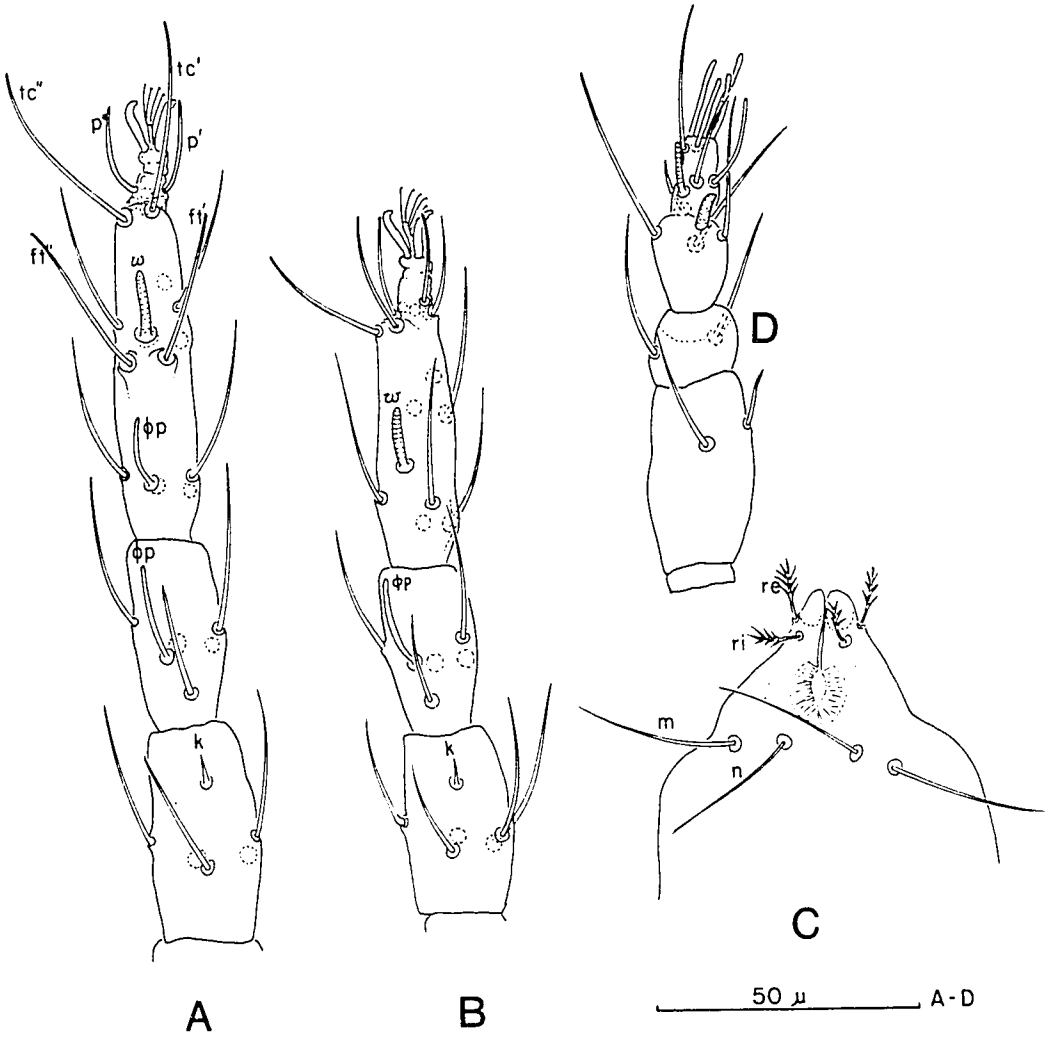

tc''
tc'
p''
p'
ft'
ft''
ω
φp
φp
k
A
ω
φp
k
B
D
re
ri
m
n
C
50 μ
A-D

Figure 42

Raphignathus n.sp. C, larva

A. Dorsal habitus showing setal notations

B. Distal 4 segments of leg III

C. Leg I

D. Leg II

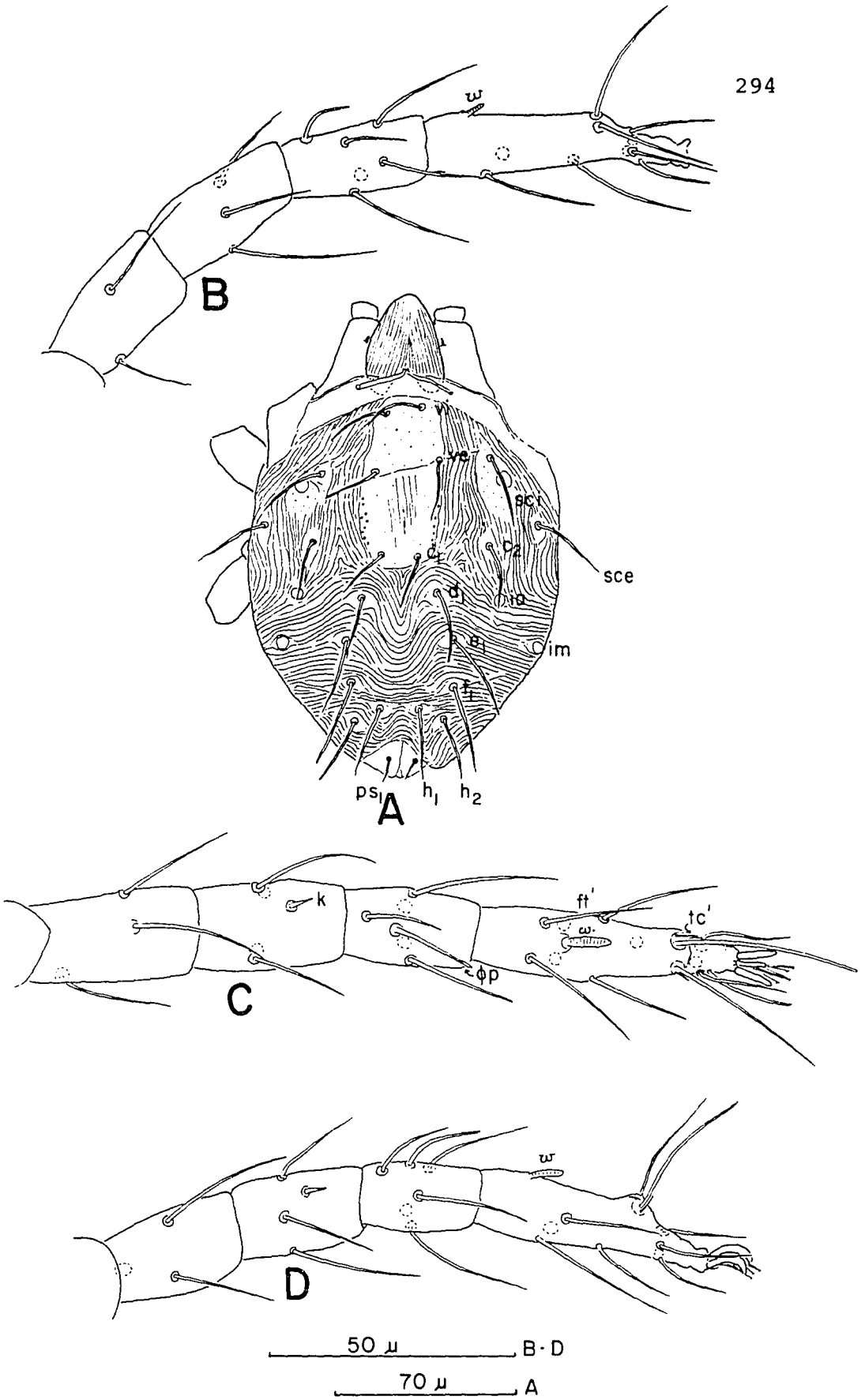

ω
B
vi
ve
sci
sce
c1
c2
d1
d2
e1
im
f1
ps1
h1
h2
A
k
ft'
tc'
ω
φp
C
ω
D
50 μ
B-D
70 μ
A

Figure 43

Raphignathus n.sp. D, female

A. Dorsal habitus

B. Ventral habitus

C. Dorsal seta

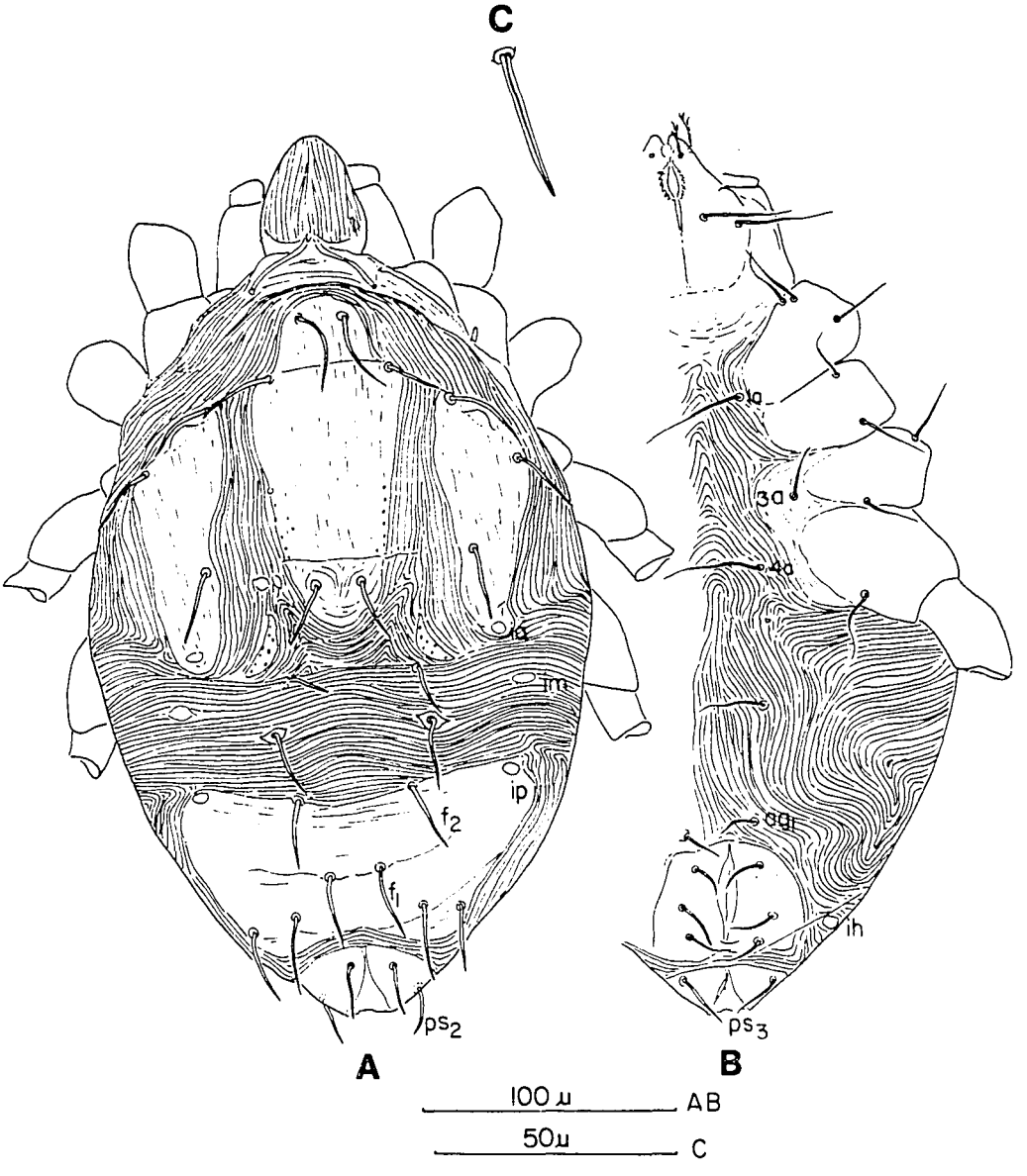

C
1a
3a
4a
im
ip
f_2
f_1
ps_2
ggr
ih
ps_3
A
B
100 µ
AB
50µ
C

Figure 44

Raphignathus n.sp. D, female

A. Distal 4 segments of leg I

B. Leg II

C. Leg III

D. Infracapitulum

E. Palpus

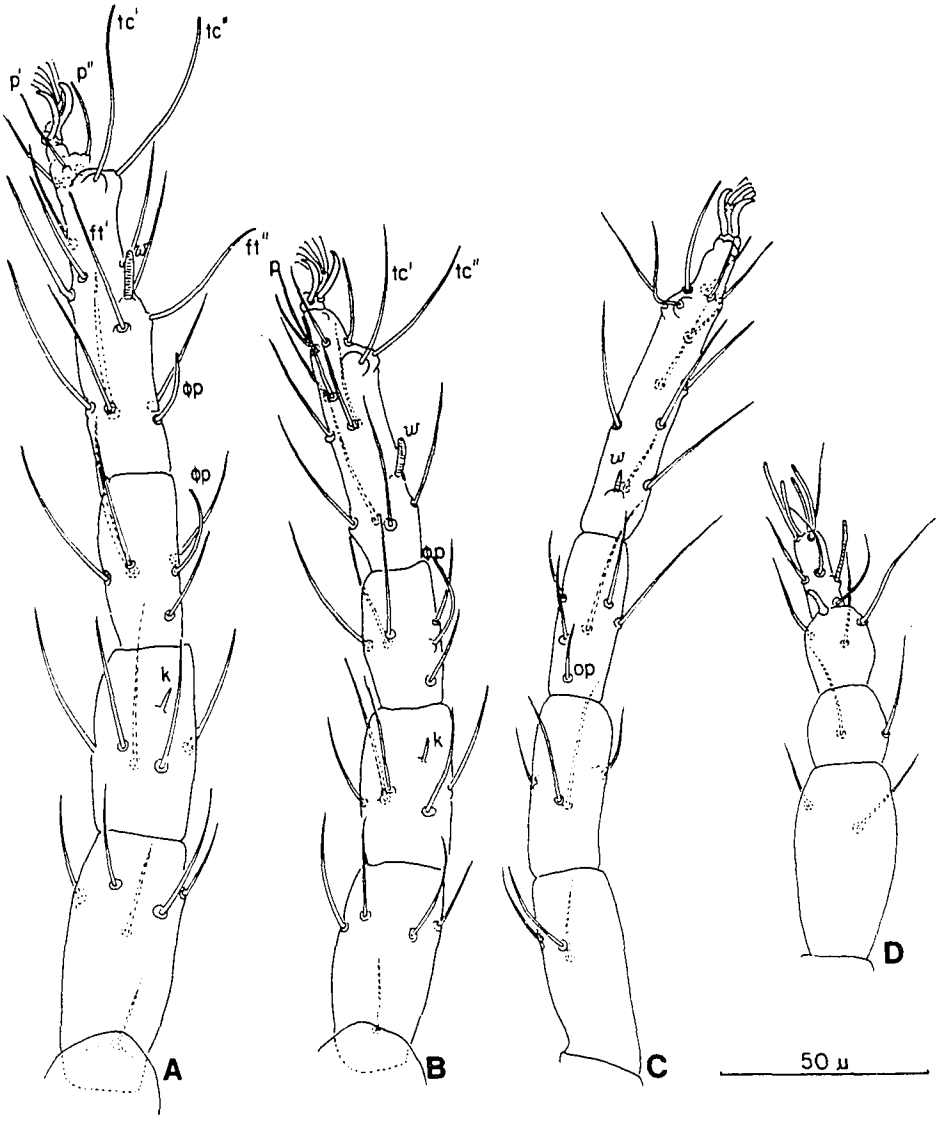

tc'
tc"
p'
p"
ft'
ft"
φp
φp
k
A
tc'
tc"
ω
φp
k
B
ω
op
C
D
50 μ

Figure 45

Raphignathus n.sp. E, female

A. Dorsal habitus

B. Ventral habitus

C. Dorsal seta

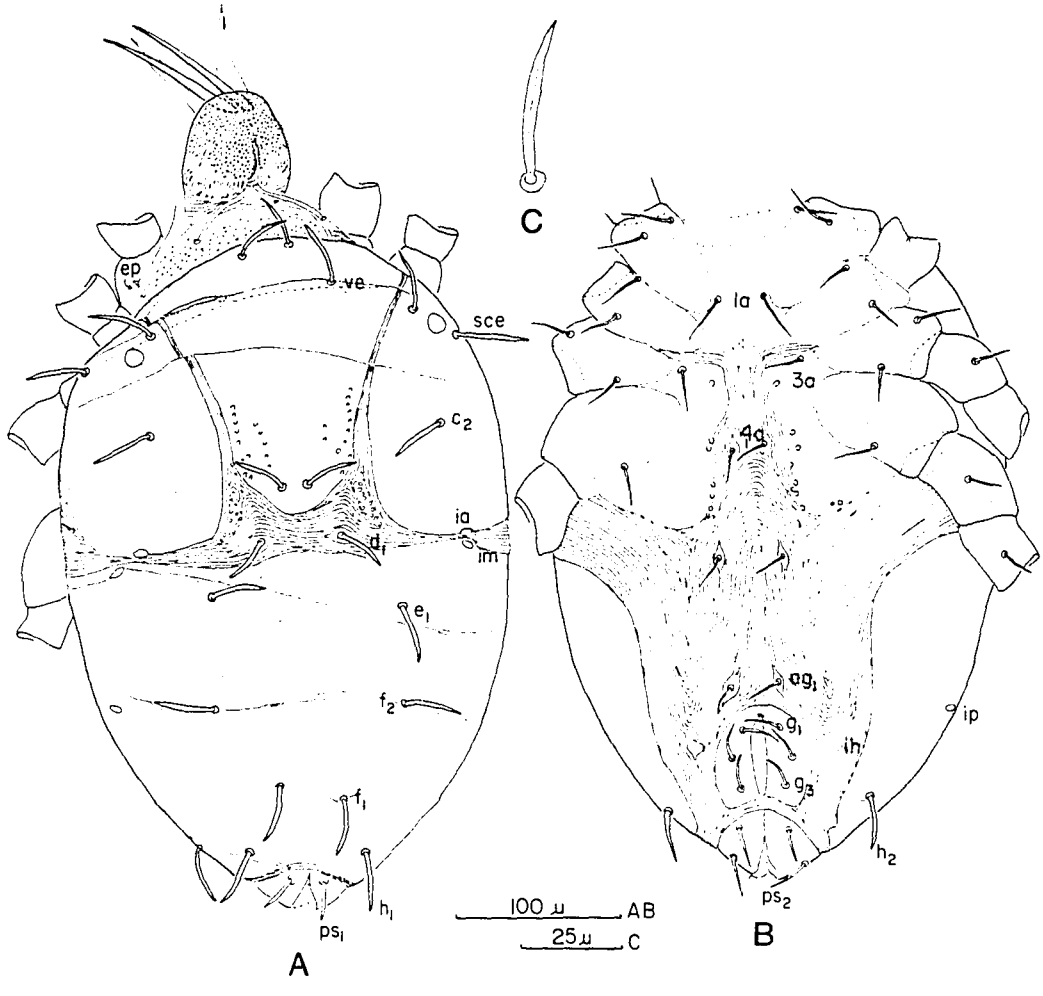

C
ep
ve
sce
la
3a
4a
c_2
ia
d_1
im
e_1
f_2
ag_1
g_1
ih
g_3
ip
f_1
h_2
h_1
ps_2
ps_1
100 μ AB
25 μ C
A
B

Figure 46

Raphignathus n.sp. E, female

A. Distal 3 segments of leg I

B. Leg II

C. Palpus

D. Stylophore with peritremes

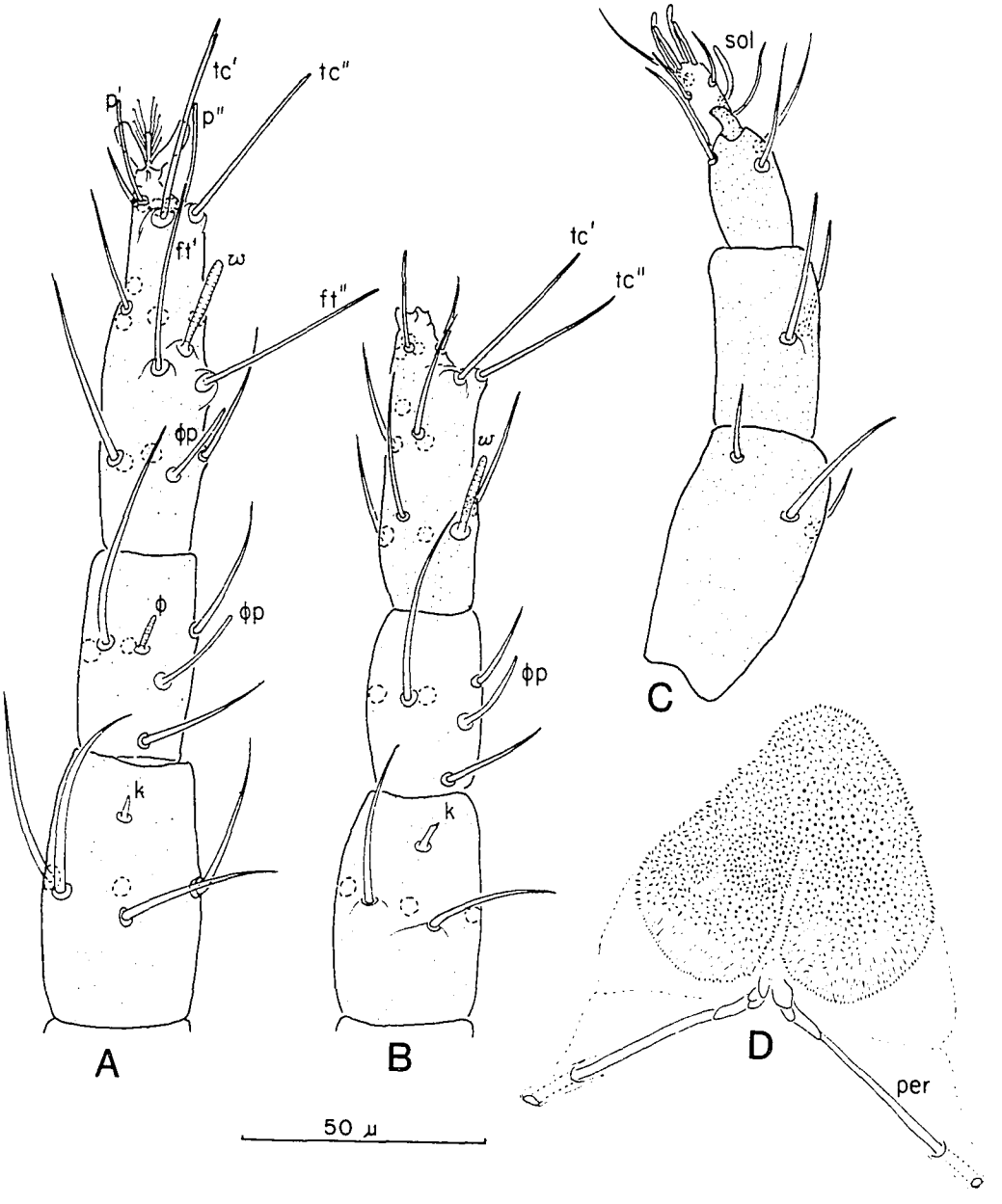

tc'
tc"
p'
p"
ft'
ω
ft"
φp
φ
φp
k
A
tc'
tc"
ω
φp
k
B
sol
C
D
per
50 μ

Figure 47

Raphignathus n.sp. E, male

A. Dorsal habitus

B. Ventral habitus

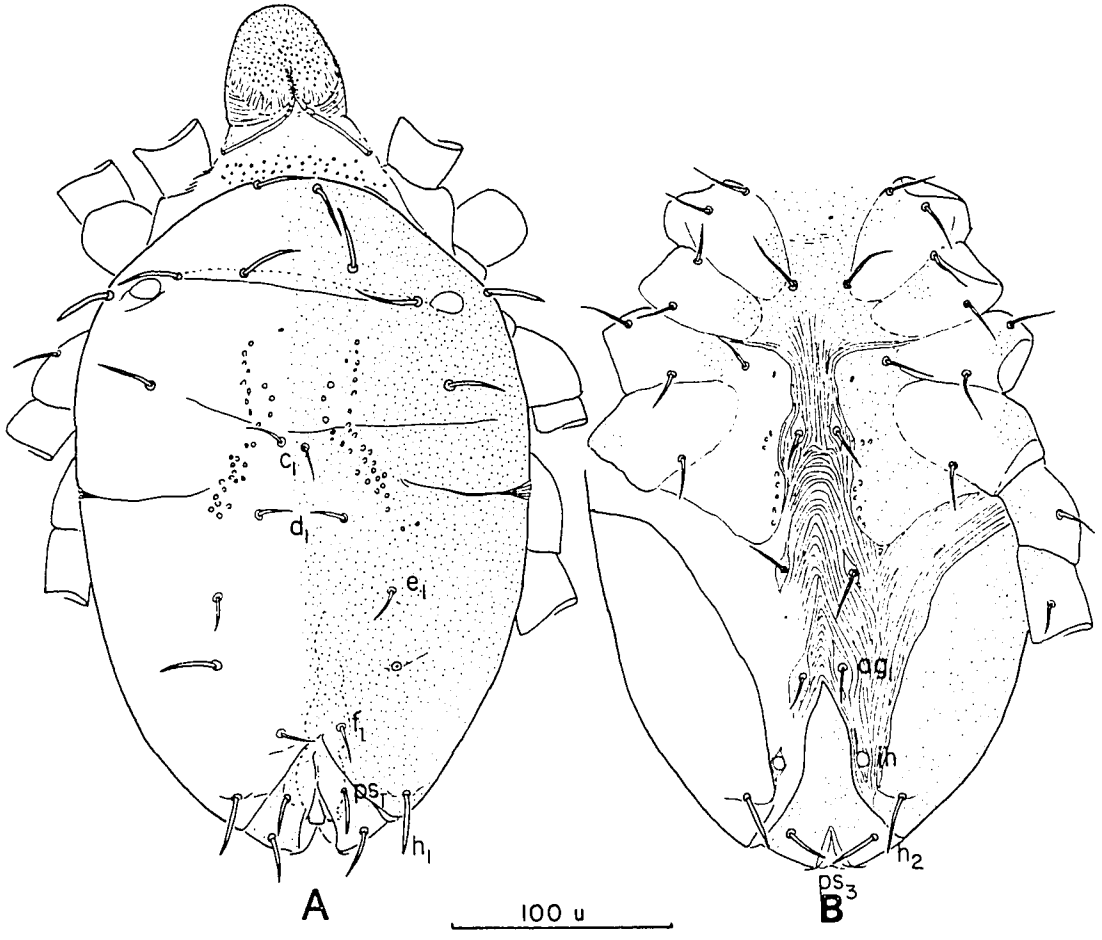

c1
d1
e1
f1
ps1
h1
A
100 u
ag1
ih
h2
ps3
B

Figure 48

Raphignathus n.sp. E, male

A. Tibia and tarsus of leg I

B. Aedeagus

C. Infracapitulum

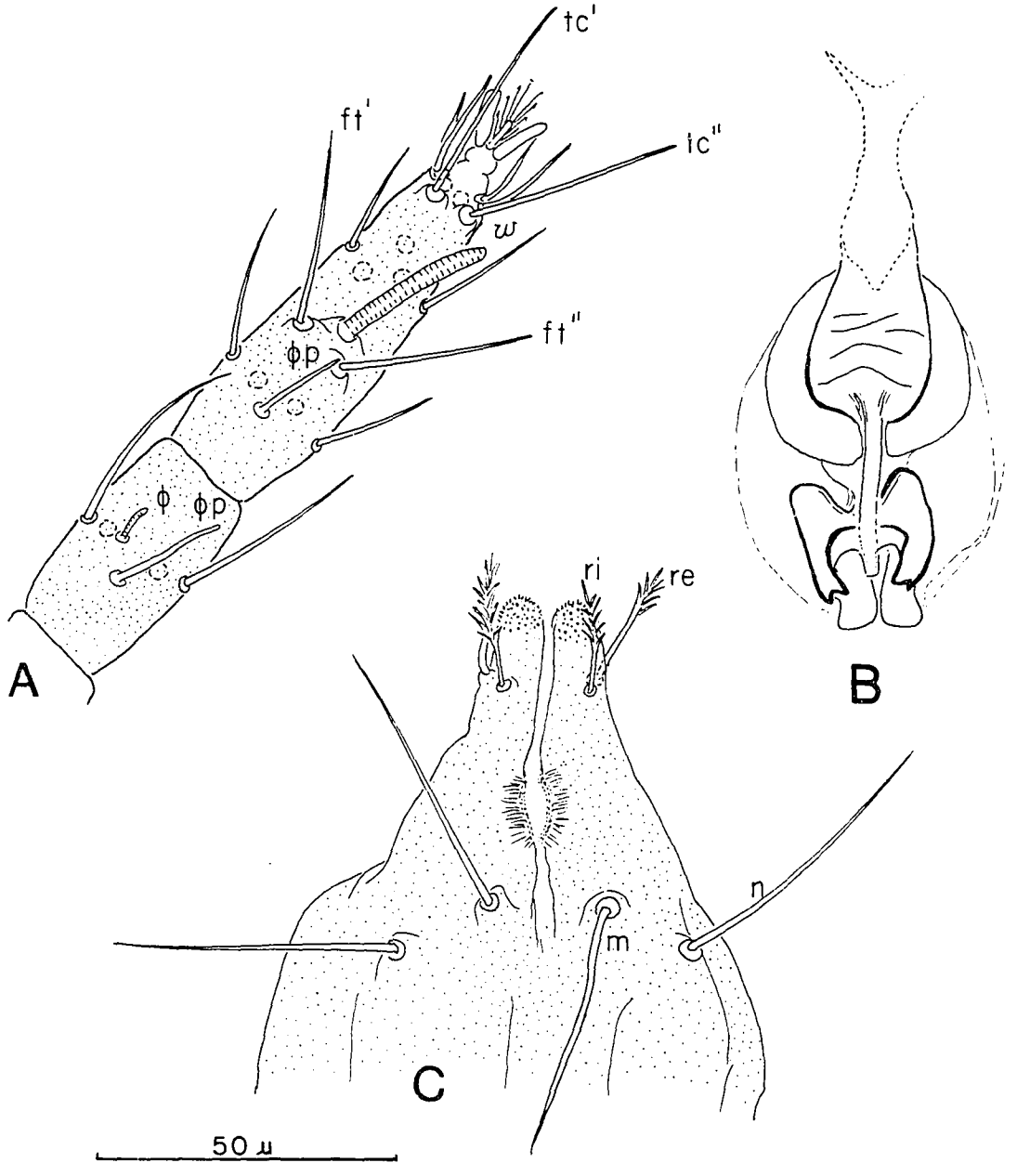

tc'
ft'
tc"
ω
ft"
φp
φ
φp
A
B
ri
re
n
m
C
50 μ

Figure 49

Raphignathus n.sp. F, female

A. Dorsal habitus

B. Ventral habitus

C. Dorsal seta

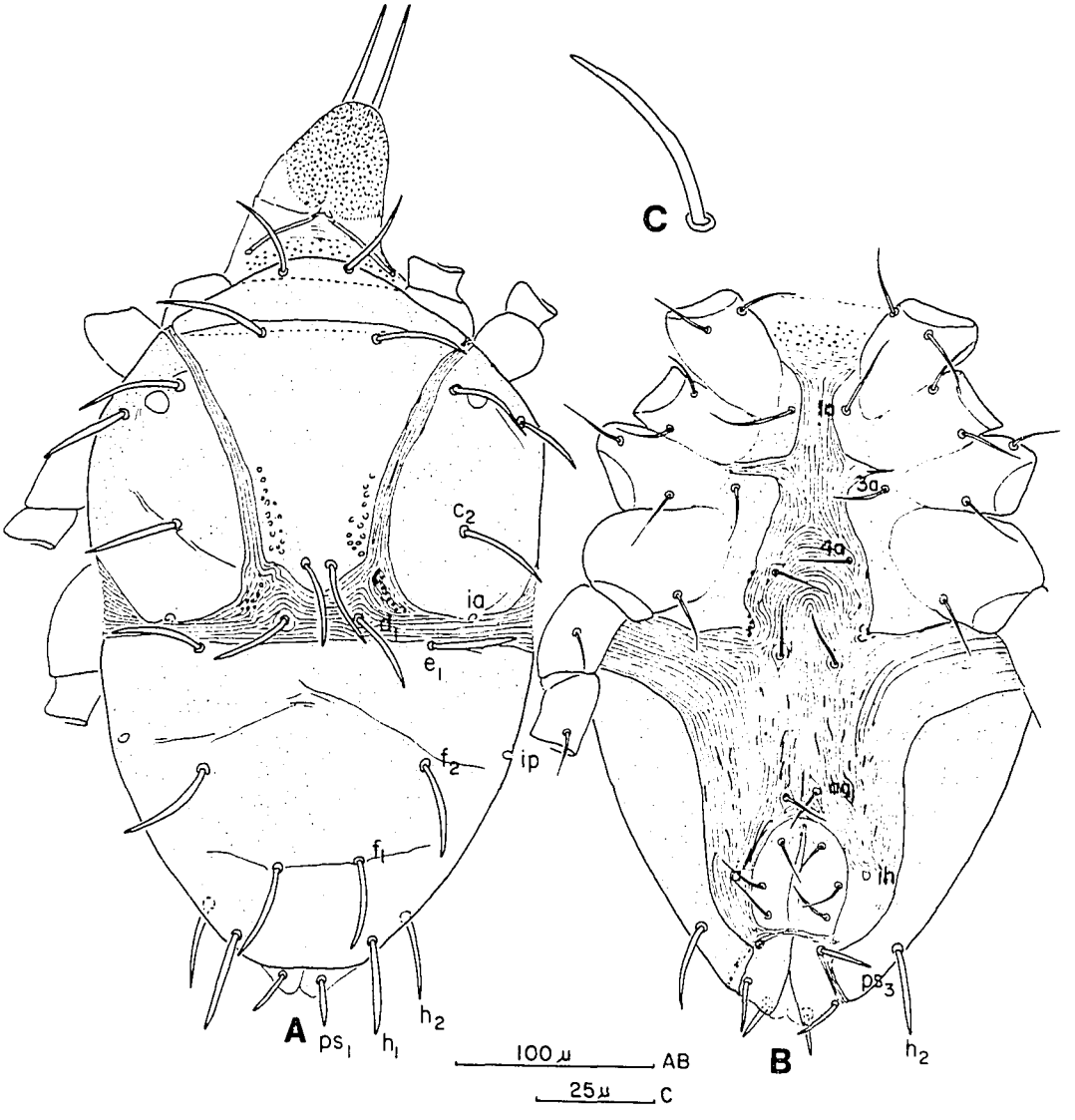

C
1a
3a
4a
c_2
ia
d_1
e_1
f_2
ip
mg
ih
f_1
ps_3
h_2
A
ps_1
h_1
h_2
100 µ
AB
25µ
C
B

Figure 50

Raphignathus n.sp. F, female

A. Tibia and tarsus of leg I

B. Leg II

C. Femur IV

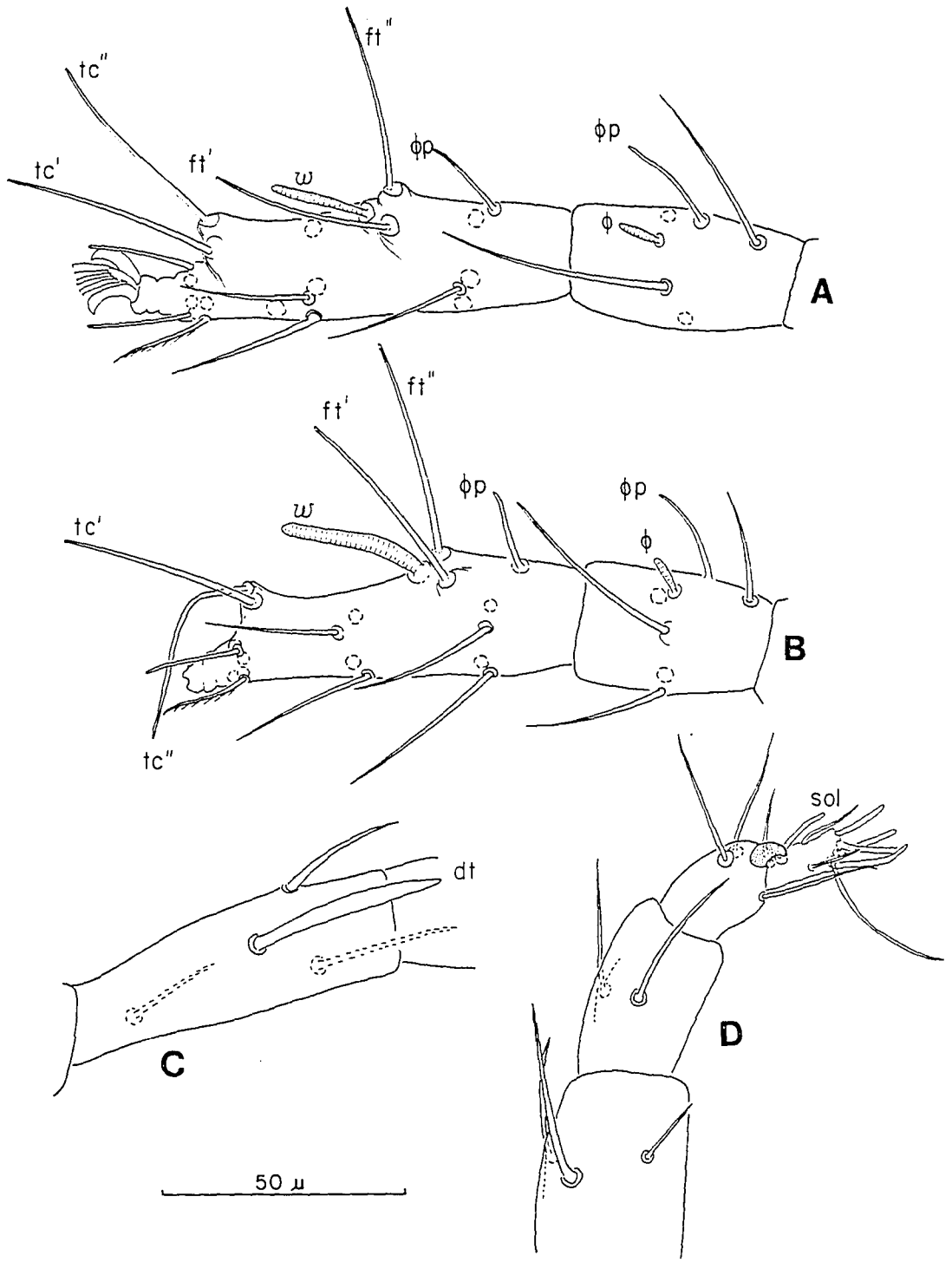

ft"
tc"
tc'
ft'
ω
φp
φp
φ
A
ft"
ft'
φp
φp
ω
tc'
φ
B
tc"
sol
dt
C
D
50 μ

Figure 51

Raphignathus n.sp. F, female

A. Infracapitulum

B. Dorsal opisthosoma showing aedeagus and setal arrangement

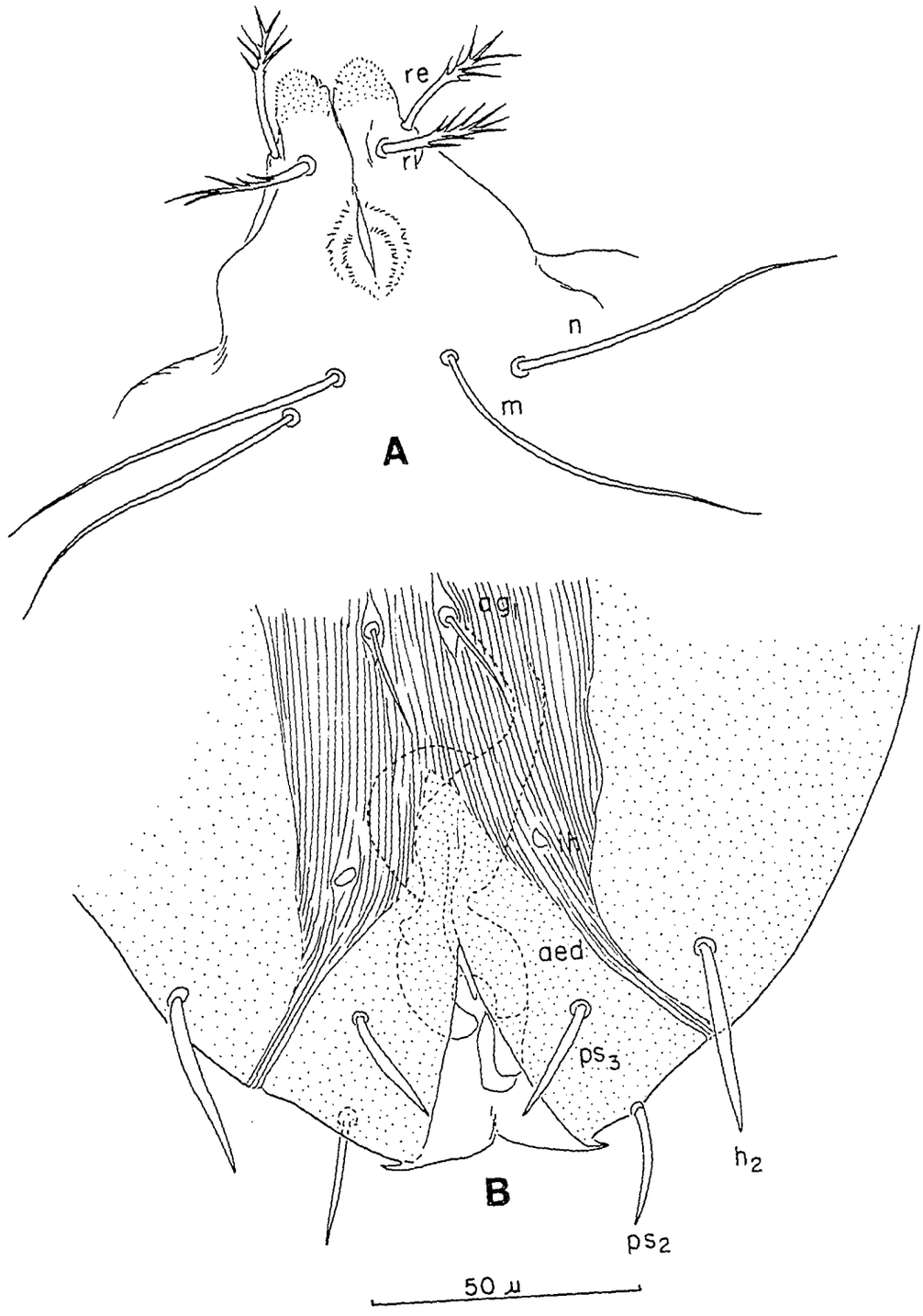

re
rv
n
m
A
agr
aed
ps3
h2
B
ps2
50 µ

Figure 52

Raphignathus n.sp. G, female

A. Dorsal habitus

B. Ventral habitus

C. Dorsal seta

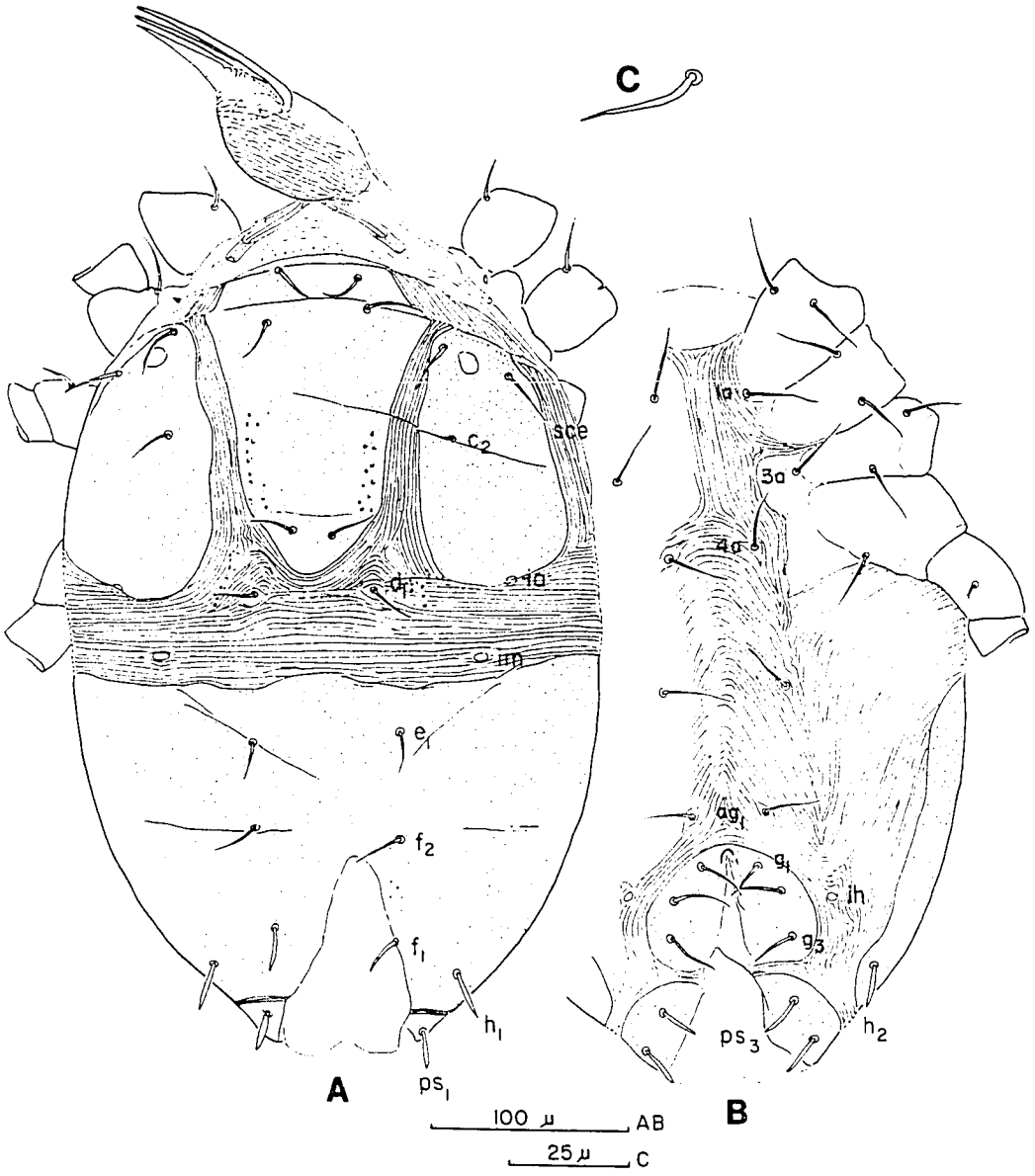

C
sce
c_2
d_1
10a
im
e_1
f_2
f_1
h_1
ps_1
A
1a
3a
4a
ag_1
g_1
ih
g_3
ps_3
h_2
B
100 μ
AB
25 μ
C

Figure 53

Raphignathus n.sp. G, female

A. Distal 3 segments of leg I

B. Leg II

C. Palpus

D. Infracapitulum

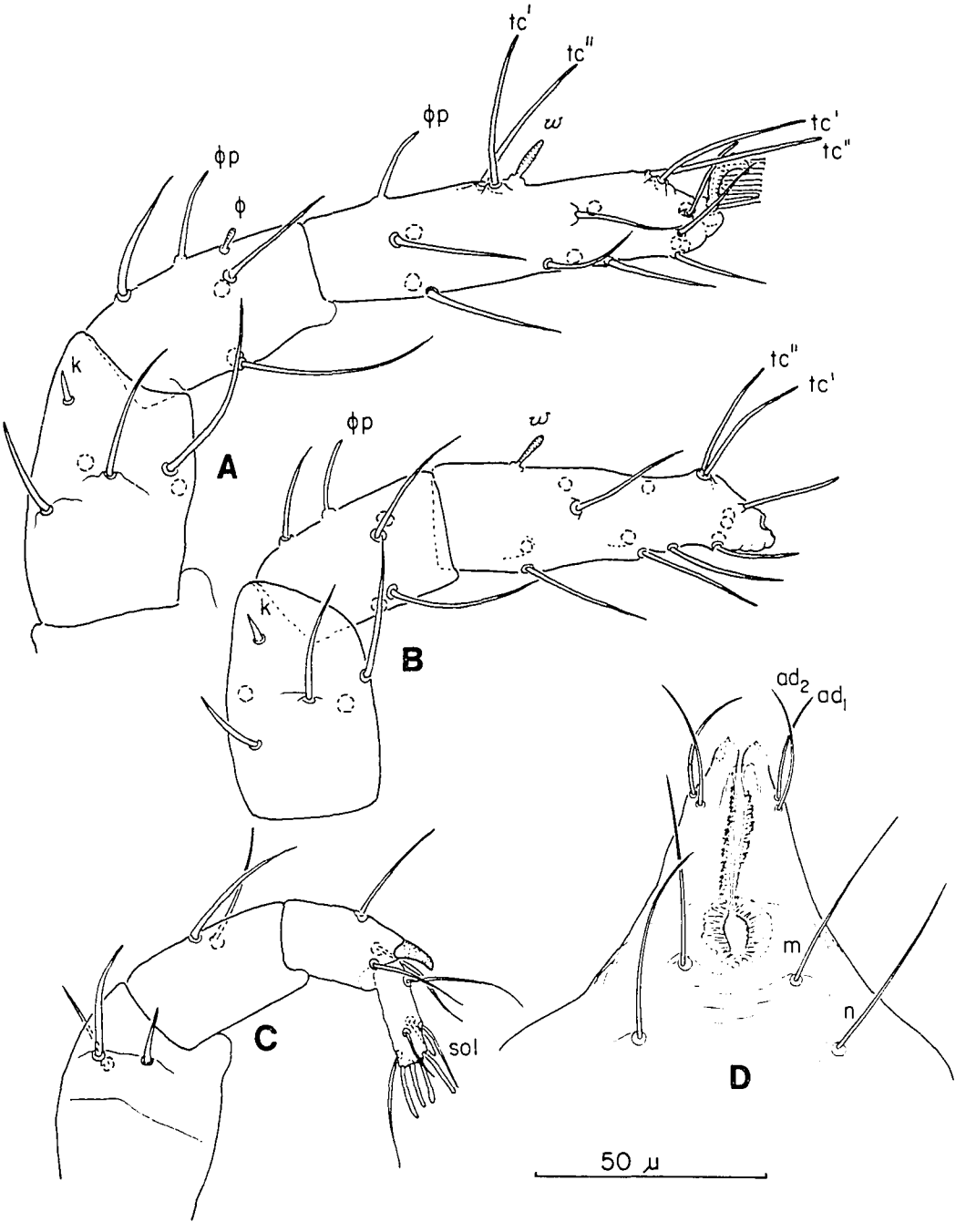
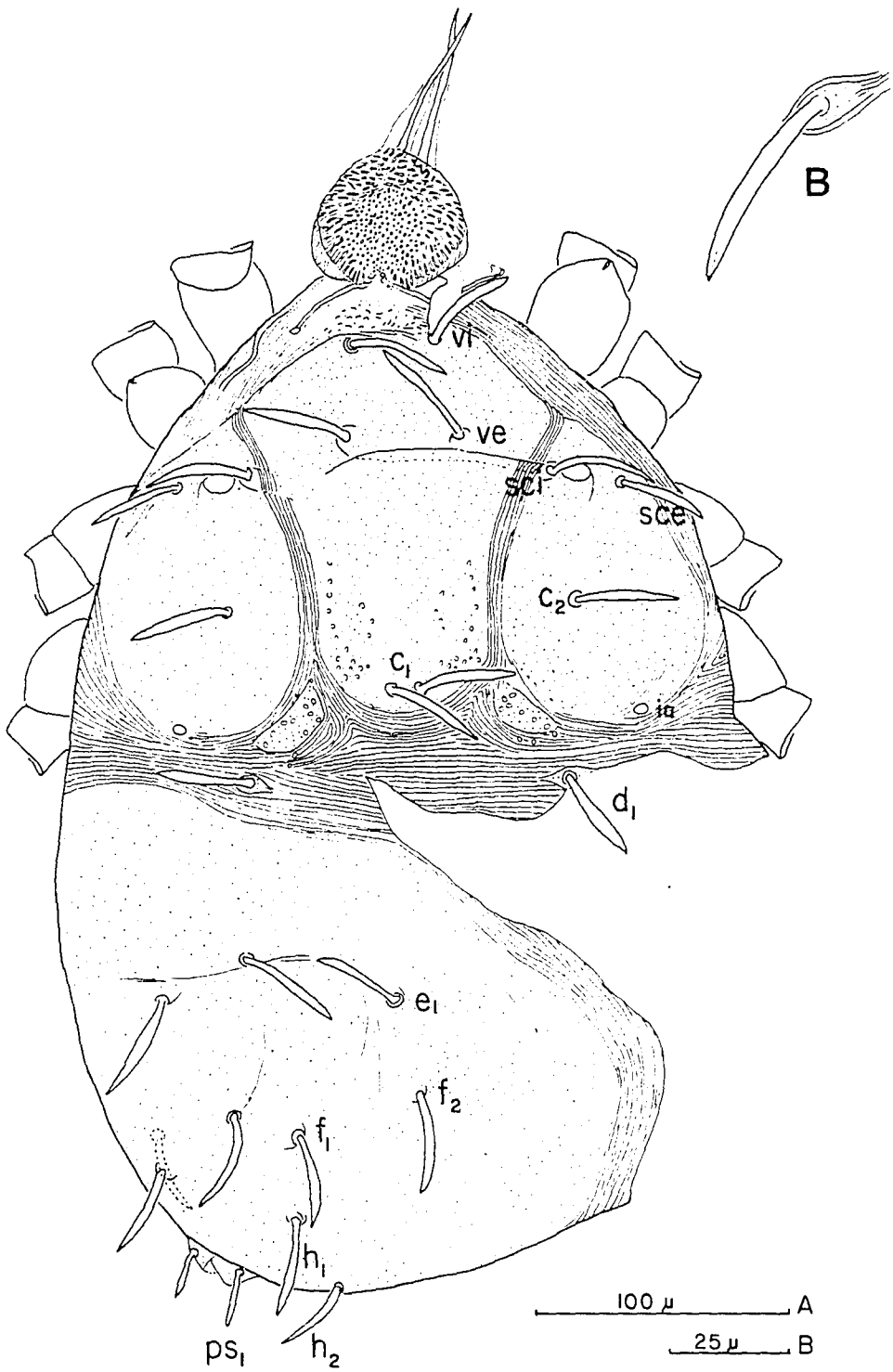

tc'
tc"
ωp
ω
tc'
tc"
ωp
ω
k
A
tc"
tc'
ωp
ω
k
B
ad2
ad1
m
n
C
sol
D
50 μ

Figure 54

Raphignathus n.sp. H, female

A. Dorsal habitus

B. Dorsal seta



A

Figure 55

Raphignathus n.sp. H, female

A. Ventral opisthosoma

B. Detail of genitalia

C. Palpus

D. Detail of coxae

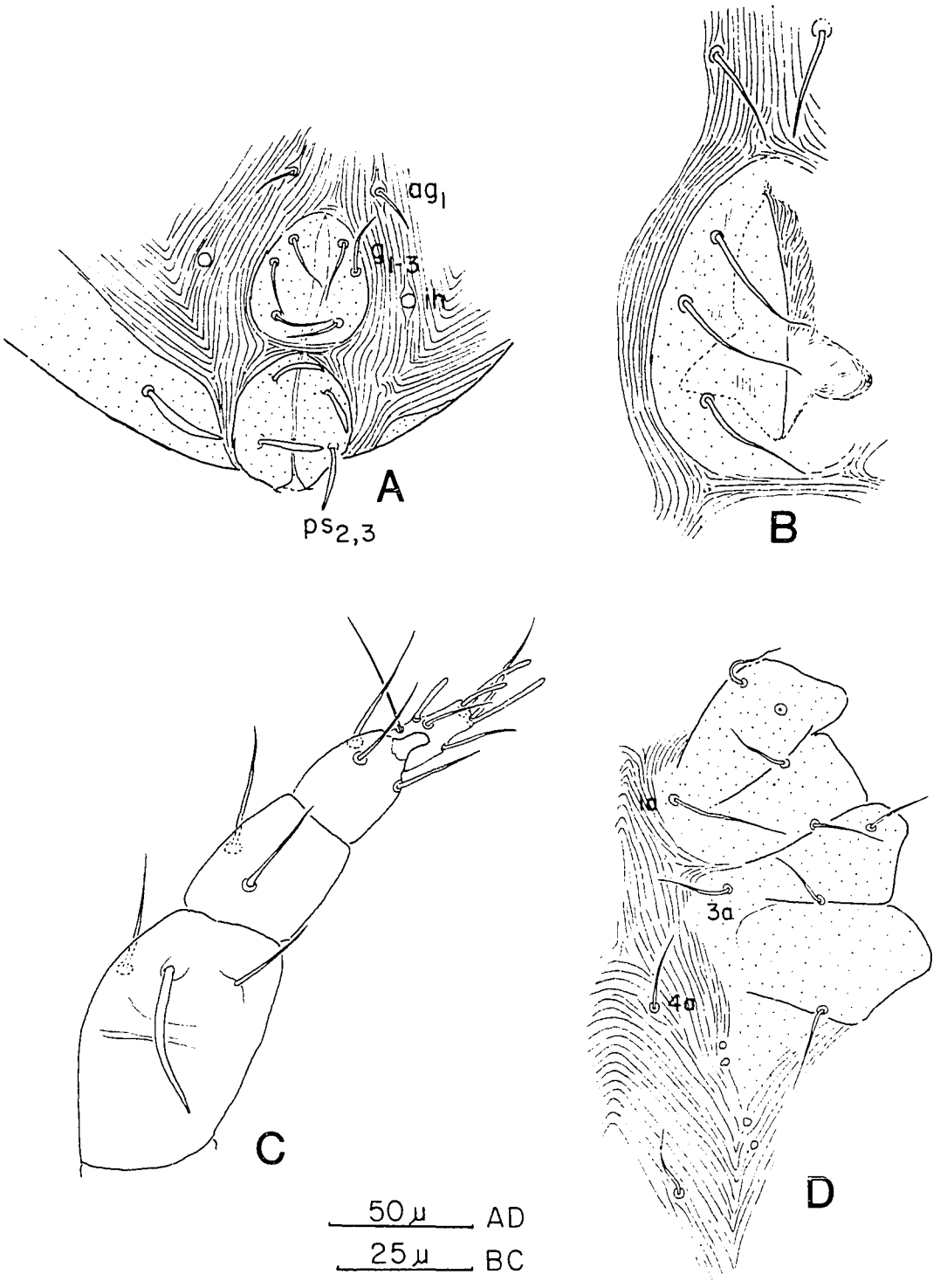

ag1
g1-3
ih
A
ps2,3
B
C
1a
3a
4a
D
50 µ AD
25 µ BC

Figure 56

Raphignathus n.sp. H, male

A. Dorsal habitus

B. Ventral habitus

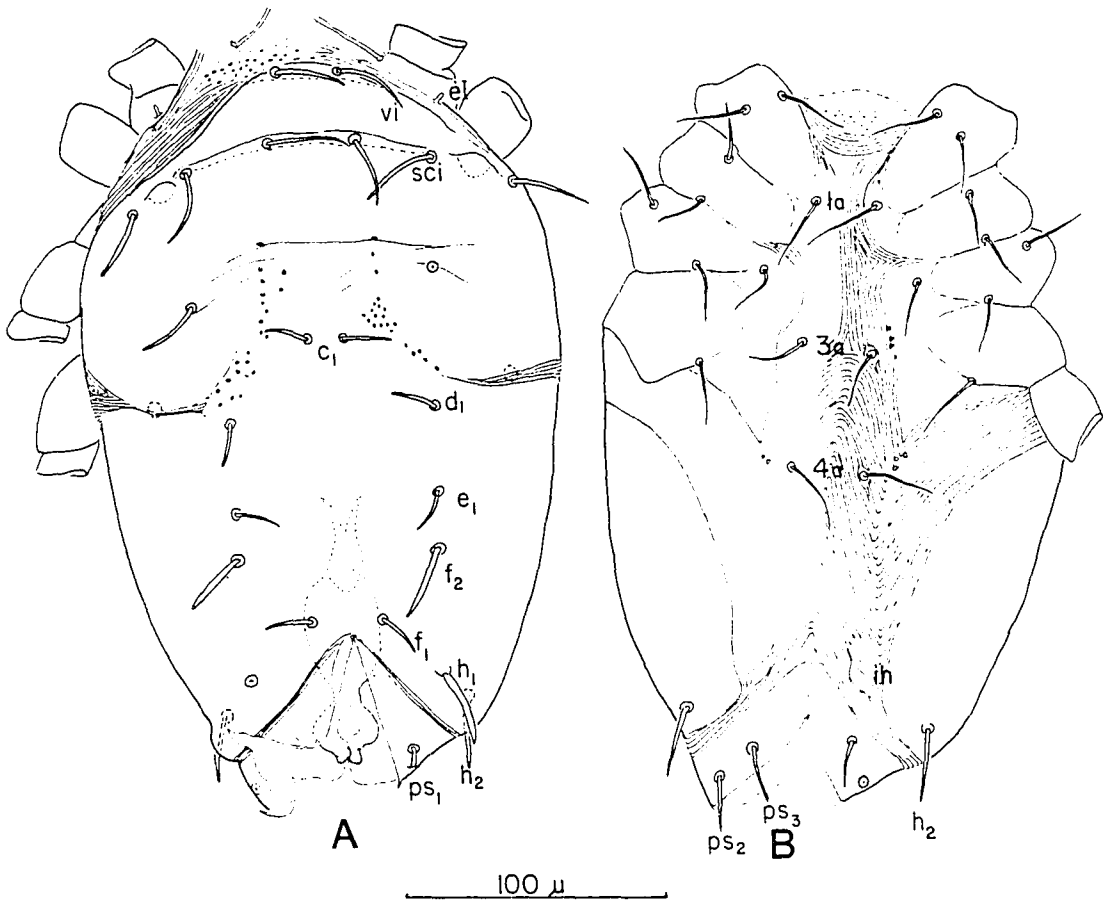

vl
el
sci
c1
d1
e1
f2
f1
h1
h2
ps1
A
1a
3a
4a
ih
ps2
ps3
h2
B
100 µ

Figure 57

Raphignathus n.sp. H

A. Distal 3 segments of leg I, female

B. Leg II, female

C. Tarsus of leg I, male

D. Tarsus of leg II, male

E. Tarsus of leg III, male

F. Tarsus of leg IV

G. Empodium

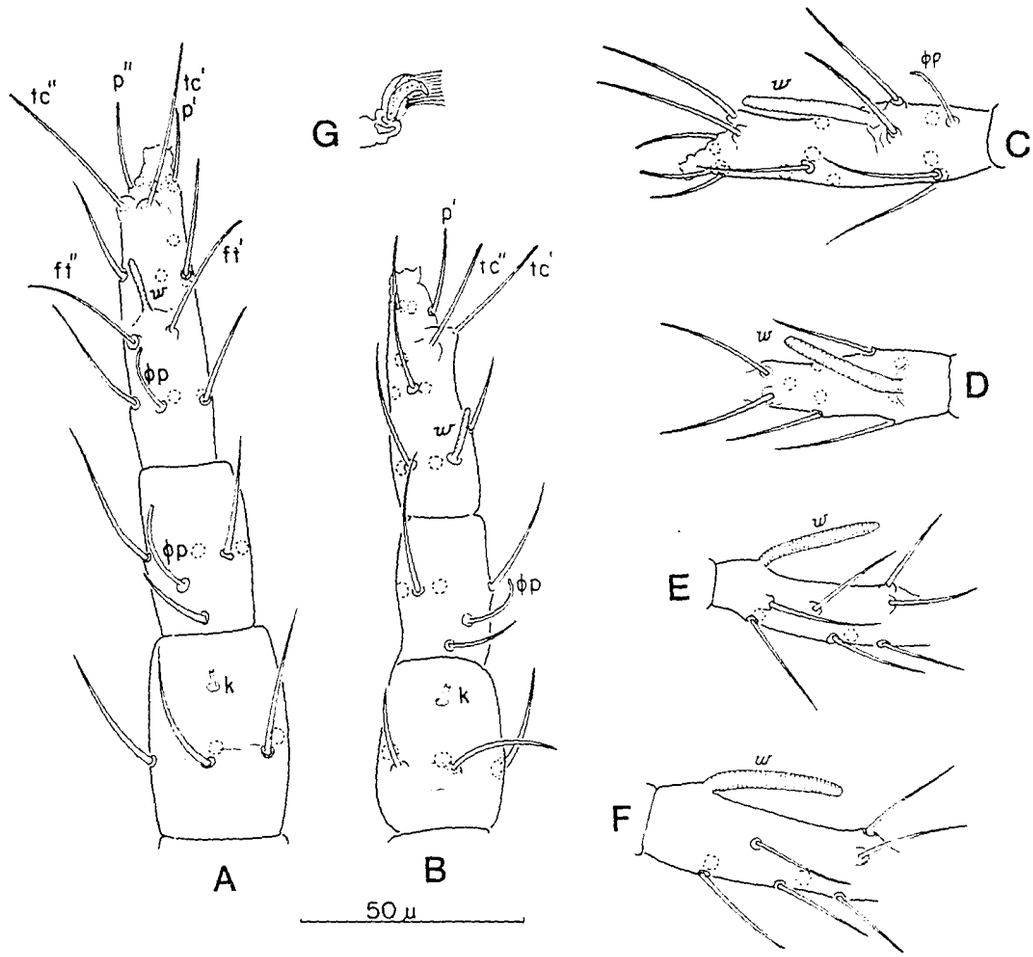

tc''
p''
tc'
p'
ft''
ft'
w
φp
φp
k
A
G
p'
tc''
tc'
w
φp
k
B
50 μ
w
φp
C
w
D
w
E
w
F

Figure 58

Eryngiopus n.sp. A, female

A. Dorsal habitus

B. Ventral habitus

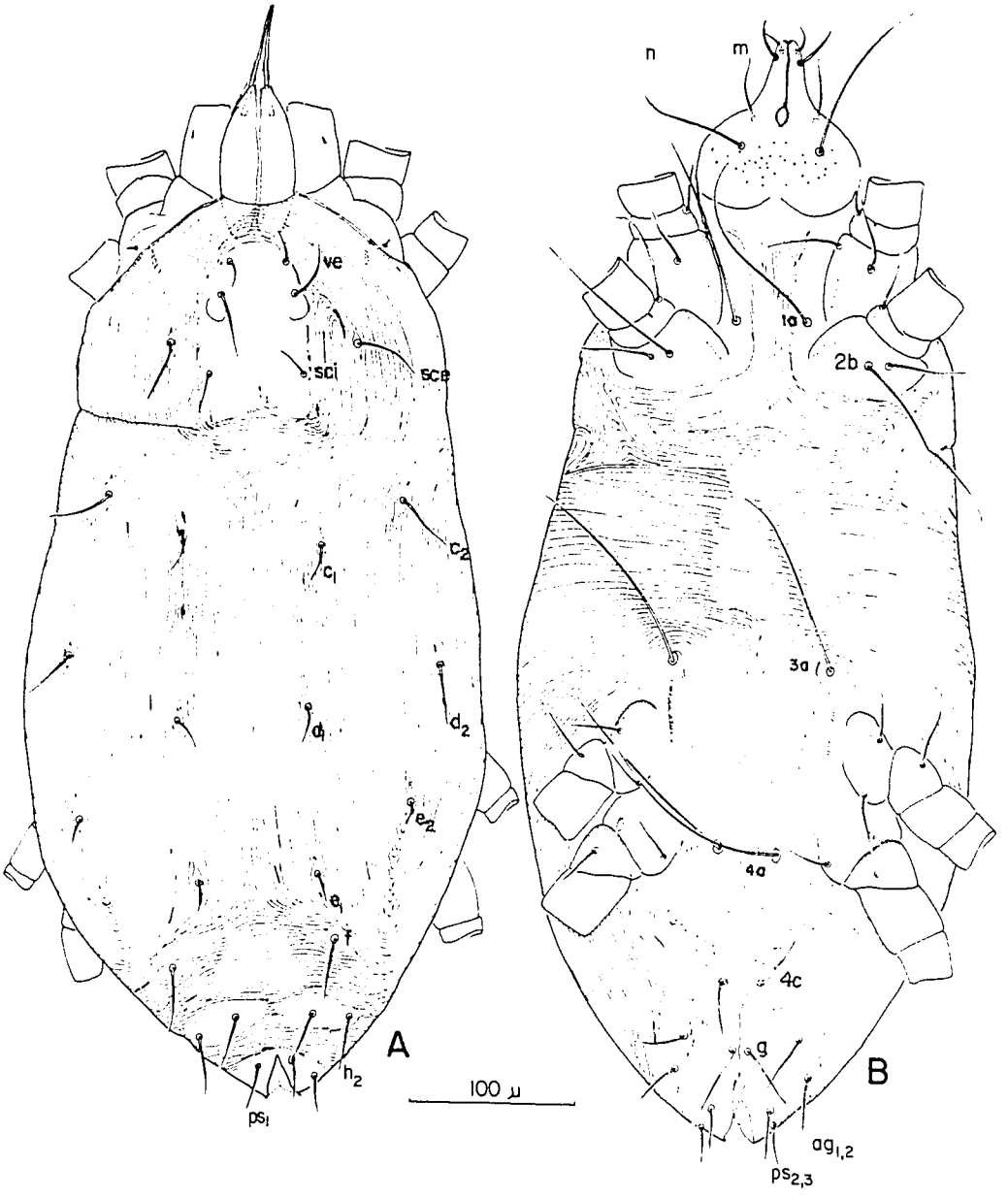

ve
sci
sce
c1
c2
d1
d2
e2
e1
f
h2
ps1
A
100 µ
n
m
1a
2b
3a
4a
4c
g
ag1,2
ps2,3
B

Figure 59

Eryngiopus n.sp. A, female

A. Distal 3 segments of leg I

B. Leg II

C. Palpus

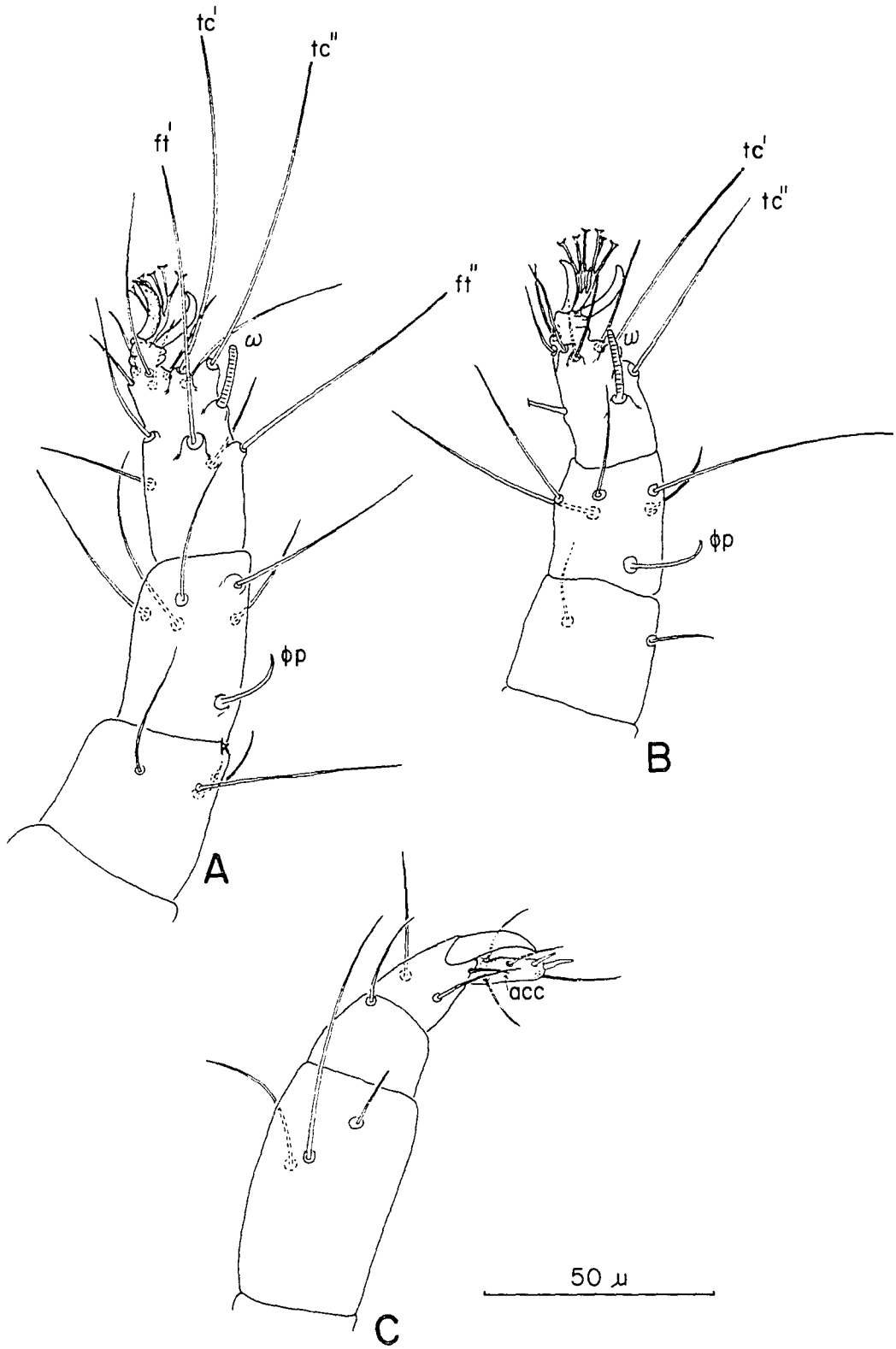

tc'
tc''
ft'
ω
ft''
φp
A
tc'
tc''
ω
φp
B
acc
C
50 μ

Figure 60

Eryngiopus n.sp. A

A. Tarsus I of male

B. Tarsus II of male

C. Tarsus III of male

D. Tarsus IV of male

E. Anogenital area of male showing aedeagus

F. Dorsal view of male anogenital opening

G. Dorsal view of female anal opening

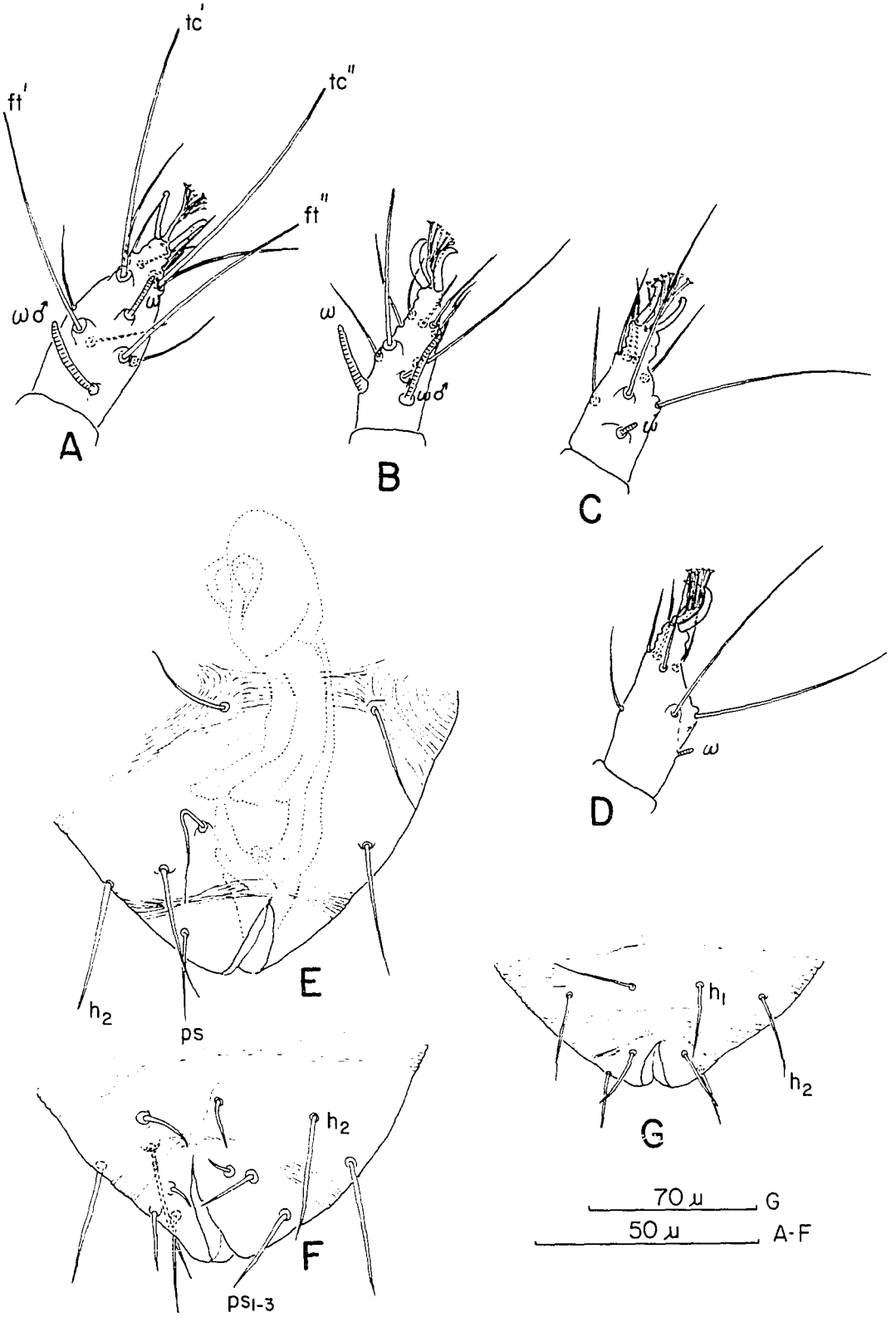

tc'
tc"
ft'
ft"
ωσ
ω
A
ω
ωσ
B
C
ω
D
h2
ps
E
h2
psI-3
F
hI
h2
G
70 μ
G
50 μ
A-F

Figure 61

Agistemus congolensis (Gonzalez-Rodriguez), female

A. Dorsal habitus

B. Palptibia and tarsus

C. Dorsal seta

D. Genu I

E. Genu I, A. floridanus (Gonzalez-Rodriguez)

F. Ventral view of anogenital area

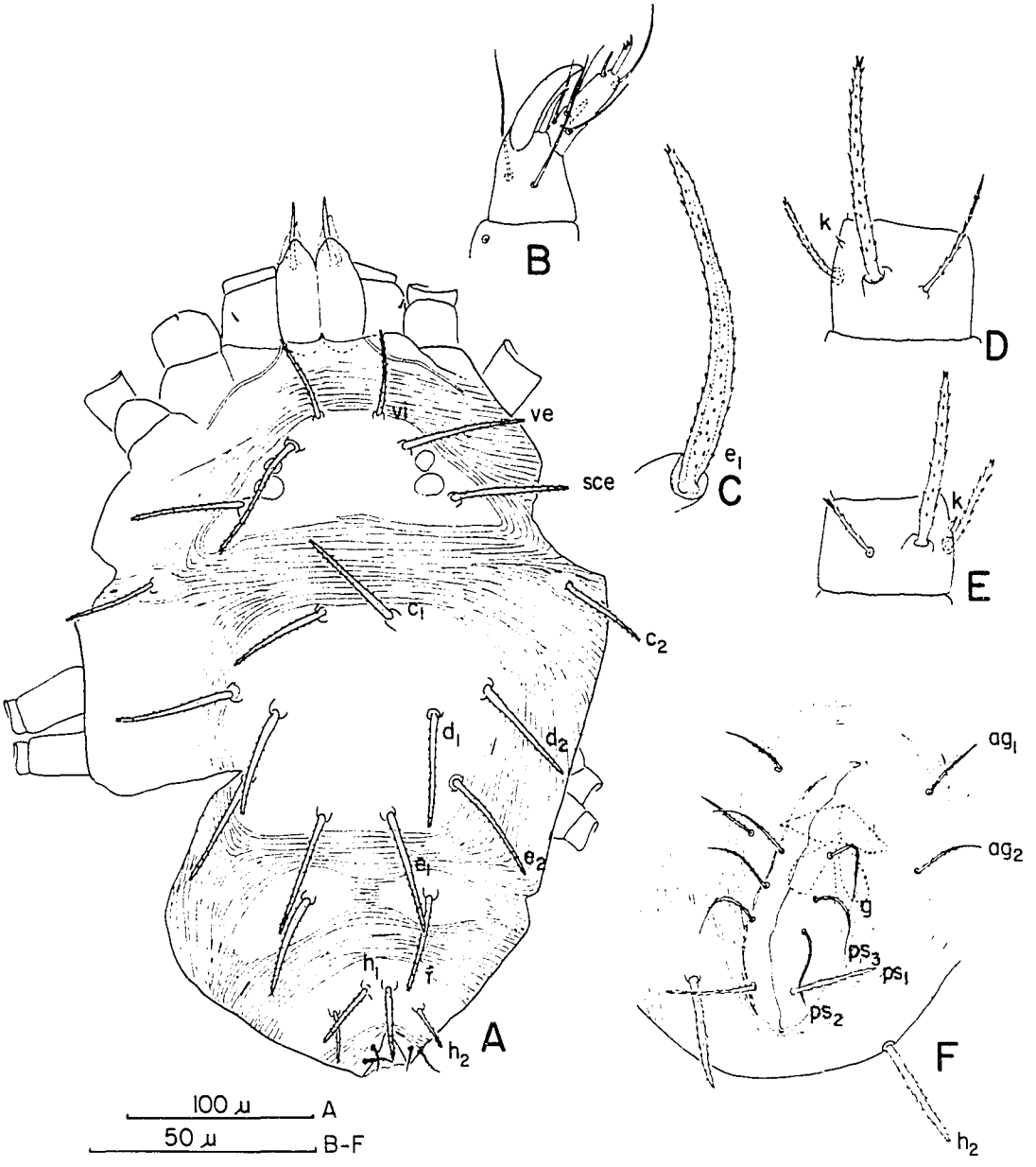

B
C
D
E
F
A
vi
ve
sce
c_1
c_2
d_1
d_2
e_1
e_2
h_1
f
h_2
k
e_1
k
ag_1
ag_2
g
ps_3
ps_1
ps_2
h_2
100 μ
A
50 μ
B-F

Figure 62

Ledermuelleriopsis n.sp. A, female

A. Dorsal habitus

B. Ventral habitus

C. Detail of reticulation on integument

D. Dorsal setae

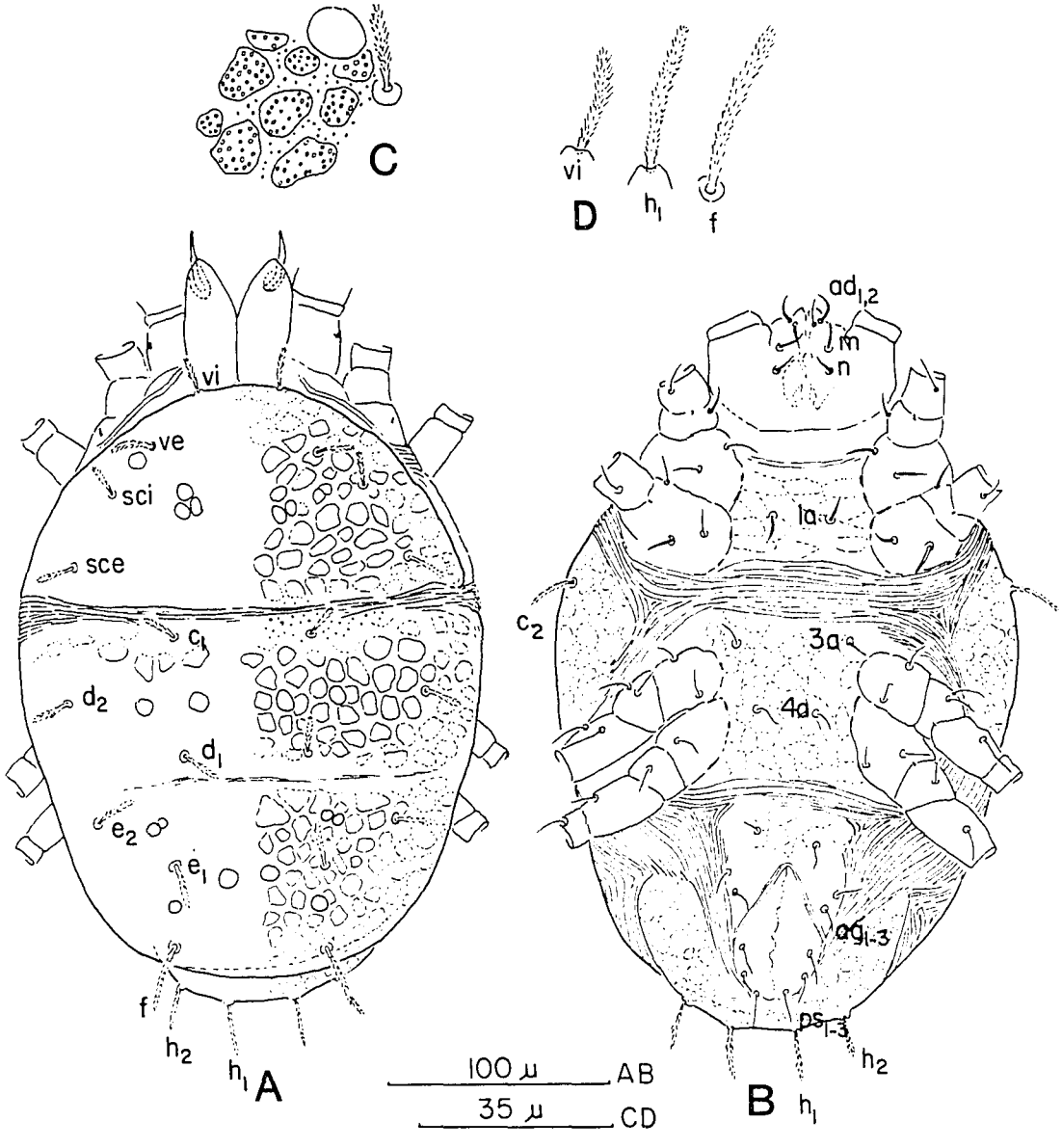

C
vi
h1
f
D
vi
ve
sci
sce
c1
d2
d1
e2
e1
f
h2
h1
A
100 µ
AB
35 µ
CD
ad1,2
m
n
la
c2
3a
4a
ag1-3
ps1-3
h2
B
h1

Figure 63

Ledermuelleriopsis n.sp. A, female

A. Infracapitulum

B. Palpus

C. Detail of podocephalic canal

D. Anogenital area of male showing aedeagus

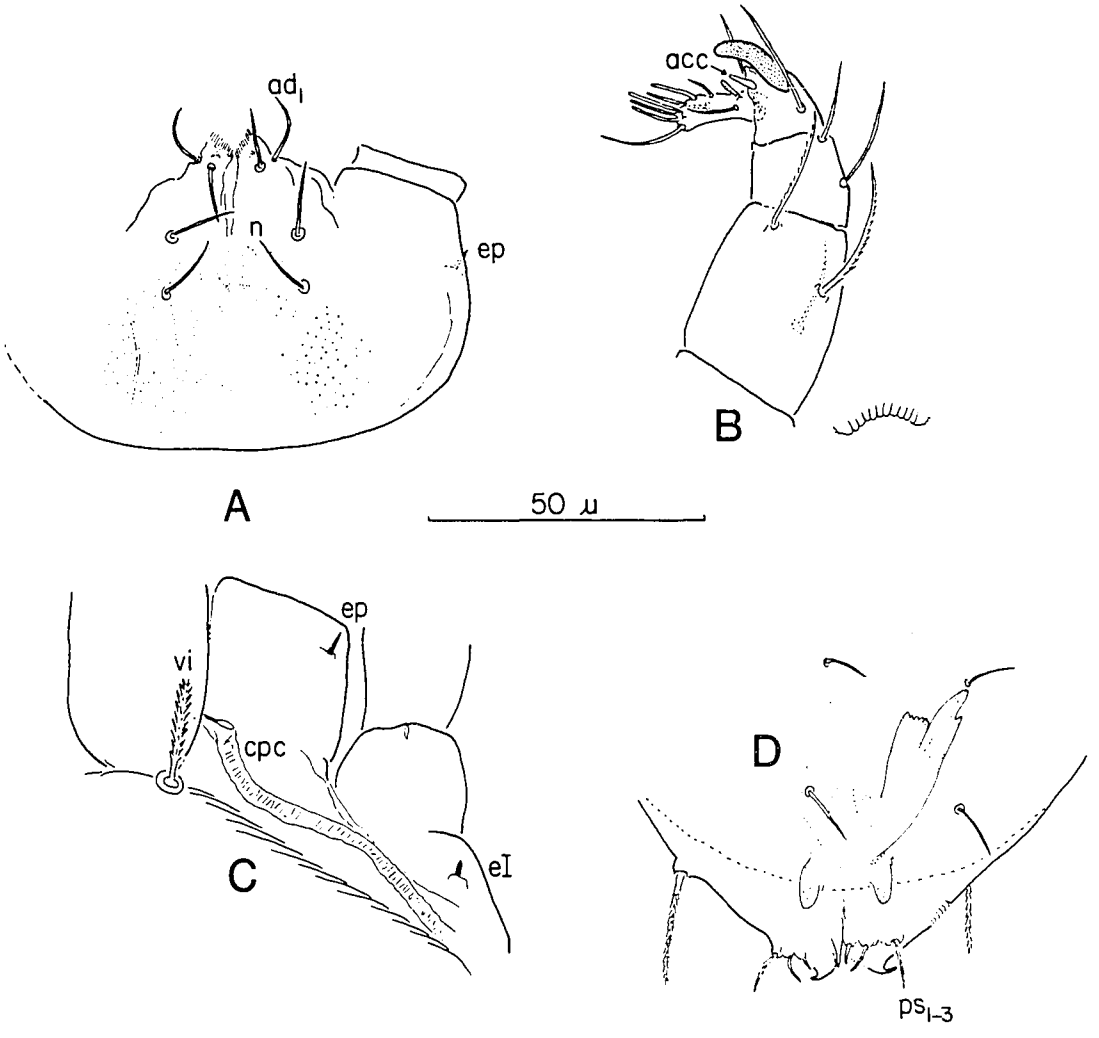

ad1
n
ep
A
acc
B
50 μ
ep
vi
cpc
eI
C
D
ps1-3

Figure 64

Ledermuelleriopsis n.sp. A

A. Distal 3 segments of leg I, female

B. Leg II, female

C. Tarsus I of male

D. Tarsus II of male

E. Tarsus III of male

F. Tarsus IV of male

G. Empodium

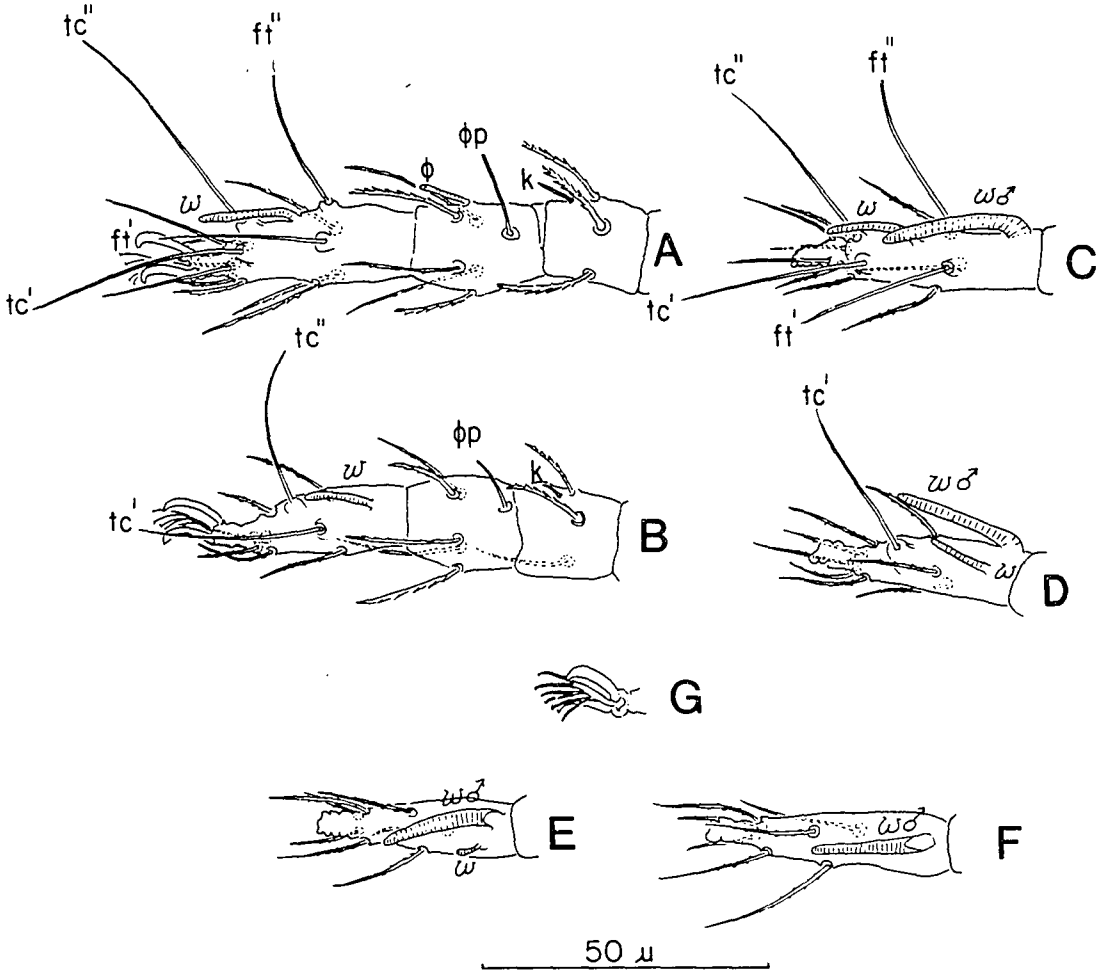

tc"
ft"
ωp
φ
k
ω
ft'
tc'
A
tc"
ft"
ω
ωσ
C
ft'
tc"
ωp
ω
k
tc'
B
tc'
ωσ
ω
D
G
ωσ
ω
E
ωσ
F
50 μ

Figure 65

Ledermuelleriopsis n.sp. B, female

A. Dorsal habitus

B. Ventral habitus

C. Palpus

D. Dorsal seta

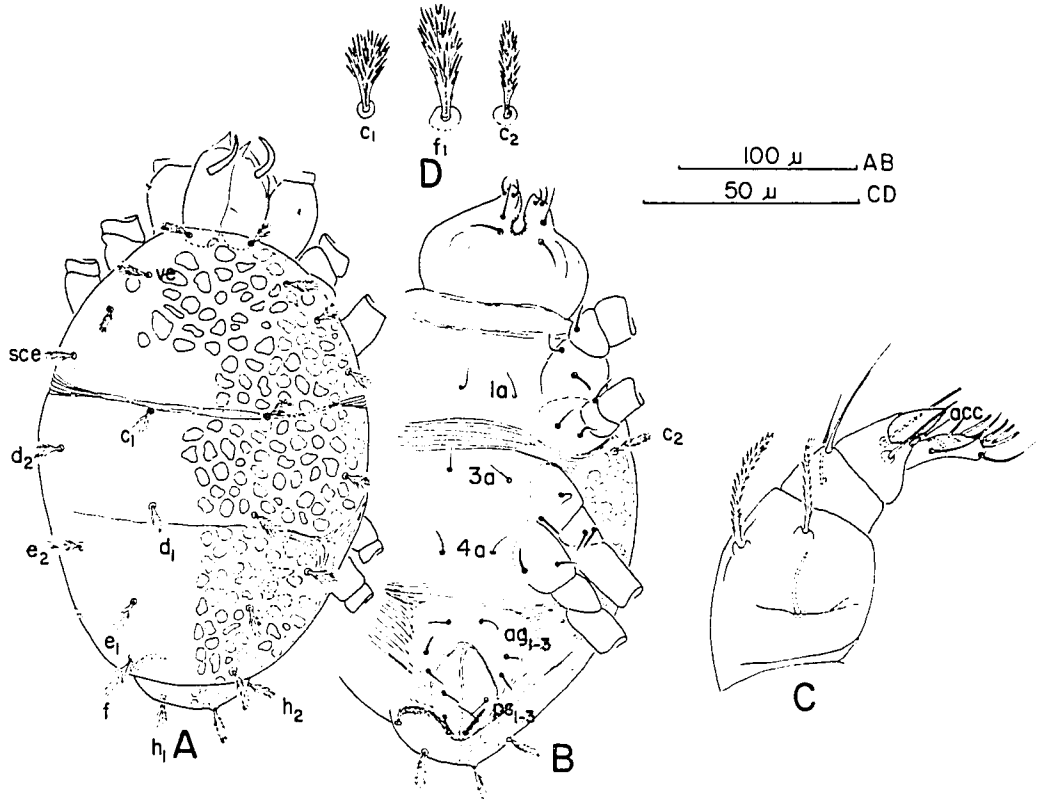

c1
f1
c2
D
100 µ
AB
50 µ
CD
sce
ve
c1
d2
e2
d1
e1
f
h2
h1
A
1a
c2
3a
4a
ag1-3
ps1-3
B
acc
C

Figure 66

Ledermuelleriopsis n.sp. B

A. Dorsal view of anogenital area of male showing aedeagus

B. Ventral view of anogenital area of male

C. Leg I, female

D. Leg II, female

E. Tarsus I, male

F. Tarsus II, male

G. Tarsus III, male

H. Tarsus IV, male

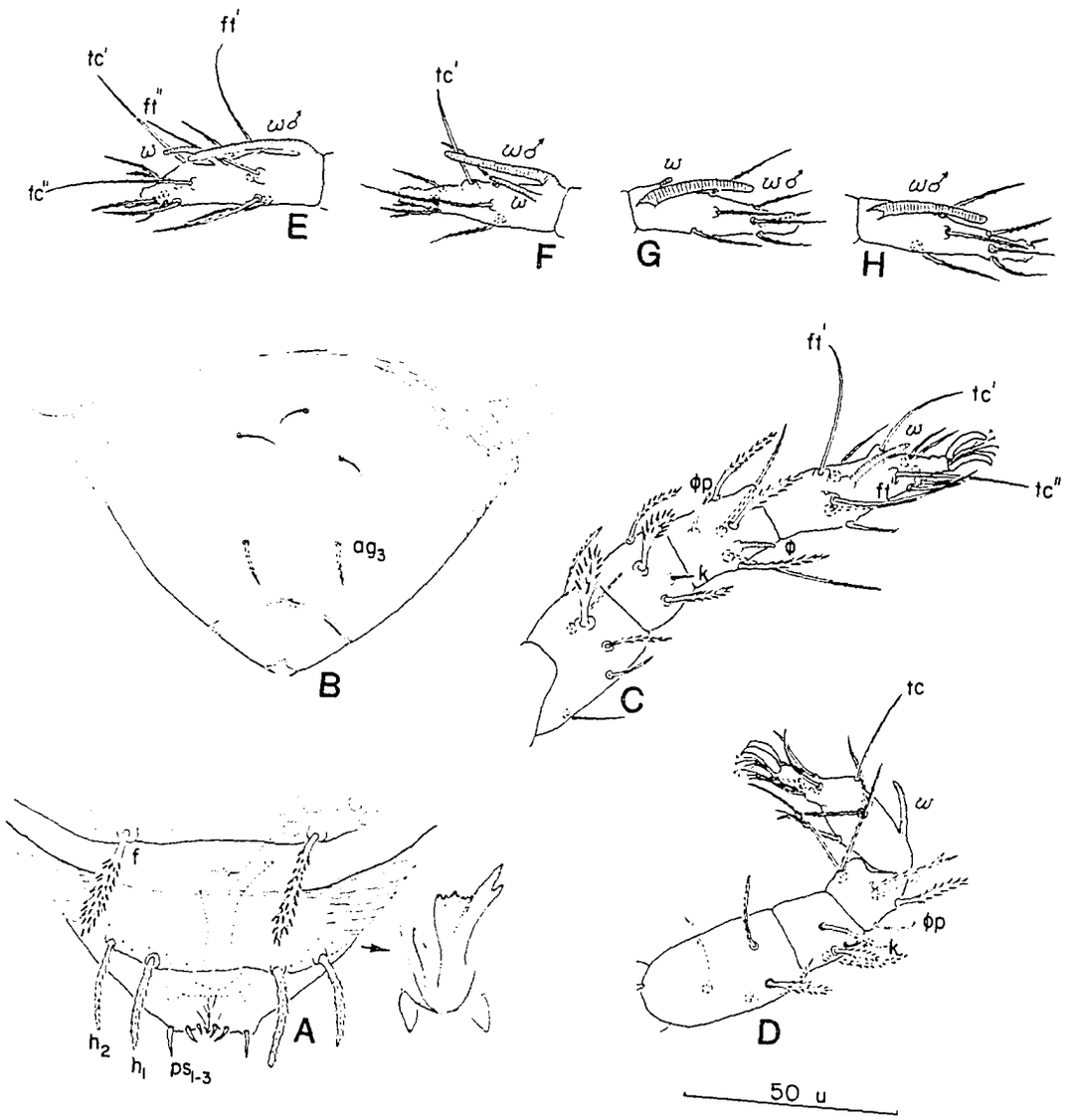

ft'
tc'
ft''
ωσ
ω
tc''
E
tc'
ωσ
ω
F
ω
ωσ
G
ωσ
H
ag3
B
ft'
tc'
ω
φp
ft''
tc''
φ
k
C
tc
ω
φp
k
D
f
h2
h1
ps1-3
A
50 u

Figure 67

Stigmaeus n.sp. A, female

A. Dorsal habitus

B. Ventral habitus

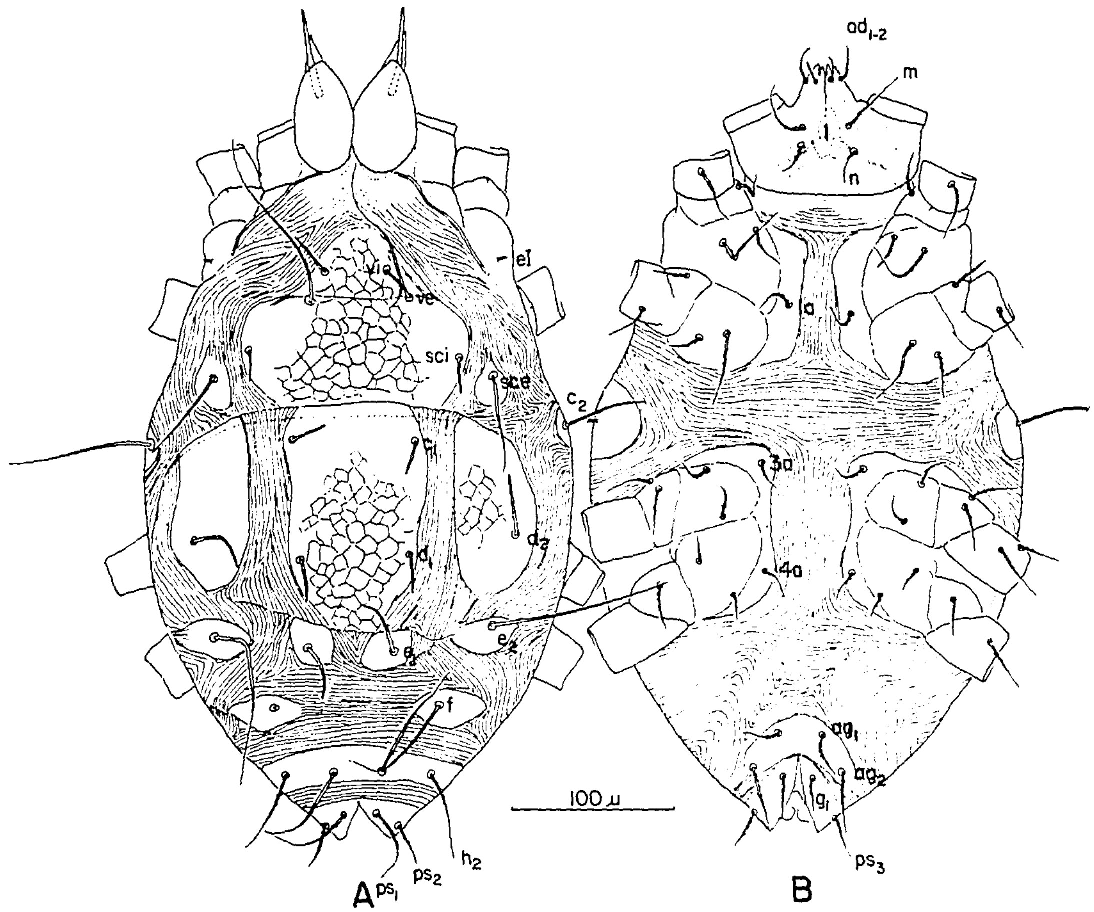

ad1-2
m
l
n
vi
ve
eI
a
sci
sce
c2
c1
3a
d1
d2
4a
e1
e2
f
ag1
ag2
g1
100 u
h2
ps1
ps2
ps3
A
B

Figure 68

Stigmaeus n.sp. A, variations in setal placement of 4c (or agl) on female anogenital area

A. Pair on individual platelets

B. One on platelet, other on striated integument

C. Pair on striated integument

D. Pair on separate plate abutting aggenital plate

E. Missing pair of setae

F. Pair on enlarged aggenital plate

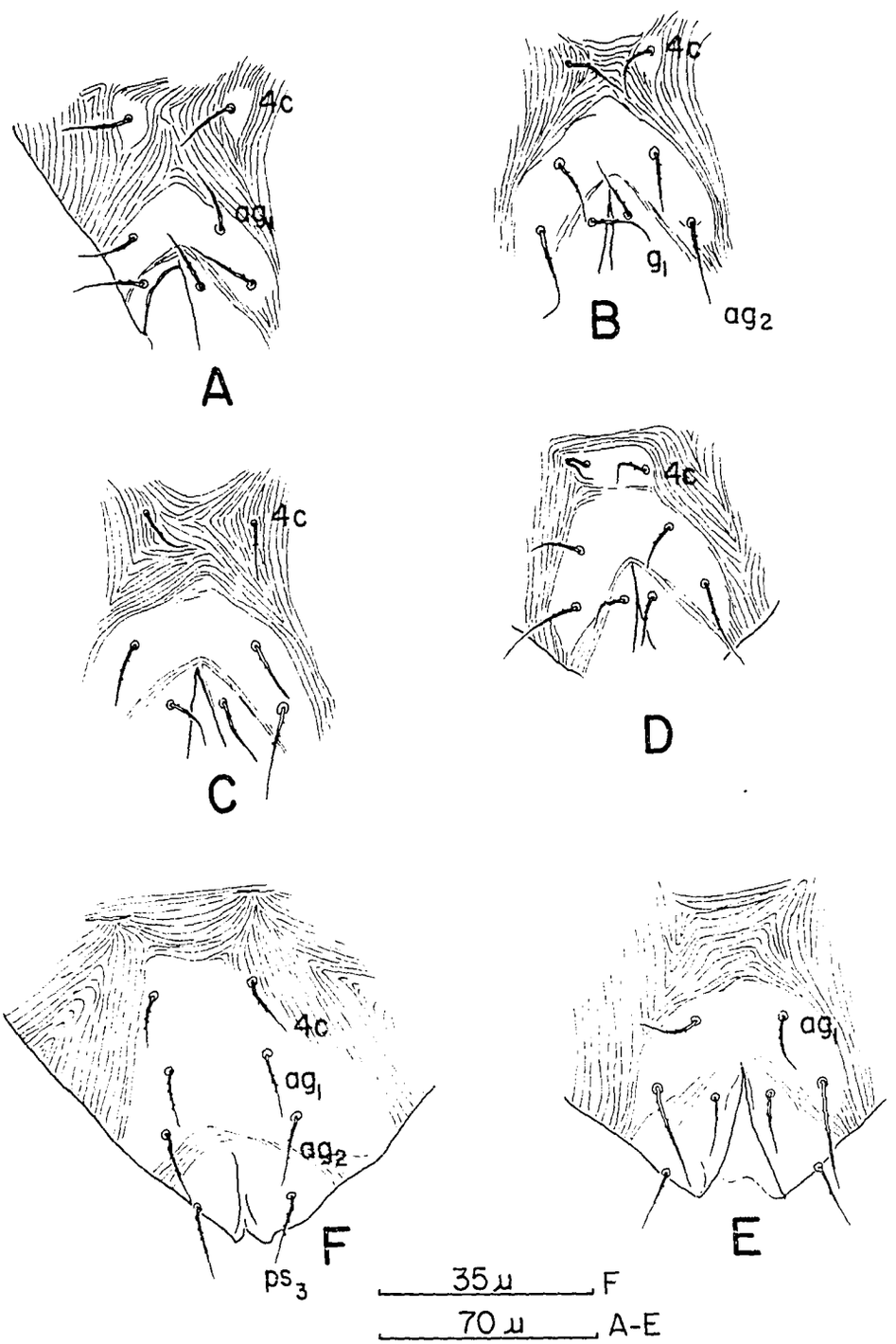

4c
ag1
A
4c
g1
ag2
B
4c
C
4c
D
4c
ag1
ag2
ps3
F
ag1
E
35 μ
F
70 μ
A-E

Figure 69

Stigmaeus n.sp. A, female

A. Distal 3 segments of leg I

B. Distal 3 segments of leg II

C. Dorsal gnathosoma showing cpc and ep

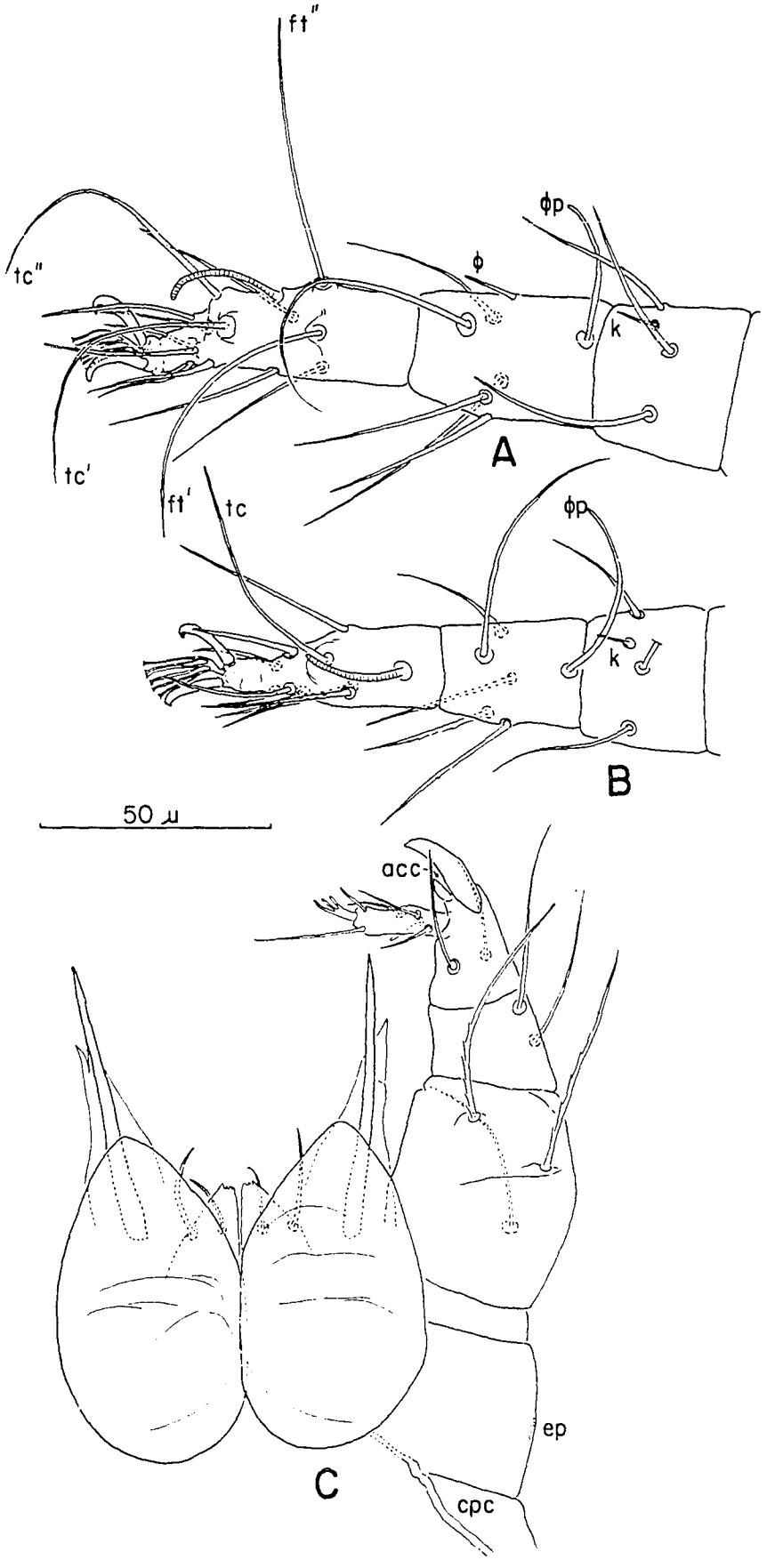

ft"
φp
φ
tc"
k
tc'
A
ft'
tc
φp
k
B
50 μ
acc
ep
C
cpc

Figure 70

Stigmaeus n.sp. B, female

A. Dorsal habitus

B. Ventral habitus

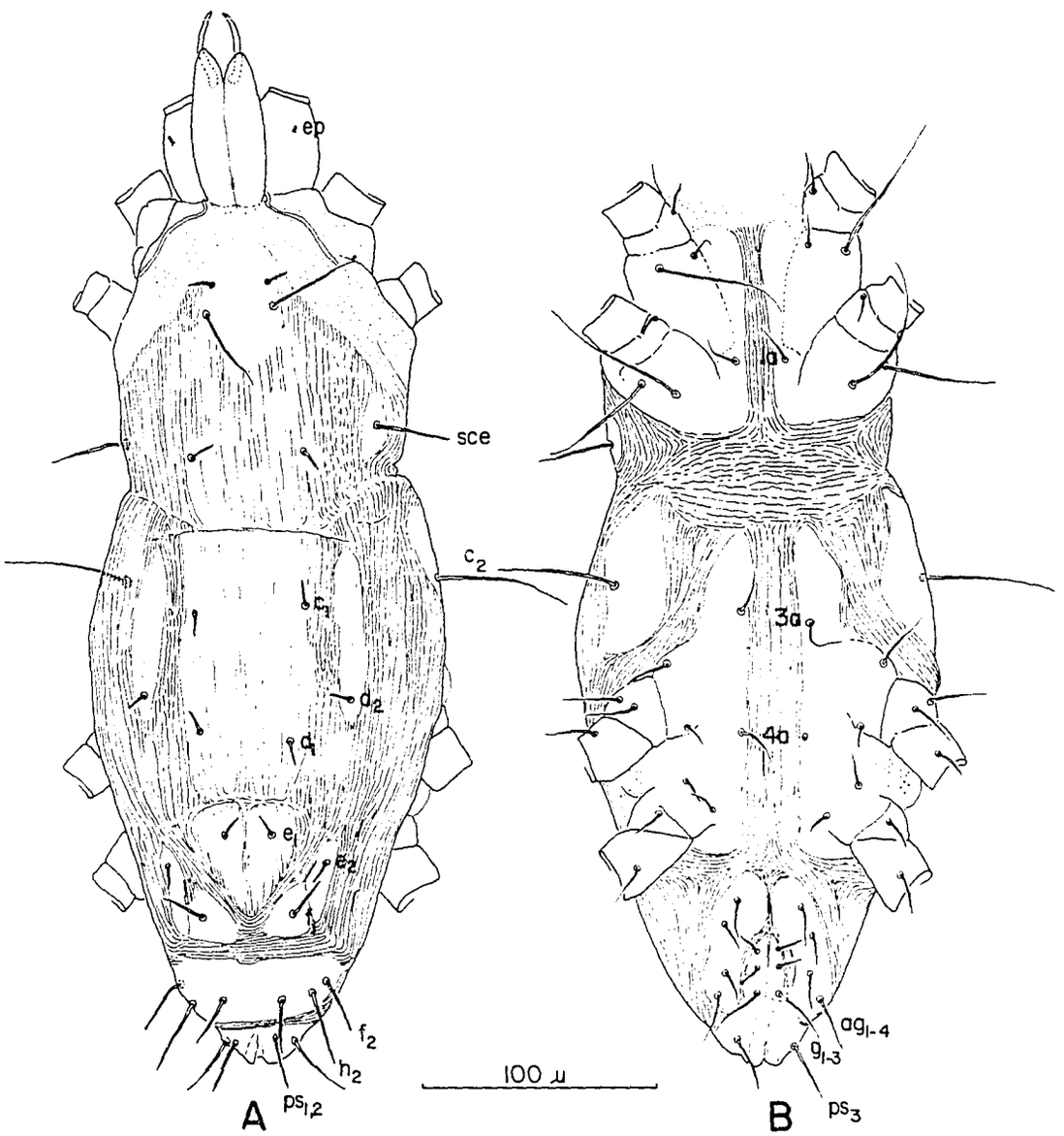

ep
sce
c_2
c_1
d_2
d_1
e_1
e_2
f_2
h_2
$ps_{1,2}$
A
100 μ
1a
3a
4a
ag_{1-4}
g_{1-3}
ps_3
B

Figure 71

Stigmaeus n.sp. B, female

A. Leg I

B. Leg II

C. Leg III

D. Leg IV

E. Ventral view of tarsus I showing pair of sclerotized apodemal on base of claws

F. Infracapitulum

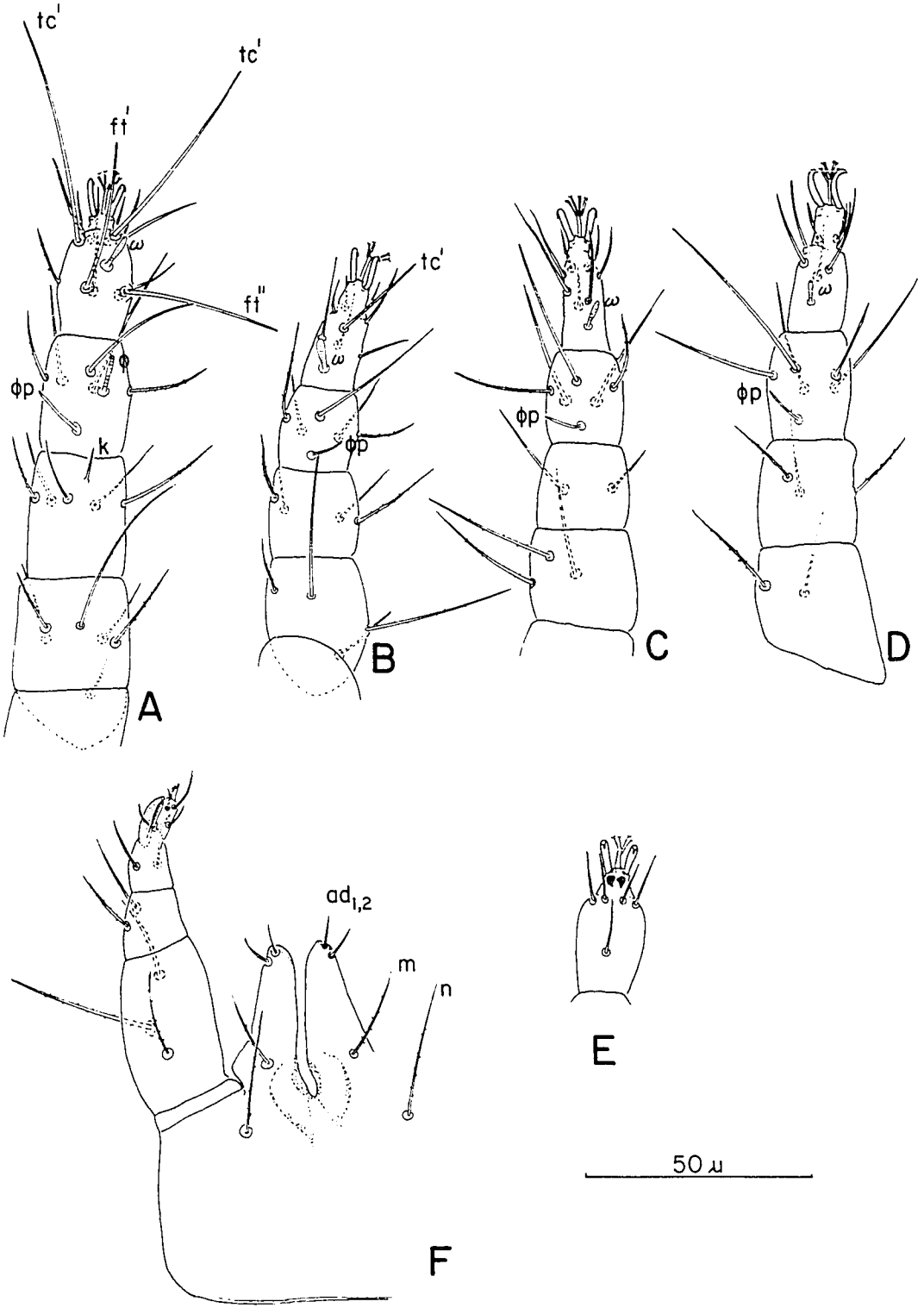

tc'
tc'
ft'
ω
ft''
φ
φp
k
A
tc'
ω
φp
B
ω
φp
C
ω
φp
D
ad1,2
m
n
F
E
50 μ

Figure 72

Stigmaeus n.sp. C, female

A. Dorsal habitus

B. Ventral habitus

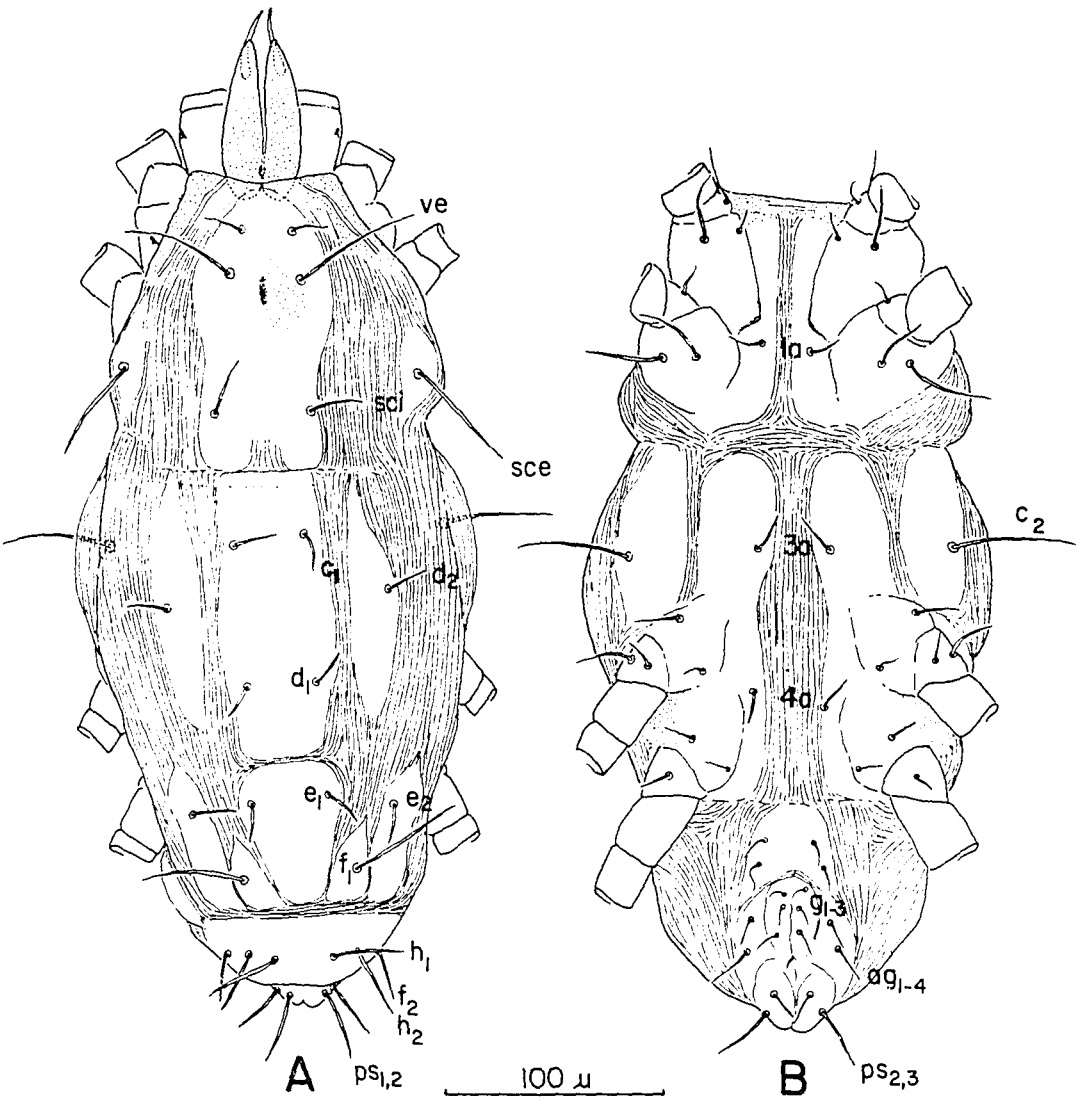

ve
sci
sce
c_1
d_2
d_1
e_1
e_2
f_1
h_1
f_2
h_2
A
$ps_{1,2}$
100 μ
1a
c_2
3a
4a
g_{1-3}
ag_{1-4}
B
$ps_{2,3}$

Figure 73

Stigmaeus n.sp. C, female

A. Leg I

B. leg II

C. Leg III

D. Leg IV

E. Empodium

F. Infracapitulum

G. Cheliceral base

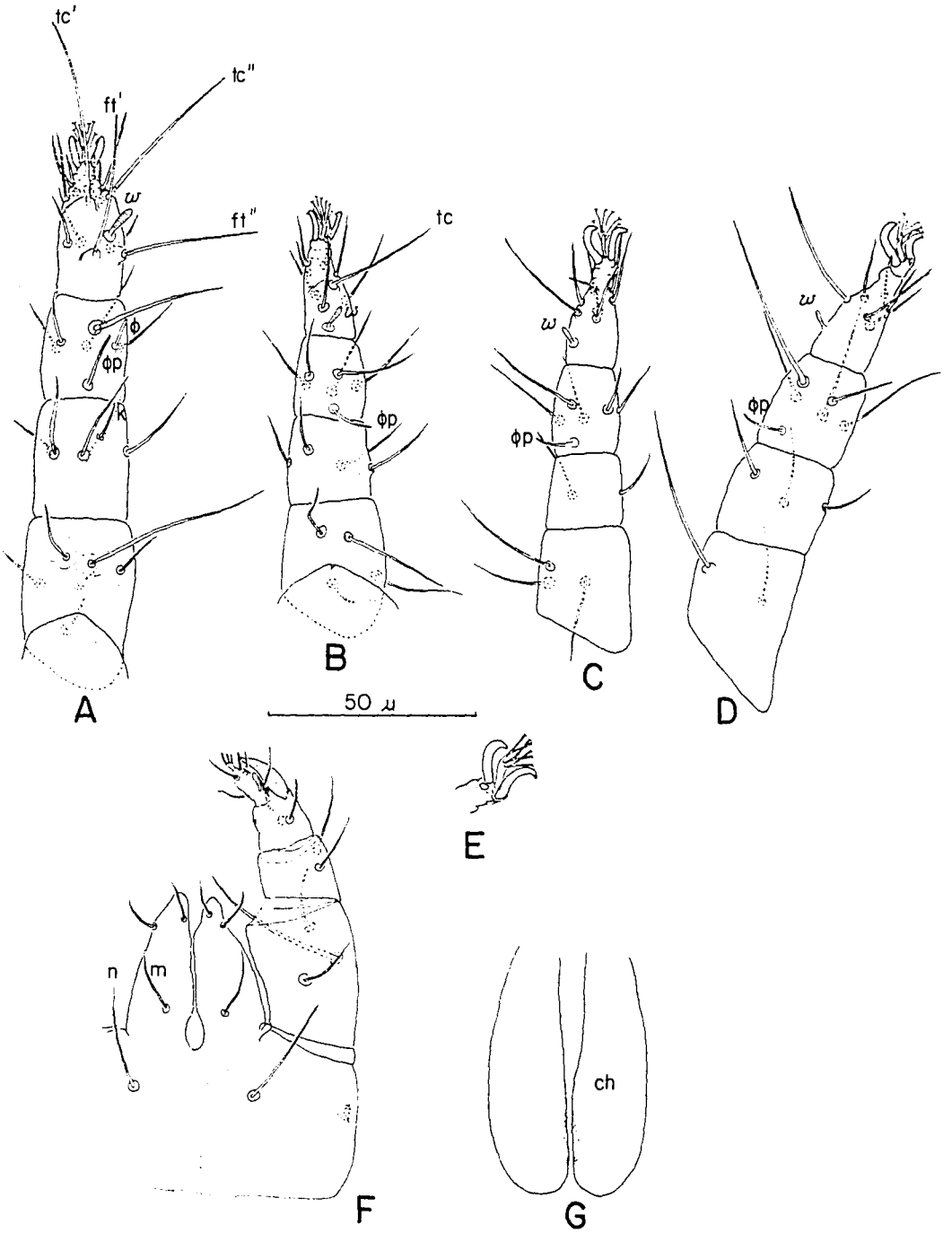

tc'
tc"
ft'
ω
ft"
φ
φp
k
A
tc
ω
φp
B
50 μ
ω
φp
C
ω
φp
D
E
n
m
F
ch
G

Figure 74

Stigmaeus n.sp. D, female

A. Dorsal habitus

B. Ventral habitus

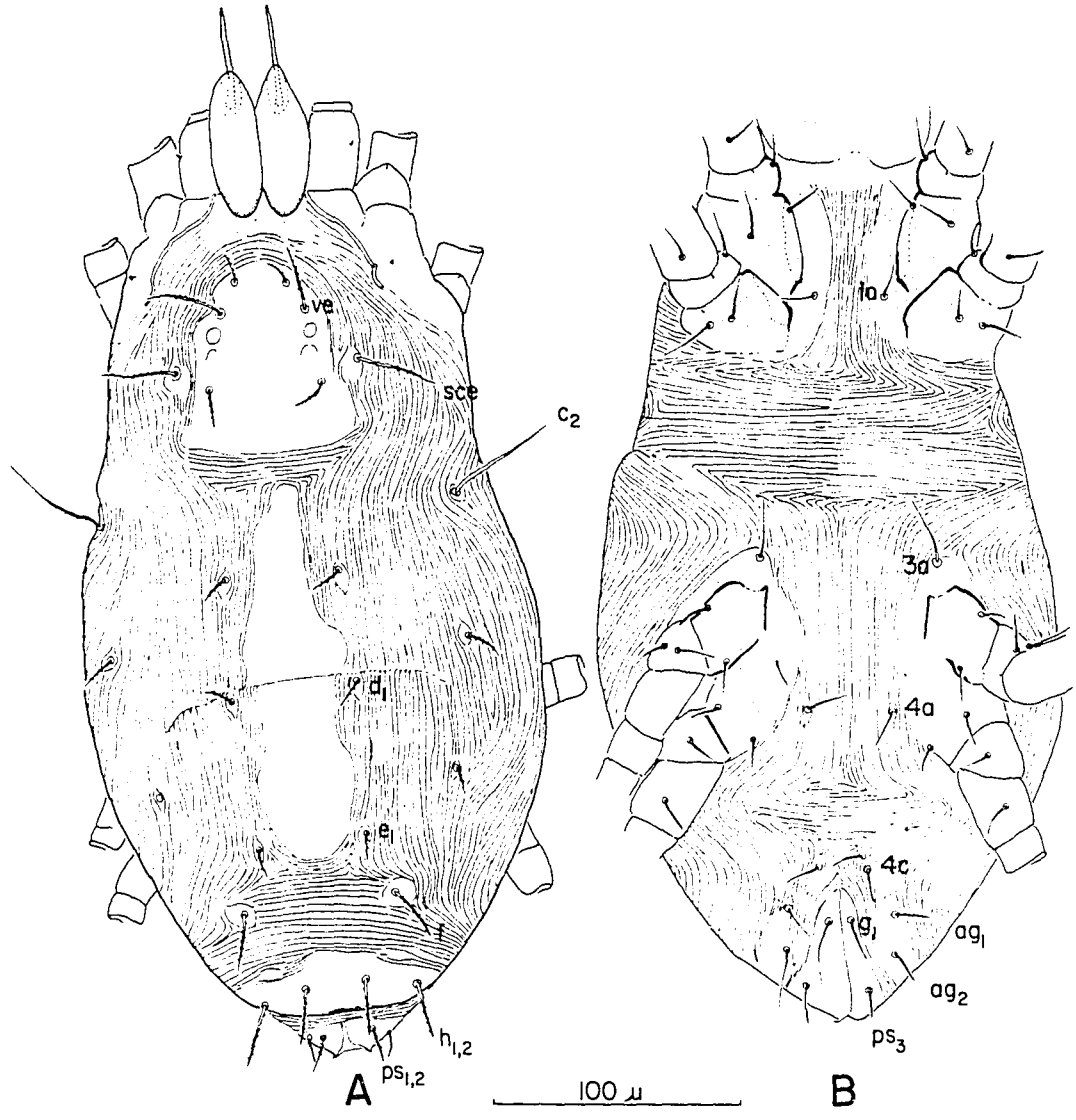

ve
sce
c_2
d_1
e_1
$h_{1,2}$
$ps_{1,2}$
A
100 μ
1a
3a
4a
4c
g_1
ag_1
ag_2
ps_3
B

Figure 75

Stigmaeus n.sp. D, female

A. Distal 3 segments of leg I

B. Distal 3 segments of leg II

C. Infracapitulum

D. Palpus

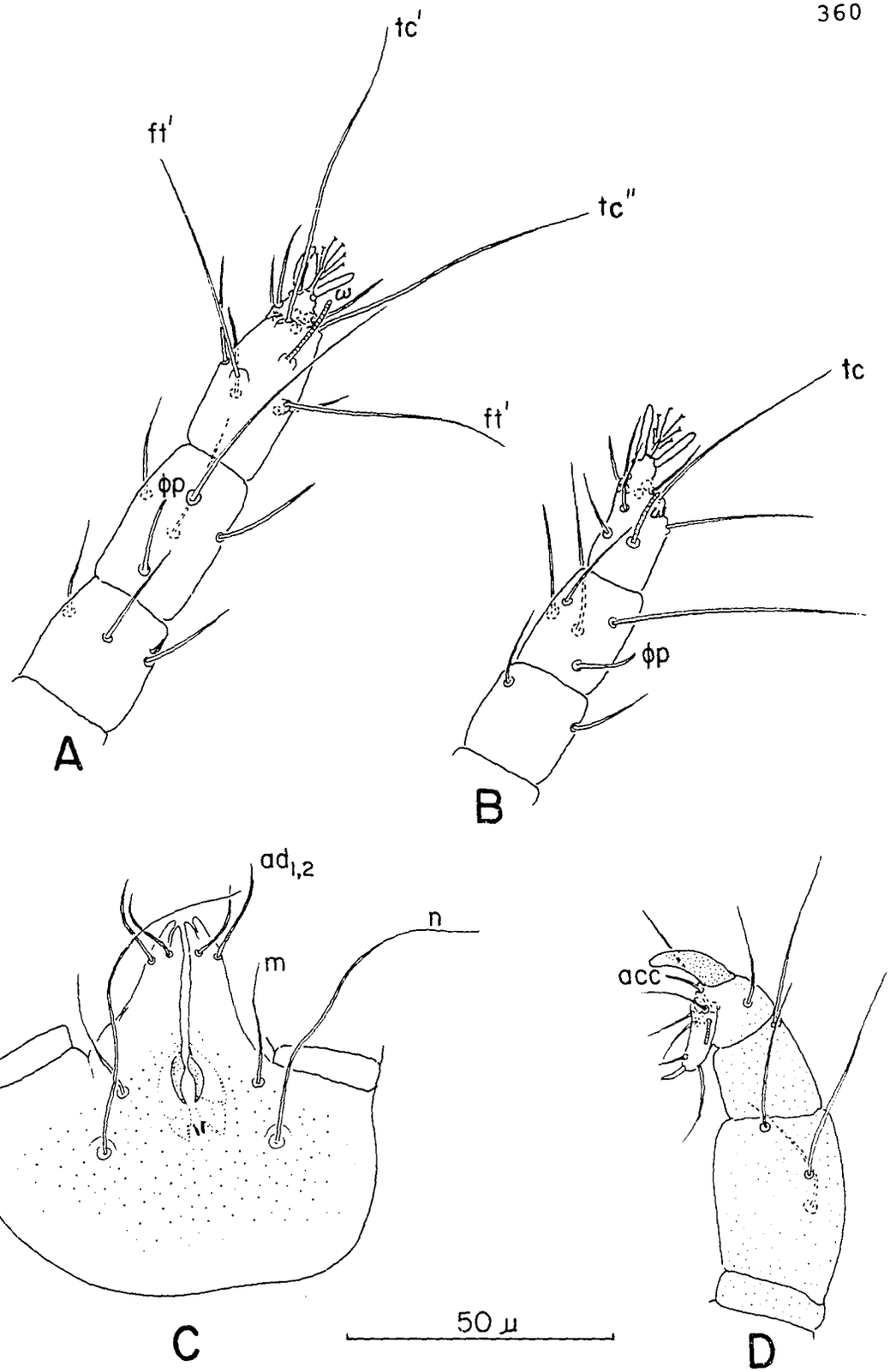

tc'
ft'
tc''
ω
ft'
φp
A
tc
φp
B
ad1,2
n
m
C
50 μ
acc
D

Figure 76

Eustigmaeus n.sp. A, female

A. Dorsal habitus

B. Ventral habitus

C. Detail of ornamentation on integument

D. Distal 3 segments of leg I

E. Distal 3 segments of leg II

F. Distal 3 segments of Leg III

G. Palpus

H. Empodium

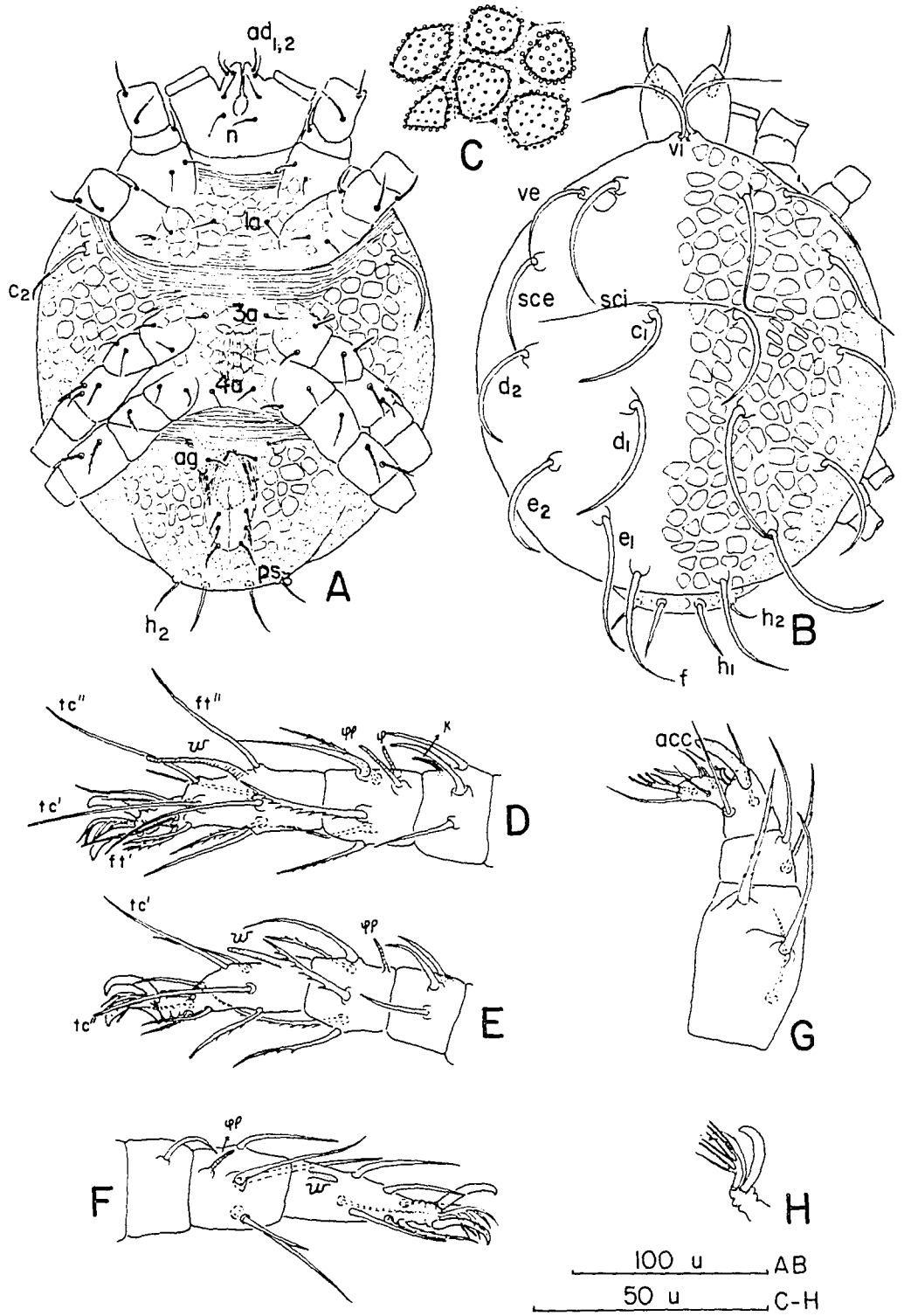

ad1,2
n
C
vi
ve
la
c2
sce
sci
3a
ci
4a
d2
d1
ag
e2
e1
ps
A
h2
B
h2
f
h1
tc''
ft''
w
φp
φ
κ
tc'
ft'
D
tc'
w
φp
tc''
E
acc
G
φp
F
w
H
100 u
AB
50 u
C-H

Figure 77

Eustigmaeus n.sp. B, female

A. Dorsal habitus

B. Ventral habitus

C. Detail of ornamentation on integument

D. Dorsal setae

E. Leg I

F. Palpus

G. Posterior endopodal plate

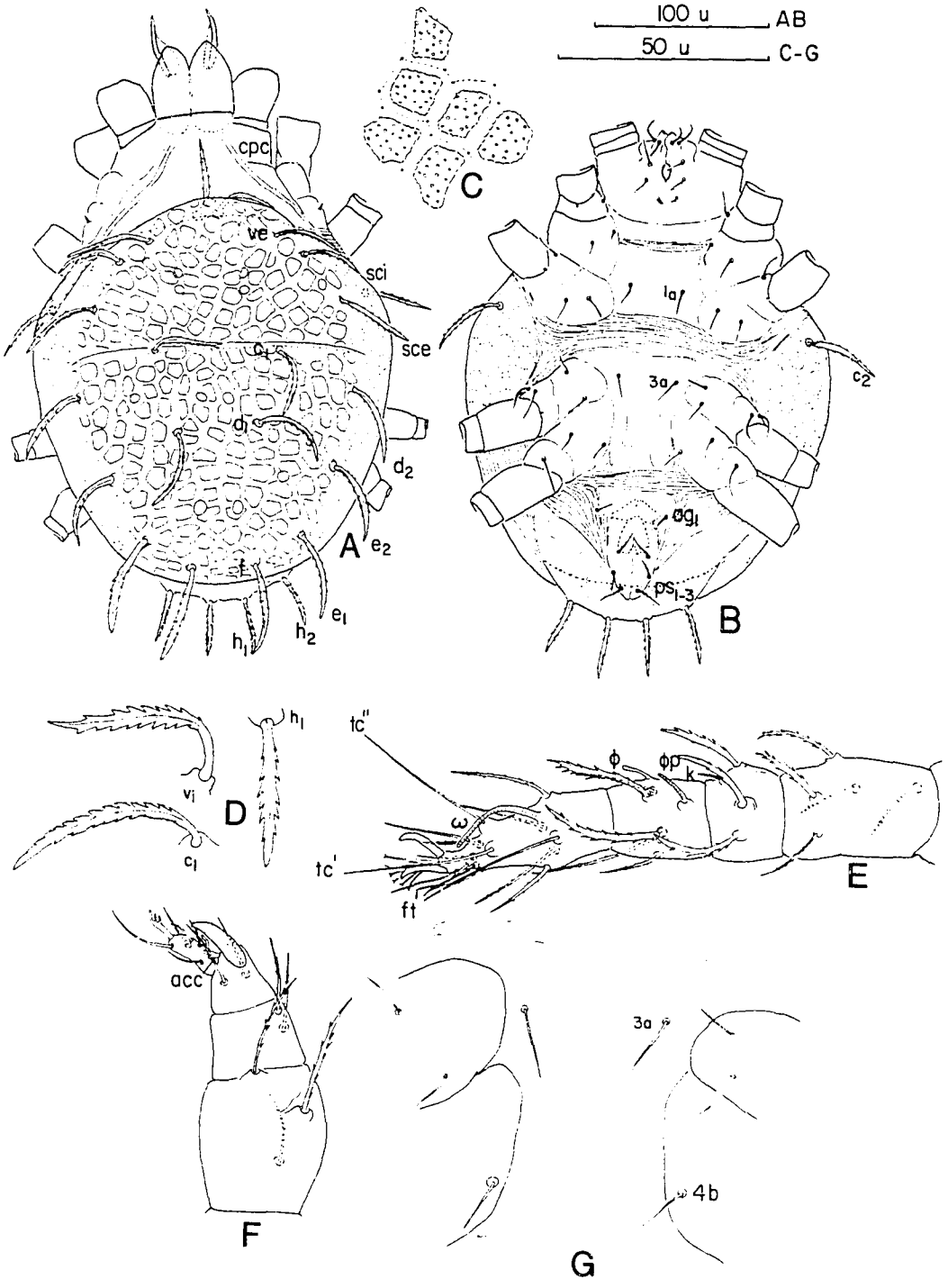

100 u
AB
50 u
C-G
cpc
ve
sci
sce
c_1
d_1
d_2
e_2
e_1
h_1
h_2
A
C
la
3a
c_2
$\varnothing g_1$
ps_{1-3}
B
h_1
v_1
c_1
D
tc''
ϕ
ϕp_k
ω
tc'
ft
E
acc
F
3a
4b
G

Figure 78

Eustigmaeus n.sp. C, female

A. Dorsal habitus

B. Ventral habitus

C. Detail of ornamentation on integument

D. Dorsal setae

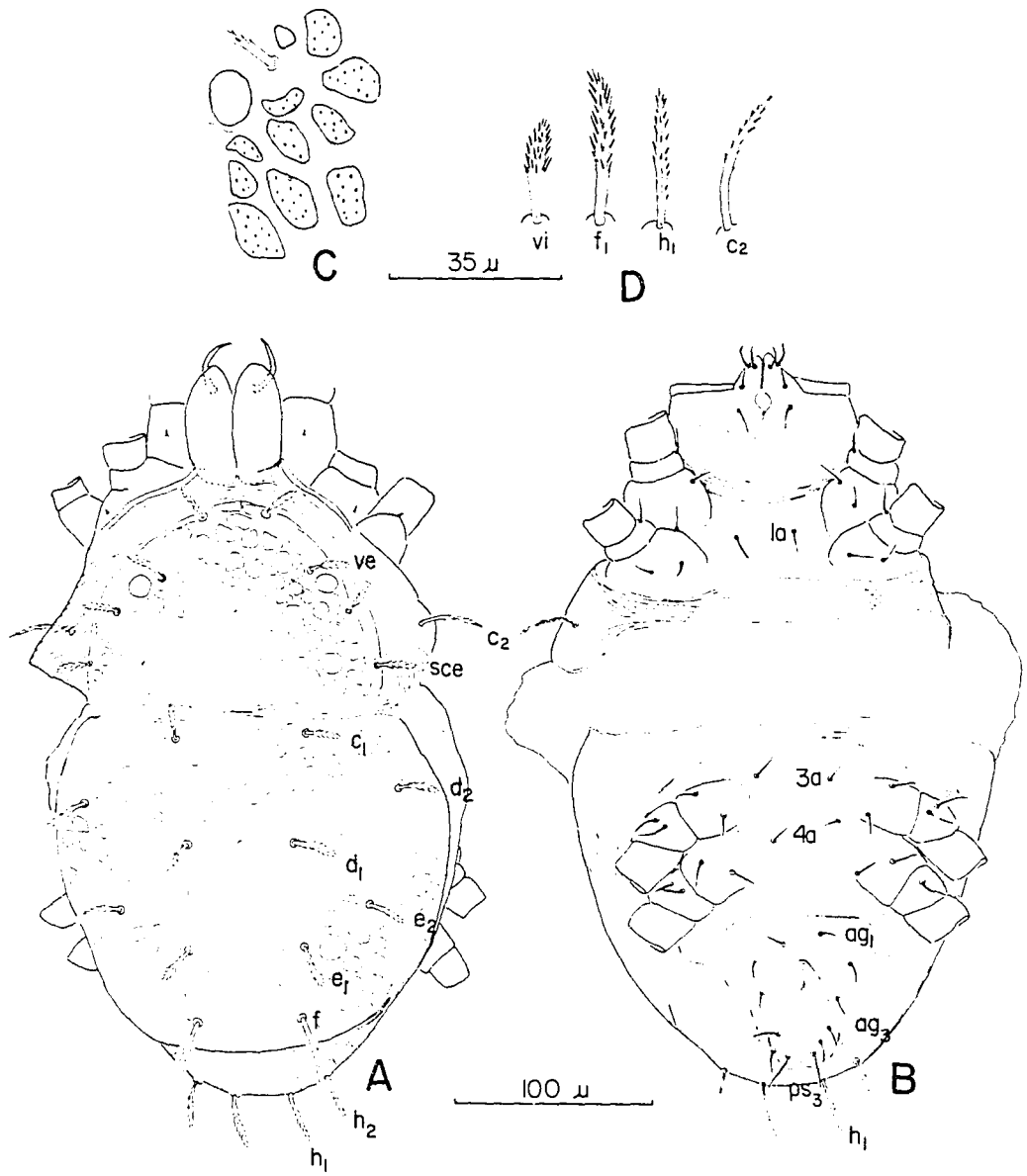

C
35 µ
vi
f1
h1
c2
D
ve
c2
sce
c1
d2
d1
e2
e1
f
h2
h1
A
100 µ
la
3a
4a
ag1
ag3
ps3
h1
B

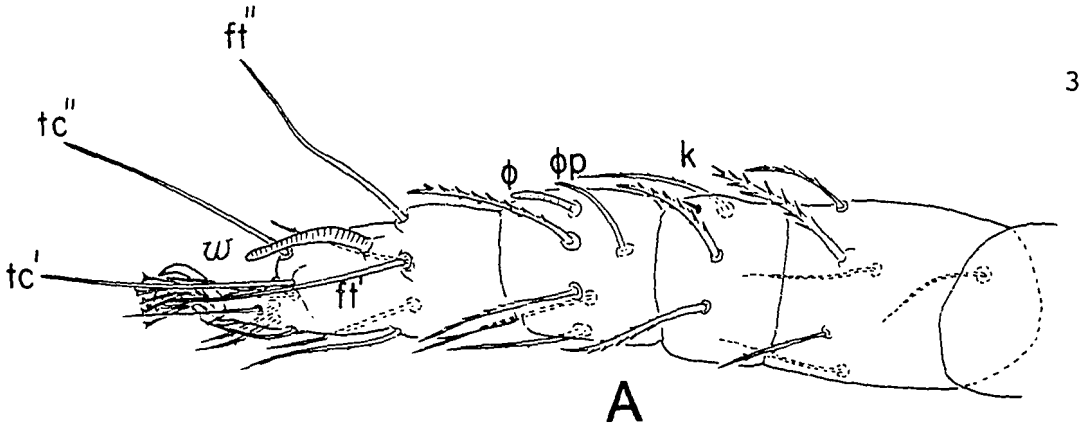
Figure 79

Eustigmaeus n.sp. D, female

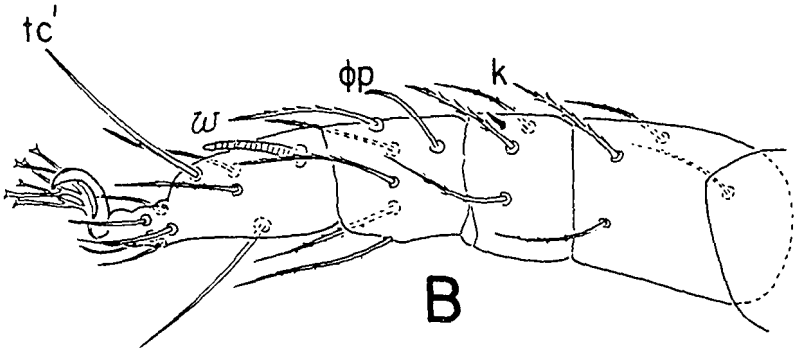
A. Leg I

B. Leg II

C. Gnathosoma

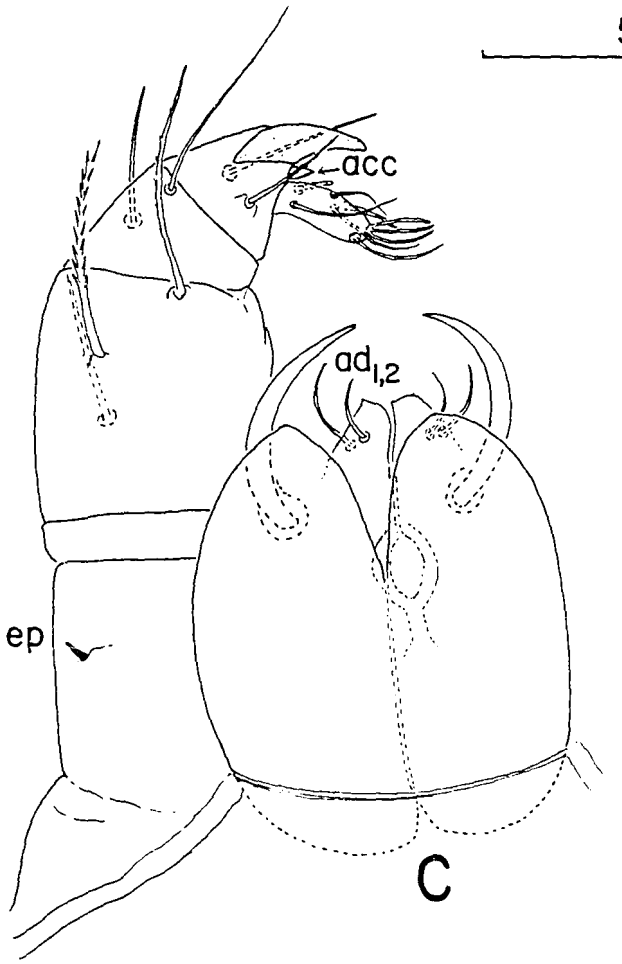


A



B

50 u



C

Figure 80

Distribution of Coptocheles n.sp. A; Coptocheles n.sp. B; Coptocheles n.sp. C; Molothrognathus n.sp. A

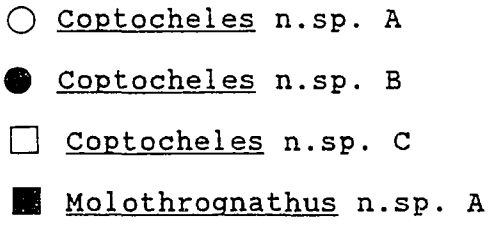
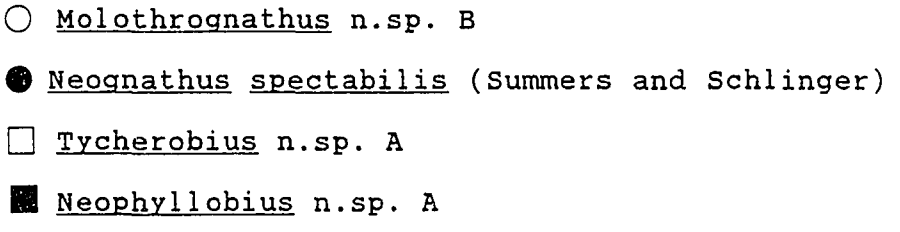
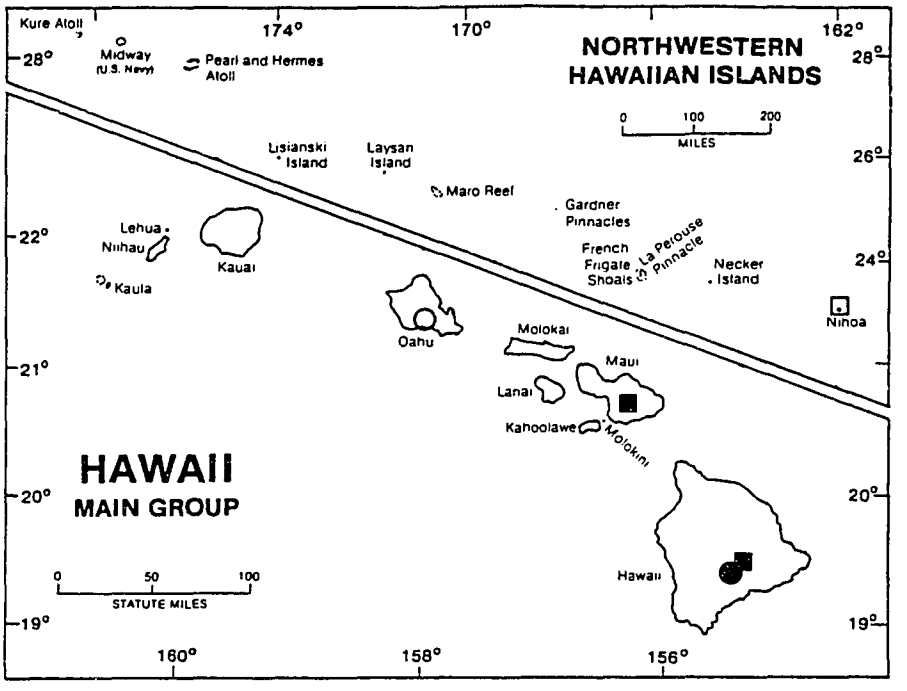
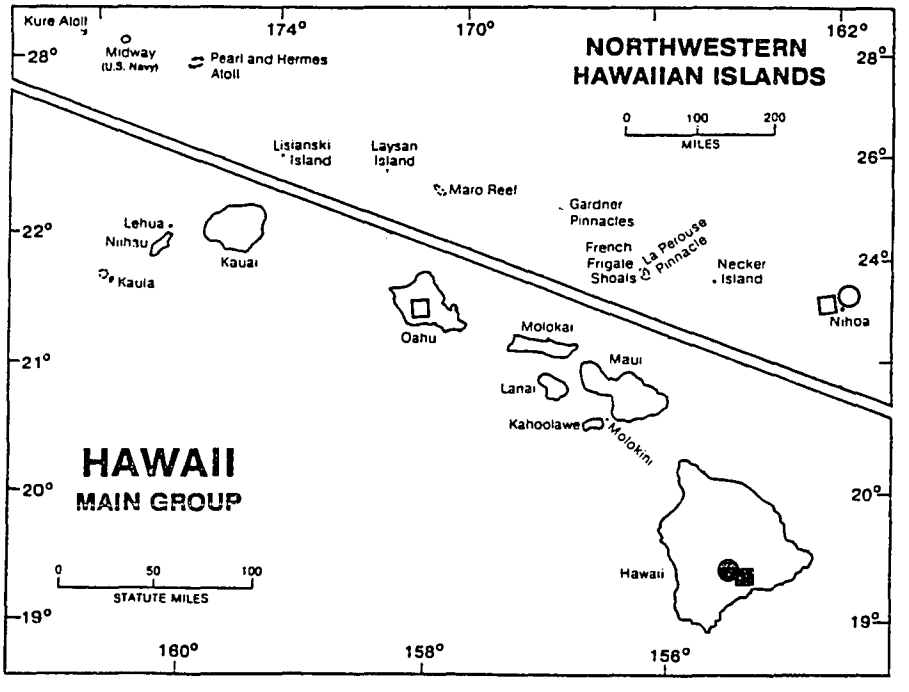


Figure 81

Distribution of Molothrognathus n.sp. B; Neognathus spectabilis (Summers and Schlinger); Tycherobius n.sp. A; Neophyllobius n.sp. A




Kure Atoll
Midway (U.S. Navy)
Pearl and Hermes Atoll
174°
170°
162°
28°
NORTHWESTERN HAWAIIAN ISLANDS
0 100 200
MILES
Lisianski Island
Laysan Island
Maro Reef
Gardner Pinnacles
French Frigate Shoals
La Perouse Pinnacle
Necker Island
Nihoa
26°
22°
Lehua
Niihau
Kauai
Kaula
24°
Oahu
Molokai
Maui
21°
Lanai
Kahoolawe
Molokini
HAWAII
MAIN GROUP
20°
0 50 100
STATUTE MILES
Hawaii
19°
160°
158°
156°


Kure Atoll
Midway (U.S. Navy)
Pearl and Hermes Atoll
174°
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NORTHWESTERN HAWAIIAN ISLANDS
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MILES
Lisianski Island
Laysan Island
Maro Reef
Gardner Pinnacles
French Frigate Shoals
La Perouse Pinnacle
Necker Island
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Niihau
Kauai
Kaula
24°
Oahu
Molokai
Maui
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Lanai
Kahoolawe
Molokini
HAWAII
MAIN GROUP
20°
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STATUTE MILES
Hawaii
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160°
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156°

Figure 82

Distribution of *Neophyllobius* n.sp. B; *Neophyllobius* n.sp. C; *Neophyllobius consobrinus* (De Leon); *Favognathus* n.sp. A

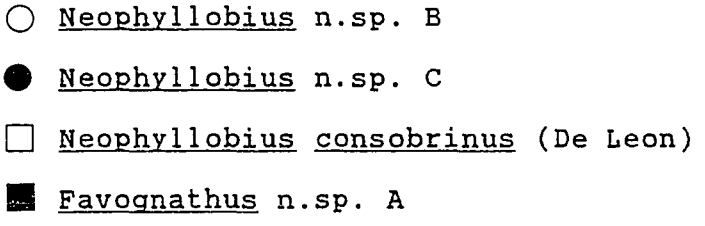
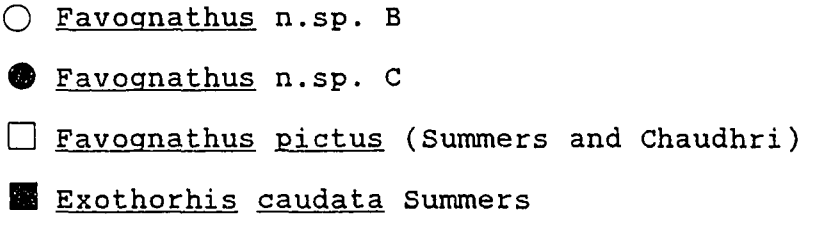
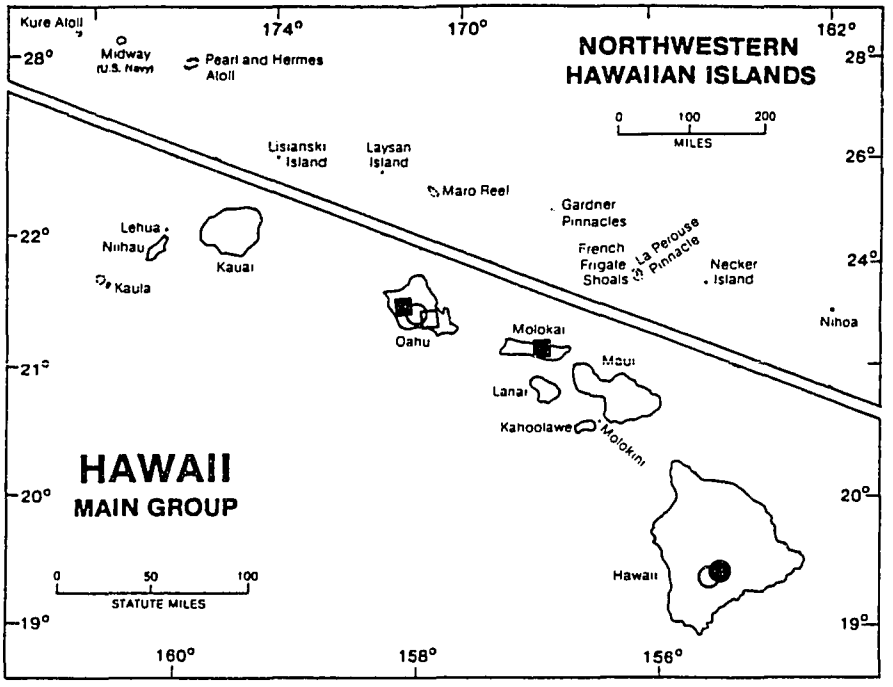


Figure 83

Distribution of *Favognathus* n.sp. B; *Favognathus* n.sp. C; *Favognathus pictus* (Summers and Chaudhri); *Exothorhis caudata* Summers




Kure Atoll
Midway (U.S. Navy)
Pearl and Hermes Atoll
174°
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NORTHWESTERN HAWAIIAN ISLANDS
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Lisianski Island
Laysan Island
Maro Reef
Gardner Pinnacles
French Frigate Shoals
La Perouse Pinnacle
Necker Island
Nihoa
Lehua
Niihau
Kaula
Kauai
Oahu
Molokai
Maui
Lanai
Kahoolawe
Molokini
HAWAII
MAIN GROUP
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STATUTE MILES
Hawaii
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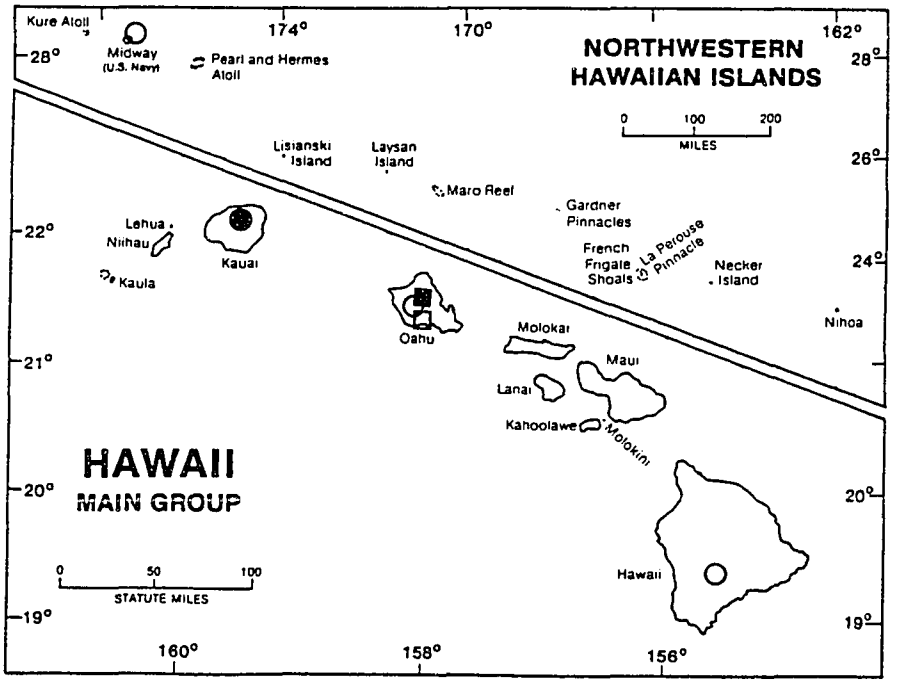
156°


Kure Atoll
Midway (U.S. Navy)
Pearl and Hermes Atoll
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Lisianski Island
Laysan Island
Maro Reef
Gardner Pinnacles
French Frigate Shoals
La Perouse Pinnacle
Necker Island
Nihoa
Lehua
Niihau
Kaula
Kauai
Oahu
Molokai
Maui
Lanai
Kahoolawe
Molokini
HAWAII
MAIN GROUP
0 50 100
STATUTE MILES
Hawaii
160°
158°
156°

Figure 84

Distribution of Saniosulus nudus Summers; Raphignathus n.sp. A; Raphignathus n.sp. B; Raphignathus n.sp C

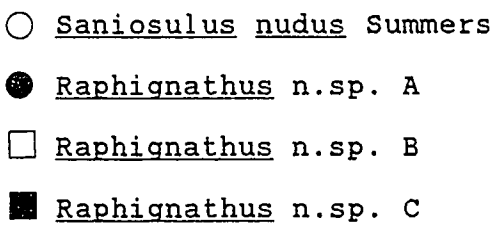
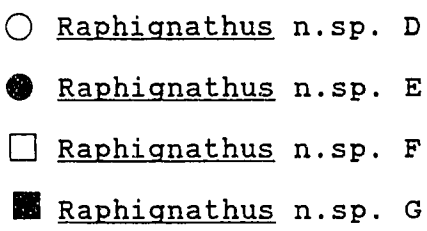
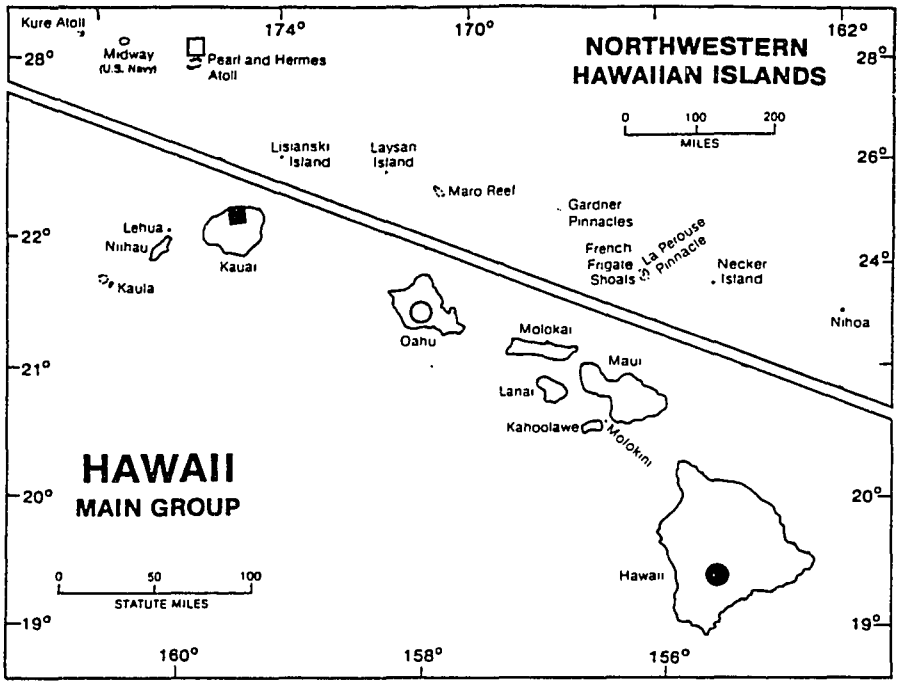


Figure 85

Distribution of Raphignathus n.sp. D; Raphignathus n.sp. E; Raphignathus n.sp. F; Raphignathus n.sp. G

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Midway (U.S. Navy)
Pearl and Hermes Atoll
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Laysan Island
Maro Reef
Gardner Pinnacles
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Niihau
Kauai
Kaula
French Frigate Shoals
La Perouse Pinnacle
Necker Island
24°
Nihoa
Oahu
Molokai
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Maui
Lanai
Kahoolawe
Molokini
HAWAII
MAIN GROUP
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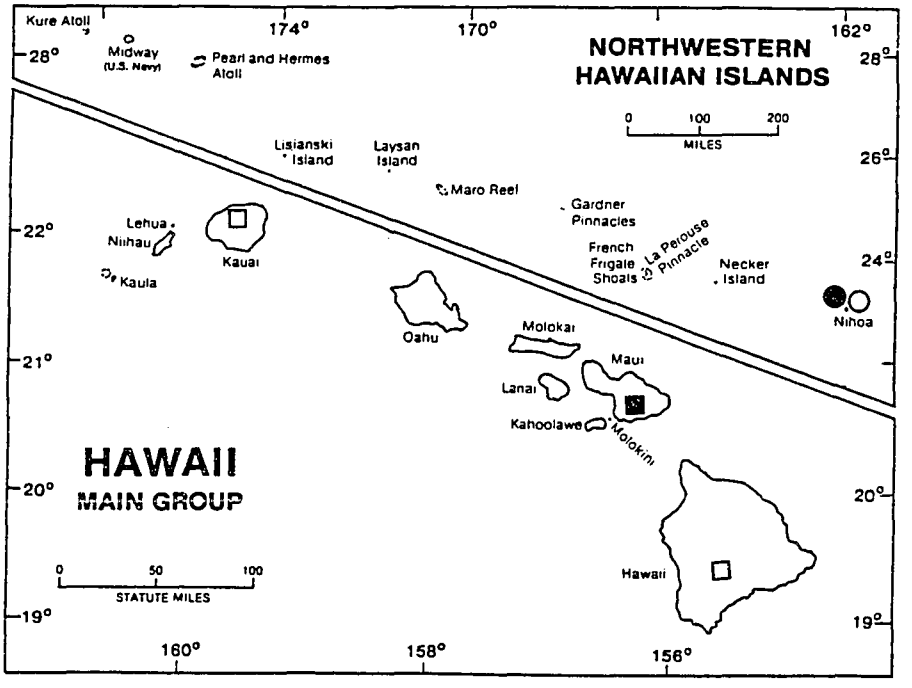
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Midway (U.S. Navy)
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Laysan Island
Maro Reef
Gardner Pinnacles
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Lehua
Niihau
Kauai
Kaula
French Frigate Shoals
La Perouse Pinnacle
Necker Island
24°
Nihoa
Oahu
Molokai
21°
Maui
Lanai
Kahoolawe
Molokini
HAWAII
MAIN GROUP
20°
0 50 100
STATUTE MILES
Hawaii
19°
160°
158°
156°

Figure 86

Distribution of Raphignathus n.sp. H; Raphignathus aethiopicus (Meyer and Ryke); Agistemus congolensis Gonzalez-Rodriguez; Agistemus terminalis (Quayle)

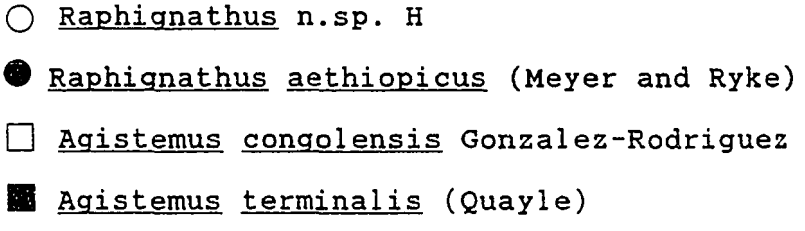
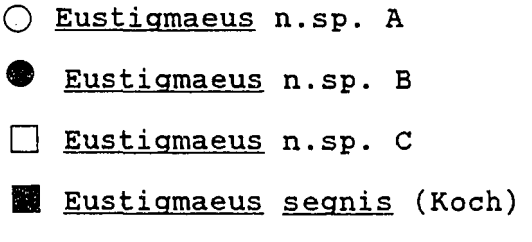
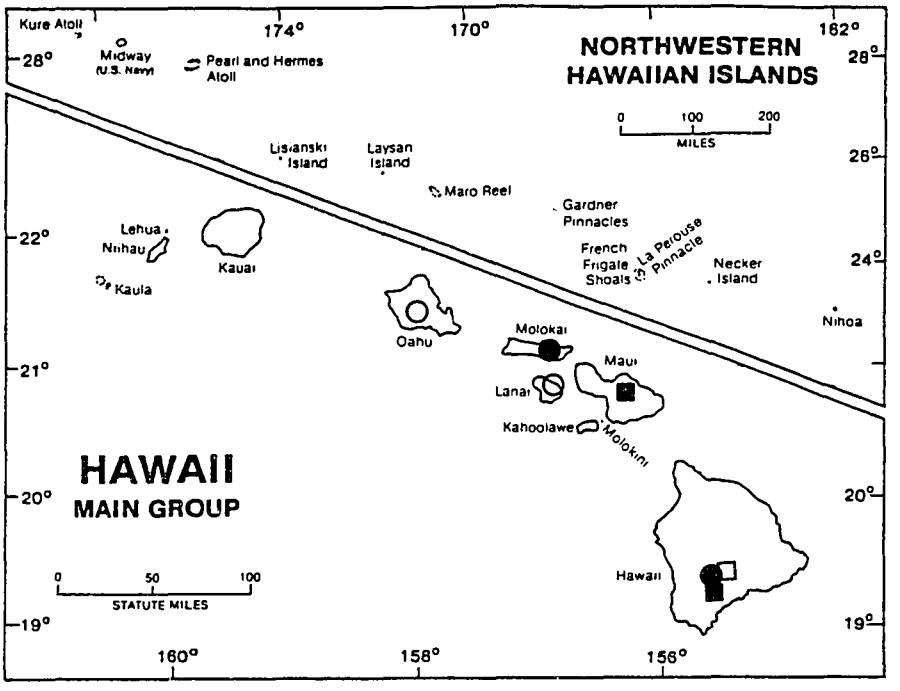


Figure 87

Distribution of Eustigmaeus n.sp. A; Eustigmaeus n.sp. B; Eustigmaeus n.sp. C; Eustigmaeus segnis (Koch)




Kure Atoll
Midway (U.S. Navy)
Pearl and Hermes Atoll
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Laysan Island
Maro Reef
Gardner Pinnacles
French Frigate Shoals
La Perouse Pinnacle
Necker Island
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Lehua
Niihau
Kaula
Kauai
Oahu
Molokai
Maui
Lanai
Kahoolawe
Molokini
Hawaii
HAWAII
MAIN GROUP
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STATUTE MILES
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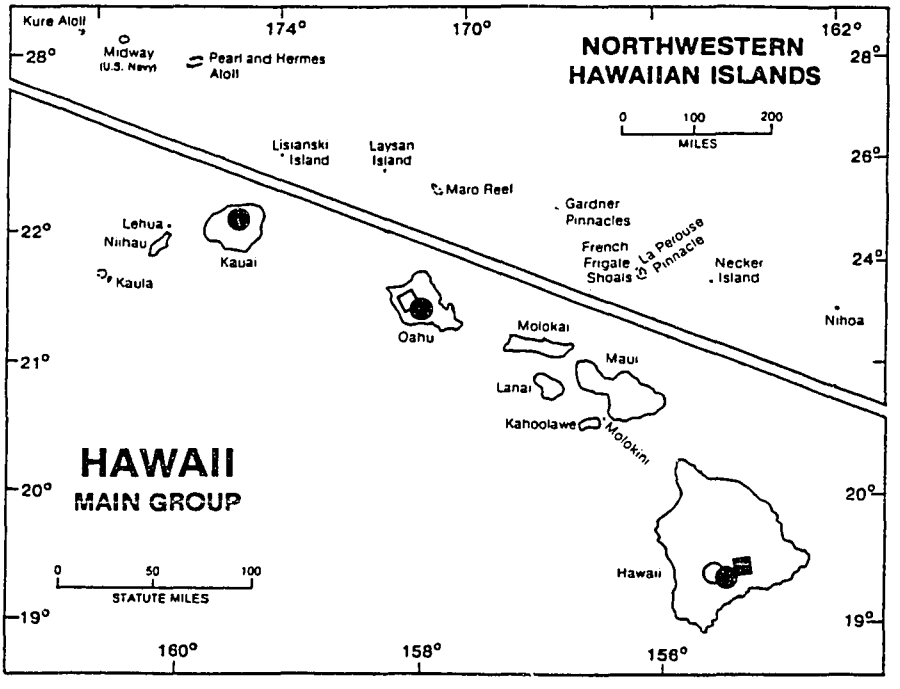
Kure Atoll
Midway (U.S. Navy)
Pearl and Hermes Atoll
NORTHWESTERN HAWAIIAN ISLANDS
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Laysan Island
Maro Reef
Gardner Pinnacles
French Frigate Shoals
La Perouse Pinnacle
Necker Island
Nihoa
Lehua
Niihau
Kaula
Kauai
Oahu
Molokai
Maui
Lanai
Kahoolawe
Molokini
Hawaii
HAWAII
MAIN GROUP
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STATUTE MILES
174°
170°
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28°
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21°
20°
19°
160°
158°
156°

Figure 88

Distribution of Eustigmaeus microsegnis Chaudhri; Eustigmaeus kauaiensis Swift et al.; Eustigmaeus ornatus Ueckermann and Meyer; Eryngiopus n.sp. A

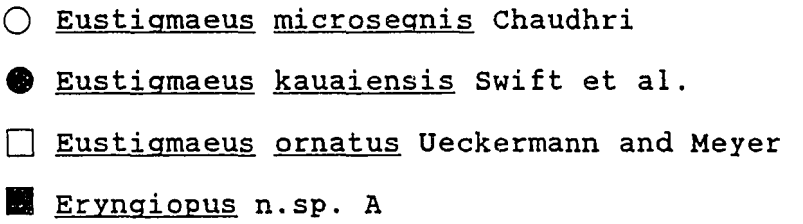
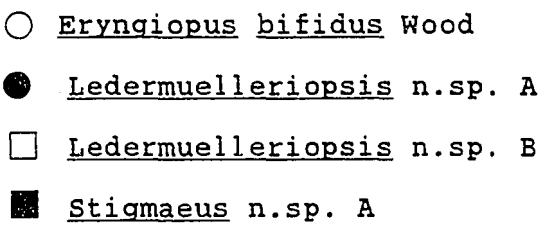
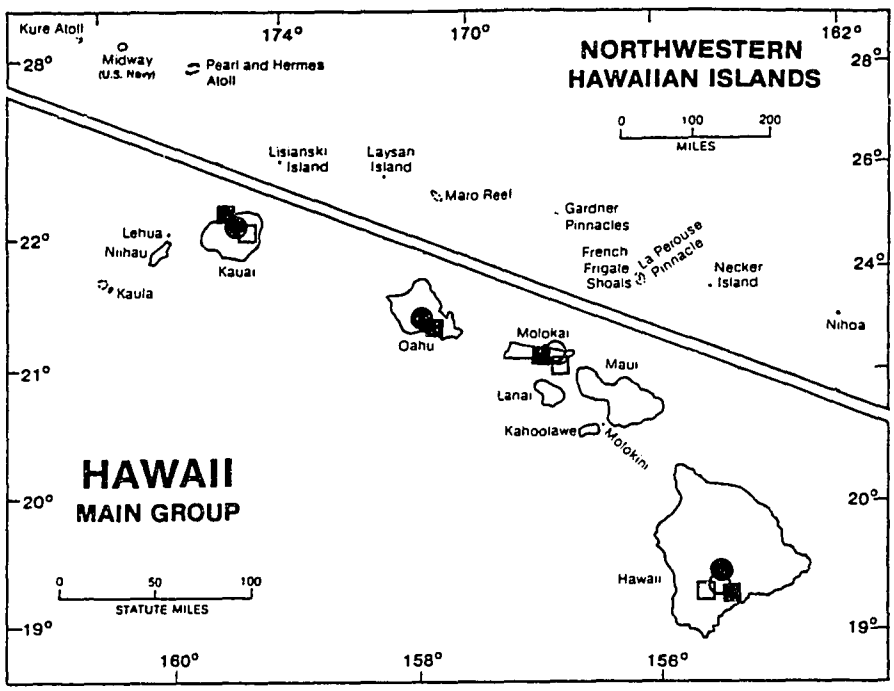


Figure 89

Distribution of Eryngiopus bifidus Wood; Ledermuelleriopsis n.sp. A; Ledermuelleriopsis n.sp. B; Stigmaeus n.sp. A




Kure Atoll
Midway (U.S. Navy)
Pearl and Hermes Atoll
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NORTHWESTERN HAWAIIAN ISLANDS
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MILES
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Laysan Island
Maro Reef
Gardner Pinnacles
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Lehua
Niihau
Kauai
Kaula
French Frigate Shoals
La Perouse Pinnacle
Necker Island
24°
Nihoa
Oahu
Molokai
Maui
21°
Lanai
Kahoolawe
Molokini
HAWAII
MAIN GROUP
20°
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19°
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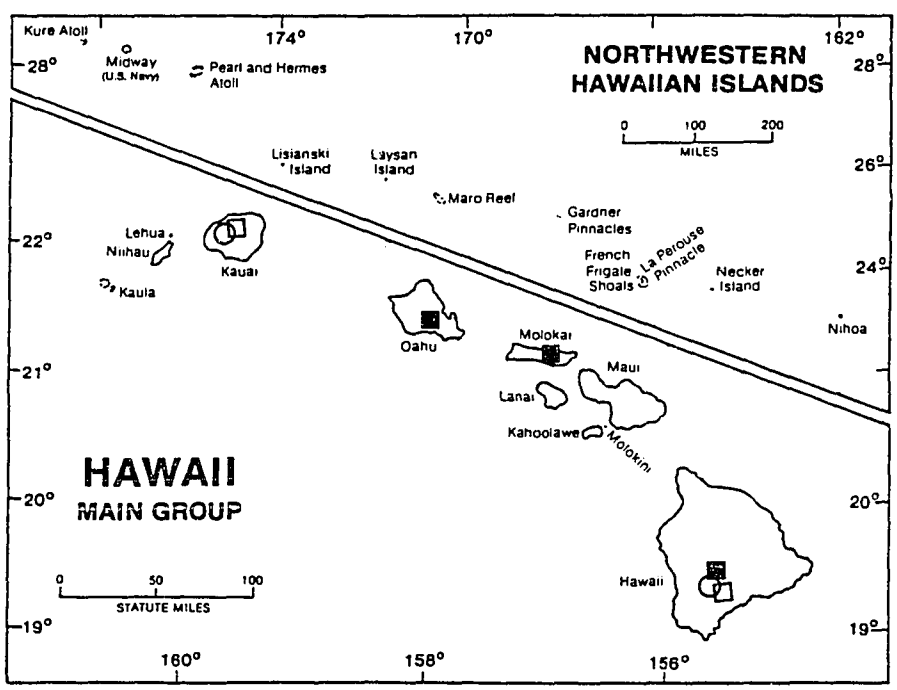
Kure Atoll
Midway (U.S. Navy)
Pearl and Hermes Atoll
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NORTHWESTERN HAWAIIAN ISLANDS
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MILES
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Laysan Island
Maro Reef
Gardner Pinnacles
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Lehua
Niihau
Kauai
Kaula
French Frigate Shoals
La Perouse Pinnacle
Necker Island
24°
Nihoa
Oahu
Molokai
Maui
21°
Lanai
Kahoolawe
Molokini
HAWAII
MAIN GROUP
20°
Hawaii
0 50 100
STATUTE MILES
19°
160°
158°
156°

Figure 90

Distribution of Stigmaeus n.sp. B; Stigmaeus n.sp. C; Stigmaeus n.sp. D

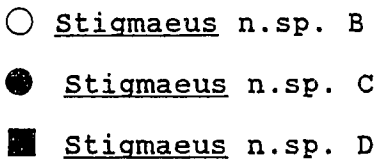
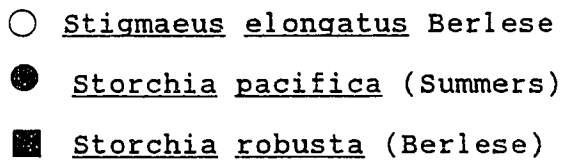
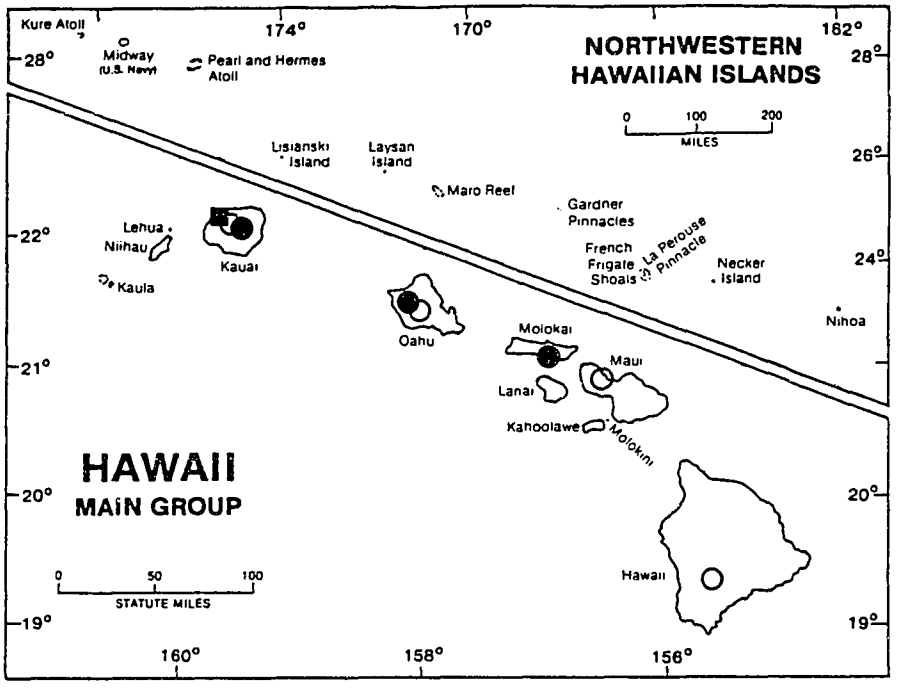


Figure 91

Distribution of Stigmaeus elongatus Berlese; Storchia pacifica (Summers); Storchia robusta (Berlese)

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Pearl and Hermes Atoll
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Laysan Island
Maro Reef
Gardner Pinnacles
French Frigate Shoals
La Perouse Pinnacle
Necker Island
Nihoa
Lehua
Niihau
Kaula
Kauai
Oahu
Molokai
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MAIN GROUP
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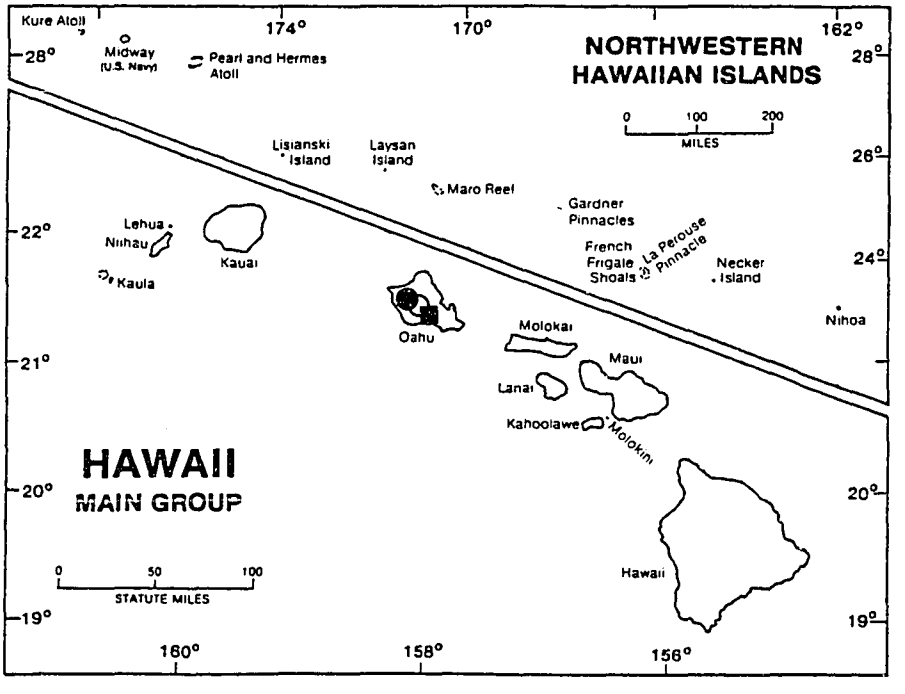
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